# ARE ASSISTIVE TECHNOLOGIES AN ENHANCEMENT TO THE PRESENT HEALTH, CARE, AND SUPPORT MECHANISMS?

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# Statement of Originality

I declare that the work presented in this thesis is my own work, unless explicitly highlighted.

Signed.....................................

# Acknowledgements

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# Abstract

The present health, care and support mechanisms are unable to truly meet the demands made upon it. Between 1992 and 1996 the total number of home care hours increased by 50% while the number of households receiving the service declined by around 7%. A more intensive service is being delivered to a minority of people yet at the same time the number of people who may need support is increasing. Health spending on people aged 75 and over is 6 times that of the average for the rest of the population but between 1995 and 2025 the UK will see a 43.6% increase in the 60 and over age range. A similar trend is apparent across much of the developed world.

In order to meet this new demand the use of technology has been suggested, yet a review of the literature indicates that little evidence exists to indicate if users would welcome technology and whether it would be effective. This research therefore seeks to answer the question 'Are assistive technologies an enhancement to the present health, care and support mechanisms?' The NHS and Community Care Act 1990 suggests that resources should move from hospitals and institutions to the community and therefore since 80% of older people want to stay in their own homes it would seem appropriate that assistance is provided to people in these locations. The literature review has also highlighted 4 key areas, which are addressed in this thesis, namely: user requirements, system modelling, cost analysis and service delivery.

Currently relatively simple technology, refereed to as the community alarm system is used to assist, predominately older people, in the community. Using these people and the technology as a base level this research indicates that such users would welcome more advanced technology. Indeed, in a survey of 176 users, 77% welcomed automatic fall detection, 68% welcomed lifestyle monitoring where changes in the pattern of behaviour generates an automatic alarm, 57% welcomed telemedicine where medical parameters are measured in the users home and the doctor is contacted if necessary, and 46% welcomed videoconferencing.

To assist people in their own homes telecare has been defined as an appropriate model with the community alarm system being defined as the 1st generation system. Several authors have attempted to define subsequent generations of telecare in generalities with no one defining the actual system and data flows. To address this insufficiency, and provide a structure to developments, based on the availability of technology and the views of users, a target system has been defined which could be available within 15 years. In order to move from the present 1st generation system to this 4th generation, 2 stepping stone systems have been defined and it is hoped that subsequent work will use these system definitions and create and trial the technology and systems suggested.

Telecare is an emerging area of research and therefore little attention has been given to cost-effectiveness, in order to address this area a financial model has been created using Excel worksheets. The results indicate that, in comparison to the present system a 2nd generation telecare system could potentially save £8.3m over the 10-year system life cycle. Various sensitivity analyses are performed and in each and every constraint the 2nd generation telecare system is more profitable than the present

community alarm system. Extrapolating the results to represent the whole of the UK indicates that there is the potential to save £832m over the 10-year system life cycle.

As with any system the introduction of a 2nd generation telecare system will inevitably change the way people work. In order to discover the impact that the introduction of such a system may have a model has been created to estimate the impact at the community alarm control centre, currently the centre of activity in the present system. The net result is that the number of calls increases by 321%, however many of these calls regard data that do not require human attention. When analysing the impact on service delivery the actual amount of time required speaking to people in need of assistance reduce by 55%. This is predominantly achieved by reducing the number of calls activated by mistake through the greater use of effective technology.

Overall it could be argued that this research has added considerably to the knowledge base and the results indicate that telecare has tremendous potential to address the ageing population difficulties that the UK and other developed countries face.

# Overall methodology

This thesis covers four main themes as indicated in Fig A.

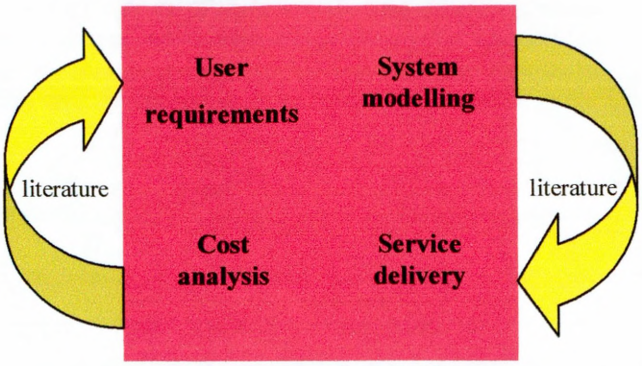


Figure A: *Overall methodology*

These four areas were identified by a literature review conducted in chapters 1 and 2. The aims of this literature review were to:

- Discover if the present health, care and support mechanisms were 'stretched' and whether this was likely to continue in the future, i.e. was this research needed.
- Identify research and developments in assistive technologies. What research had been conducted, what was happening, and what were the likely trends.

These aims helped to identify if this research was required and also identify areas were I could make a contribution to the field.

With respect to the methodology employed this was 4 step approach:

1. *Search of online databases*: For example, Medline, Cochrane database of systematic reviews, Health Technology Assessment database, and the National Research Register. This helped to identify key papers, journals and authors for step 2.
2. *Physical library search*: Key papers could now be acquired relating to the aims of the literature search.
3. *Grey/internet search*: To obtain a rounded search conference proceedings and the internet were searched based on the papers, authors and key phrases used in the literature, i.e. telecare, telehealth etc. The search engines of Yahoo and AltaVista were used to give a general and more academic search.
4. *Contact with key researchers*: Authors and leading personal which were identified in the previous sections were contacted for further information regarding their work and further contacts.

Based on the results of the literature review and discussions with the project review group the four key areas in Fig A were identified. Each of these areas have been researched with support of additional literature searches. This therefore ensured that the work being conducted was still required but also that the appropriate methodology was being applied to each of these areas. Details of the specific methodology employed is discussed when introducing each of the key areas.

# Chapter Structure

| Chapter | Description |
|---|---|
| 1 | The structure of the project and general area of the research is identified. Particular attention is given to the current health, care and support mechanisms in order to identify the current position and therefore provide a base from which to investigate. Attention is also given to why technology is being seen as a possible way of enhancing the current system. |
| 2 | The assistive technologies currently available are described along with research and development work that started prior to this project and that which has continued since the project commenced. Particular attention is given to telecare, telemedicine and smart homes. |
| 3 | Based on a questionnaire the views of users, both current and potential, are investigated. Emphasis was placed on the people themselves and what technology they would like to maintain their independence. A questionnaire was also conducted with providers of the current technology system. |
| 4 | In order to develop the present community alarm system and move to advanced or 2$^{nd}$ generation telecare systems an understanding of the technological possibilities is required. This chapter therefore considers what technology is currently available and what may be available in the future. Based on this review and the findings of Chapter 3, a target system for implementation within 15 years is defined. |
| 5 | In order to achieve the goals of the target system, stepping stone systems are required that bridge the gap. This chapter therefore defines two systems in terms of the technology required and how it should interact, but also the impact that the systems may have on the information flows between various organisations. Finally the target system is fully described and analysed, providing a framework for development for the next 15 years. |
| 6 | The first stepping stone system or 2$^{nd}$ generation telecare system is used to develop a cost analysis model and discover the costs and potential savings involved. This chapter reviews the current literature, indicating the formal constraints imposed in the development of an effective cost analysis tool, and explains how the cost analysis model was developed. |
| 7 | Having created a cost analysis tool the model is investigated and the results reported using various economical assessment procedures. |
| 8 | Having defined what a 2$^{nd}$ generation telecare system should consist of and analysed the financial implications the ability to deliver the service is analysed. This chapter therefore describes how a simulation tool should operate and what assumptions are included in the service delivery model. Particular attention is given to how the model simulates call activity to the community alarm control centre. |
| 9 | Having created the service delivery model, particular attention is given to validating the model to ensure it simulates the current system. Once this has been achieved the impact of the 2$^{nd}$ generation telecare system described in Chapter 5 is estimated and included in the model to discover the service delivery implications. |
| 10 | The final chapter brings together the preceding chapters and based on the evidence presented in this thesis answers the original research question. Consideration is also given to how this research can be taken forward in the next 2 years, 3 – 5, and 6 – 10 years. |

# Contents page

# 1 Introduction

***Chapter structure:*** *The structure of the project and general area of the research is identified. Particular attention is given to the current health, care and support mechanisms in order to identify the current position and therefore provide a base from which to investigate. Attention is also given to why technology is being seen as a possible way of enhancing the current system.*

## 1.1 Project Theme

Over recent years, health and community care services for community alarm[1] users and other user groups have increasingly become under budgetary pressure. At the outset of this project it was thought that the use of more technology in the home would enable more to be achieved from the same resources. However, there was little evidence to support such a hypothesis. In particular, questions that needed to be addressed were:

- Can technology assist people to maintain their independence?
- If technology can be used, what form should it take to meet the requirements of users and providers?
- What are the implications of introducing advanced technology, in terms of:
  - financial considerations, and
  - service delivery

When the research began the potential benefits from the more widespread use of technology were unclear. Nevertheless community alarm manufacturers were aware of the market potential if benefits were identified and a consortium was therefore formed to investigate assistive technologies. Details of the consortium partners are provided in Appendix A1.1.

## 1.2 Initial objectives

At the beginning of the project the consortium partners developed a framework for the initial research and discussion (27 May 1997). The resulting statement is reproduced below:

***Project:*** *The research is to be in the area of telemedicine but with specific reference as to how user related medical, life style or behavioural data collected in the home can be used effectively by community medical or carer staff.*

***Background:*** *We believe there is a need for a product which will gather data collected about individuals within their own homes in the community and make this data available in a readily useable form to interested staff in the local medical staff social services, carer agencies, carers and other related community individuals or organisations (the target users of this product).*

*We would see this product being essentially software based which links the 'home' to the place of work for the target user. The place of work could be an office, at home, in a car or indeed at any place where the target user is based. At its simplest, this product could be viewed as a 'decision support' system which would enable the target users to choose selected data (from a range of available data) for a*

[1] Community alarms enable a user to contact a control centre from which assistance can be provided. They are explained in further detail in Chapter 2.1

*specified individual, have this data presented in a useful way which will allow the user to make decisions about the individual's status and subsequent care requirements. The data could be presented in comparison with expected norms or standards, it could show trends over time, it could display variations from set parameters etc.*

***Key aims****: We believe there is a need for the type of product described. We could be wrong or our ideas of the product could be wrong. There may not be a market at all for this type of data collection and presentation. Or there may be a need but no one is prepared to pay anything for such information. It may be that the information actually needed cannot be provided.*

*In simple terms, we need to have enough information to decide if there is a market for this type of product and if yes, then to define the market, the users and the product specification.*

*The commercial objective is to approach the telemedicine concept from the 'other end' and to:*

- *Define who are likely to be target users of such data.*
- *Determine what data would be useful for each group within the target user categories.*
- *Define how this data would be used by the target groups and where the data would be used.*
- *Define how the data should be presented to users.*
- *Determine how the use of this data would improve the efficiency or reduce the costs of the care provided.*
- *Determine who would be the 'purchasers' (as distinct from the users) of the proposed product – e.g. GP fund holders, social services, care agencies, hospital trusts, health service, etc.*

A literature review has been conducted to identify the exact objectives and these are reported on page 42.

## 1.3 Project Structure

The project was led by Professor David Bradley at the University of Abertay, Dundee. Quarterly meetings were held with the consortium partners to present the work in the proceeding quarter and to agree a framework acceptable to all parties for the next two quarters. Particular reference was given to the immediate quarter in question. Throughout the project additional meetings have been held with the consortium partners to discuss and develop specific applications and areas of work based on the results of the project research.

In terms of project organisation, after an initial set-up period of a few months the researcher has not been based at the University. However, regular contact with the project supervisor, Professor David Bradley, has been maintained by email and telephone conversations. In addition, when necessary, meetings have been held throughout the country and several weeklong trips to the University have taken place.

## 1.4 Research Background

Based on the initial objectives and the general theme of the research program, a title for the research was agreed, namely:

**Are assistive technologies an enhancement to the present health, care and support mechanisms?**

The term 'assistive technology' is an umbrella term used to describe any device or system that allows a person to accomplish a task they would otherwise be unable to do or increases the ease and safety with which the task can be performed[1]. The author of this definition has subsequently acknowledged that it is a very broad definition and could include swimming goggles or flippers[2]. In the context of this research examples would include the technically simple, for example a walking stick, to complex aids such as intelligent wheelchairs or height adjustable sink and kitchen units. The purpose of this research is to investigate possible assistive technologies in the health, care and support environment that could assist people to maintain their independence in their own home. Underlying the purpose of this research is the ideal that the current care system can be improved through the use of assistive technology.

In the UK care provision is often split into domiciliary and community care. Domiciliary care, now sometimes referred to as home support services, endeavours to provide personal and practical help to people in their own homes[3] through two main functions. They provide expert professional help that the family cannot supply and they provide unskilled or semi-skilled assistance for persons who do not have families or whose families are not always able to help[4].

Community care does not appear to have a satisfactory definition[5]. Clegg suggests that there is no agreed definition of community among academic sociologists, social workers or the makers of social policy[6]. The Seebohm Report suggests that community care has come to mean providing assistance outside of hospitals or residential homes[7]. Other authors suggest it is providing the services and support which people require to live as independently as possible in their own home, or in 'homely' settings in the community[8]. The governments own plans suggests that there are four key components for community care, namely developing services that[9]:

- Respond flexibly and sensitively to the needs of individuals and their carers.
- Provide a choice of options for consumers.
- Intervene no more than is necessary to foster independence.
- Target those people with the greatest needs.

As part of the governments focus on community care the NHS and Community Care Act was introduced in 1990 and aims to[10]:

- Facilitate the development of domiciliary care to support people in their own homes and prevent unnecessary admission to residential care.
- Create 'Care Packages' that are designed to support people's individual needs, based on an assessment of 'that need'. The assessment should be a multi-disciplinary assessment arranged by the local authority, and collaboration between medical and nursing colleges will be required.
- Give responsibility to local authorities to assess and pay the fees of those people who need public assistance to enter a nursing home. This came into affect in April 1993.

However, it has been suggested that:

*"To the politician, the NHS and Community Care Act is a useful piece of rhetoric; to the sociologist, it is a stick with which to beat institutional care providers; to the civil servant, it is a cheap alternative to institutional care which can be passed to the local authorities for action or inaction; to the visionary it is a dream of the new society in which people really do care; to social services departments, it is a nightmare of heightened public expectations and inadequate resources to meet them*[11]*"*.

For the end user the Act suggests services should be available to assist them to stay in their own homes for as long as they wish.

The 1994 General Household Survey (GHS) observed that the predominant users of domiciliary services were those aged 75 and over, primarily women and people living alone[12]. Focusing purely on home care in the UK indicates that in 1996, 83% of the recipients were aged 65 and over, with 64% aged 75 and over[13]. Figures from Birmingham City Council (BCC) for the year 1997/98 suggest that 88% of available home care was directed to the 65 and over age group[14]. In terms of assisting people who live on their own, it has been suggested that local authorities are 6 times more likely to help people in single occupant dwellings[15]. It can therefore be concluded that older people living alone are the main beneficiaries of 'care'.

In the remainder of this chapter the background published literature is reviewed to provide a framework for the development of assistive technologies in the present health, care and support mechanisms. The review considers the present systems in the provision of care and support, and from published literature investigates possible future trends. The focus of the review is centred upon why technology is being investigated and consideration is also given to government policy, which may influence developments in the future.

### 1.4.1 Why assistive technologies?

There are a number of factors that are driving the development of new technologies as a means of supporting independence.

*Inadequate levels of support and care*

There is evidence to suggest that the current arrangements do not provide adequate levels of care. During the financial cutbacks of the 1980's, services such as 'Meals on Wheels' or Home Care support became more "thinly spread"[16]. This has continued in the 1990's with the Association of Social Services and the local Government Association, suggesting that home care and residential care faced cutbacks as social services departments faced an average 3.4% shortfall in the 1998 budget[17]. This has culminated in a more intensive service where greater amounts of assistance are provided to a smaller number of people. By way of illustration between 1992 and 1996, while the total number of home care hours increased by 50%, there was a reduction of around 7% in the number of households receiving the service. The resulting change in focus has been reflected with a change in name, from the original 'home help' to the now more commonly used term 'home care'[18]. In essence this is a form of rationing, giving support to those identified as the most in need. Alan Maynard, Professor of Health Economics at the University of York has said:

> "*We want to do things that benefit you (older people) but we really have a limited amount of money and we have to go for the cost-effective*[15]."

Having 'rationed' formal care to those most in need, there are evidently people who require care and support but whose need is not being met. In 1987 the Department of Health and Social Security wrote:

> '*If increasing numbers of very elderly people are to be enabled to continue living in their own homes, or in sheltered housing, rather than having to move into residential care, either a higher volume of domiciliary services will be necessary, or the currently available resources will have to be more specifically targeted to those in most need, and for whom most can be achieved*[19].'

Allen *et al*[20] observed unmet need in 1992, while across Europe there has been a reduction in long-stay facilities which has not always been counter balanced by an expansion in home care services[21].

*An ageing society*

Of fundamental importance to this research is the question of whether there will be a need to provide more care in the future? From the proceeding it is clear that older people are the main recipients of care and that care is currently being 'rationed' through financial constraints. If the user base, the number of older people, increases then the available services will be 'stretched' even further. Figures by the Commons Health Committee and echoed by the Department of Health suggest that 5.1% of the population is currently aged between 75 to 84 with 1.7%, aged 85 and over. By 2021 it is suggested that these figures will have increased to 6.2% and 2.3% respectively[22]. The European Commission has predicted that between 1995 and 2025 the UK will see a 43.6% increase in the 60 and over age range[23]. Of significance is the dramatic increase in the number of centenarians. In 1996, in England and Wales 5,523 people, 4,943 women and 580 men, were aged 100 or over, by 2036 it is estimated that there will be 39,000 centenarians[24]. Possible demographic changes for the UK are summarised in Table 1.1[25].

Table 1.1: *Population structure in the UK*

| | 1987 | 1997 | 2007 | 2017 | 2027 |
|---|---|---|---|---|---|
| Total Population('000s) | 55355 | 57062 | 58110 | 58869 | 59616 |
| Percent aged | | | | | |
| 0 - 4 | 6.4 | 7.0 | 6.1 | 6.2 | 6.3 |
| 5 - 15 | 13.7 | 14.3 | 14.8 | 13.2 | 13.6 |
| 16 - 64 | 64.3 | 63.0 | 63.5 | 63.1 | 60.9 |
| 65 - 74 | 8.9 | 8.4 | 8.1 | 10.0 | 10.3 |
| 75+ | 6.7 | 7.3 | 7.5 | 7.5 | 8.9 |
| Dependency ratios (%) | | | | | |
| Child (0-15)* | 31.3 | 33.8 | 32.8 | 30.7 | 32.7 |
| Elderly (65+)** | 24.2 | 25.0 | 24.6 | 27.8 | 31.6 |
| Overall*** | 55.6 | 58.8 | 57.4 | 58.5 | 64.3 |

* Persons aged 0-15 as percent of person's aged 16-64.
**Persons aged 65 and older as percent of persons aged 16-64.
***The ratio of those aged <16 and >65 to those aged 16-64.

Table 1.1 highlights the dependency ratio, defined as the ratio of people of working age compared to non-working age groups (<16, >65). Considering the overall dependency ratio a steady increase can be observed, from 55.6% in 1987 to an estimated 64.3% in 2027. At present, care provision in the UK is supported through tax income. With such an increase in the dependency ratio it may be difficult in the future to raise enough income from this source. However, in time other conditions could be deployed such as at present in Germany where families are legally responsible for the care of older relatives[26].

Due to the industrial revolution, demographic ageing began in the UK before many others; consequently the growth of the UK's older population has been slower in the past two decades when compared to other western countries[27]. The overall result however is that the UK is among the many countries that are faced with an ageing population.

Within the countries of the European Union in the past 50 years the older population (persons aged 60 and over) has reduced from 1 in 14, to 1 in 5. By the year 2020, 1 in 4 will be aged 60 and over and this is represented graphically in Fig. 1.1[28]. In 1991, 20.7% of the population were aged 60 and over in the UK with this being exceeded by Italy and Belgium with 20.8%. Germany, Greece and Denmark have similar age structures, with 20.6%, 20.5% and 20.4% aged over 60 respectively.

However Fig. 1.1 shows that predictions for 2020 suggest that the UK will have by far the largest percentage of the population aged 60 and over, and indeed the greatest rise in the number of people of retirement age. Denmark, closely followed by Greece, exhibit the smallest changes, yet all show increases of over 5%.

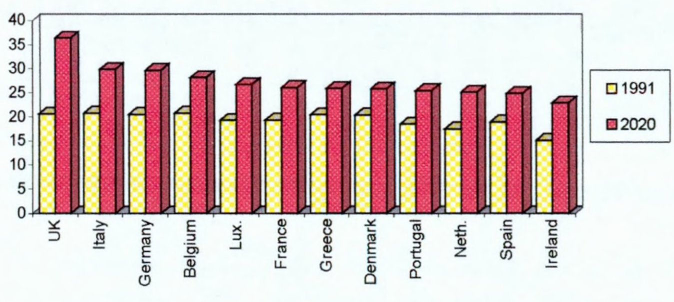


Figure 1.1: *Proportion of population aged over 60 in EU countries*

The increase in the numbers of older people is due to the dramatic changes in life expectancy. Internationally, the average life expectancy at birth in 1950-55 was 46, by 1990-95 this had risen to 62.6. For the UK, in 1995 average life expectancy for men was 74.5 years, while for women it was 79.4 years, an overall average of 77 years. By comparison, Italy enjoyed an average life expectancy of 77.8 years and Germany 76.8 years[29].

Throughout the world, the number of older people is increasing, and this is a triumph for twentieth century medicine. Indeed medicine in the twenty-first century may go further. The Aeivios science group suggests that by 2015 people could live forever supported by the growth of complete replacement organs. Depending on accident rates, the average life span is suggested at between 400 and 1000 years[30].

The actual future improvements in life expectancy over the coming years are, at present, unknown but all of the literature indicates that the number of older people, and the percentage of the population they represent, is increasing. Older people are the predominant users of care and it can be expected that greater amounts of care will be needed. Indeed the proportion of people aged 85 and over who are most likely to need support was estimated to increase by 22% from 1990 to 1995 and by 45% from 1990 to 2005[31]. For comparison, Fig. 1.2 shows the variation in dependency ratios for a number of countries.

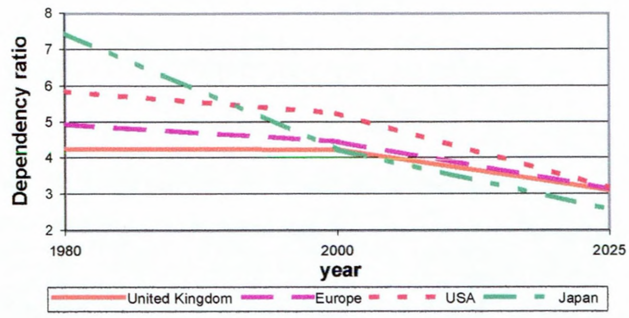


Figure 1.2: *Dependency ratios in the UK, Europe, Japan and USA*

Fig. 1.2[32] suggests that by 2025 across Europe and the developed world the dependency ratios will converge such that there will only be some 3 people of working age to fund support for each older person. Specifically for the UK, in 1961 there were almost 4 people of working age to support each pensioner, by 2040 it is estimated that there will be only 2[33, 34]. In Germany, the increased dependency ratio could result in a projected contribution rate (employer's plus employee's) of 40% in 2035 compared with 18.5% in 1984[32]. This introduces uncertainty about how the already thinly spread services can deliver the required amounts of care in the future.

*A potential shortage of informal carers?*

A carer has been defined as a "person looking after or providing some form of regular service for a sick, handicapped or elderly person living in their own home or elsewhere"[35]. Carers may be formal, i.e. they are paid to provide care, or informal when no charge is made for their support. Informal carers have historically compensated for any shortfall of formal care provision and in combination with formal care provided greater support to some people. As the number of older people increases and formal services have to provide for a growing proportion of the population there may be an increasing reliance on informal care to bridge the gap.

People between the ages of 45 and 64 provide the greatest amount of informal care with 17% of women and 13% of men being carers in this cohort[31]. In particular, children are the main source of informal support for elderly people living alone[36]. Wenger has suggested the percentage of adults who provide informal care as set out in Table 1.2[37].

Table 1.2: *Percentage of adults who were carers by sex and age*

| | 16-29 | 30-44 | 45-64 | 65+ | Total |
|---|---|---|---|---|---|
| Men | 6 | 11 | 16 | 14 | 12 |
| Women | 7 | 16 | 24 | 12 | 15 |
| All adults | 7 | 14 | 29 | 13 | 14 |

Nissel and Bonnerjea's pioneering work of 1982 focused specifically on married daughters as carers and gave the impression that they where most likely to take on caring responsibilities[35]. However, Javis is of the view that people do not turn to others just because they are related to them. They turn overwhelmingly to people who they regularly interact with. These people may be family relatives but may be friends or neighbours, proximity and intimacy are more important than whether or not people are related[38].

In terms of the support provided by informal carers, in one study where the carer was a family member, half of the carers had provided care for up to 4 years and 21% for more than 10 years[39]. However, other authors have commented that informal care is short term and cannot be relied upon for providing long-term care[40]. Table 1.3 indicates the percentage of couples where one partner cares for a spouse.

Table 1.3: *Percentage of married men and women who were caring for a spouse by age*[37]

| | 16-29 | 30-44 | 45-64 | 65+ | Total |
|---|---|---|---|---|---|
| Men | 1 | 1 | 3 | 6 | 2 |
| Women | 0 | 1 | 4 | 8 | 3 |

If informal carers predominantly care for family members then for this to be effective proximity is important. It has been suggested that 11% of older people have all or most of their relatives living near by, while 51% do not have any relatives living near by[41]. Bengston *et al* disagree with these comments and suggests that few people claim to have no relatives living near by[42]. Even if relatives live close by, how many older people are visited regularly by their relatives? In this country studies suggest that as many as 1 in 3 older people have not been visited by relatives in the last week and nearly half had not been visited by friends[41]. However, informal caring is not constrained to children and partners; brothers, sisters, nieces and nephews can all fulfil the role[42]. Indeed, Wenger has commented that there are cases where friends and neighbours have provided care when relatives do not live near by[43].

Although studies tend to suggest that informal care is predominantly provided by family members and may not be completely relied upon to provide long term care, it has been suggested that there are currently between 6[44] and 6.8[45] million informal carers in the UK. In financial terms, attempts have been made to cost informal care and these estimates conclude that informal care saves the state between £15-24 billion[44] or £34 billion[46] per annum.

Migration is defined as a move from one place (country, town, college, house) to another[47] and the physical distance between family members effects the capacity to provide informal care as shown in Table 1.4[27].

Table 1.4: *How distance affects the visiting of older relatives*

| | Residential separation (km) | | | | | |
|---|---|---|---|---|---|---|
| Frequency of visits | 0 - 1.9 | 2 - 4.9 | 5 - 19.9 | 20 - 49.9 | 50 - 99.9 | 100+ |
| 3+ per week | 39 | 20 | 4 | 2 | 0 | 0 |
| 1 or 2 per week | 42 | 44 | 43 | 11 | 6 | 2 |
| 1-3 month | 13 | 18 | 39 | 48 | 31 | 9 |
| 4-11 year | 3 | 8 | 7 | 27 | 34 | 25 |
| 3 per year or less | 3 | 10 | 7 | 11 | 29 | 65 |

The majority of migrations are over small areas, typically less than 20 km, with a move closer to a family member, or a climb 'up the social ladder', but with increased mobility and the convenience of air travel, migrations to other countries has become more common[27]. For example, since the late 1970's there has been a substantial growth in the number of British retirees moving to southern Spain and a few other Mediterranean regions[27]. In the past families have been dispersed throughout the country and abroad, often with work dictating a move, however this trend may not continue. There are 1 million teleworkers in the UK[48], and through the use of computers and telecommunications where an employee is physically located is increasingly almost irrelevant for certain jobs. As such, many people may not need to travel to find work and could move back to live near their families providing informal care where necessary.

As identified spouses are the main providers of informal care, followed by children, therefore the number of children a couple have obviously affects the number of potential carers in latter life. Over recent decades the family has changed from a pictorial horizontal spread, with many children, to a vertical spread where there are fewer children but more generations alive. This has been referred to as the transition to a 'beanpole' family[49]. The reduction of the age gap between generations observed in recent years may mean that a grandparent is far from being dependent[50]. Indeed, in a national survey it was found that the grandmother was the second most frequent source of childcare for women in employment, the most frequent being the husband[51]. As a consequence of this, in future years care could be reciprocated by both children and grandchildren[52].

Divorce may further affect informal care. Currently most Europeans between the ages of 60 and 74 are married and living with their spouses and generally they provide care for one another. The majority of men will be married until death, whereas women are often widowed. This is due to two reasons; firstly, men tend to marry women who are younger than themselves, and secondly, women have a higher life expectancy[53]. The UK has the largest number of one-parent families in Europe and it is estimated that by 2019 approximately 15% of people aged 65 or older will be divorced[54]. It is unclear if broken families will increase the number of potential informal carers with stepchildren caring or alternatively reduce the potential, as the family becomes fragmented and unwilling to provide support for one another.

There may also be less availability of informal carers as more women have careers, and this trend is expected to increase[50]. Yet while there has been an increase in the number of married women working there is little evidence to support the hypothesis that they are less likely to provide care[55].

Tinker suggests[50] that a reduction in the number of potential informal carers is a pessimistic view. In order to come to this view she considers there are four components:

1. A reduction in the number of children.
2. Increase in the number of people working.
3. The complexity of family life.
4. The emergence of the 4 generation family and their increased mobility.

It appears however that the true picture is unknown and authors are unclear as to the changes in the potential number of informal carers in the future. Nolan *et al* suggests that a pessimistic view is an accurate one, suggesting that the increasingly frail older people will require care in the community when the number of informal carers is declining[9]. As highlighted, informal care potentially saves the country annually between £15-36 billion, yet doubt has been raised as to the benefits of intensive informal care. It has been suggested that carers are more likely to receive means-tested benefits in the future as they have inadequate occupational pensions and tend to live in families that are less well off than families of non-carers[56]. Consequently a spiral may result that is almost impossible to get out off, having cared for someone you yourself then require care and rely on the state. The Department of Health and Social Security has commented that although family links are irreplaceable, it cannot be assumed that the family can carry the whole responsibility for caring for the growing numbers of very old people. Therefore the wider community may have to provide support traditionally expected of the family[57].

*Support needs to be given to people where required*

The home (or nursing home, sheltered housing etc.) is considered the most likely location in which to provide care, while people needing continuing care would also prefer to receive this within their own homes[58]. Indeed 80% of older people want to live and stay in their own homes[10]. The NHS and Community Care Act 1990 encourages people to stay in their own homes with additional help if required, yet the home care service has become an intensive service, benefiting only a few and this 'rationing' may not be desirable or cost-effective. Alber has suggested that when community services are lacking then the stress on informal carers increases and consequently an older person reliant on such care may ultimately be placed in residential care[21].

Highly dependant people can also be inappropriately positioned in institutional care when it may have been more appropriate to provide a lower level service in the community. The Joseph Rowntree Foundation has highlighted that Social Services budget constraints have led to the imposition of ceilings for expenditure on individual community care packages[59]. These ceilings are set with reference to the cost of residential care and the Independent Living Fund (ILF). The ILF 'tops up' Social Services provision when the community care package costs in excess of £200 a week, however the ILF ceilings have not changed since 1993 and people over the age of 66 do not qualify for the ILF. Some people are therefore in residential care against their will because of a failure of social services and health authorities to agree the funding of a community care package. Others are in residential care because different local authorities dispute their responsibility for funding. There are also indications that people are placed in cheaper but inappropriate nursing homes because of local authority budget constraints[59].

People want to stay in their own homes independently, yet independence goes beyond support for the basic activities of daily living[60]. Independence is a multidimensional concept associated with the physical and social context of people's lives, their resources, personality, attitudes and motivations. Independence is concerned with the degree to which individuals have control over their environment and can exercise choices regarding their activities and the support or care services that they receive[61]. The importance of independence is such that it is 'valued above all else' by older people[10]. Yet while government policy reflects that older people should be given the choice and ability to stay in their own homes in the community[58, 62], the lack of home care and funding constraints can result in such a possibility not being open to everyone.

In respect to where people live in 1997 it was stated that approximately 90% of older people lived in ordinary accommodation either owned by themselves or rented[2], 5% lived in sheltered housing and 5% lived in some form of institutional care[63]. A further article supports these figures by suggesting that 11% of retired people live in sheltered housing, residential or nursing home care[64]. The majority of these people in sheltered housing or institutional settings will be considerably older than 65 as disability rises rapidly with age[12] and the proportion of people aged 85 and over in some form of institutional care is believed to be around 20%[65].

Evidently the majority of older people live in, and want to stay in, their own homes, however staying at home may not be conducive to good health. Some 60% of pensioners who live on their own are in poorly heated houses and cold weather is estimated to cause up to 60,000 premature deaths a year with 1 in 3 ordinary homes being deemed 'unfit'. Government figures estimate that the cost of cold and damp housing to the NHS is approximately £1 billion a year[66] while poor housing per say costs the NHS an estimated £2.4 billion[67]. Throughout England in 1991, 12.4% of single people aged 60 and over lived in the worst dwellings compared with 7.6% of older couples. The worst conditions were experienced by single older people aged 60 and over in the private rented sector. These people occupied 46% of the worst houses in 1991 compared with 34% in 1986. Older couples occupied 32% of the worst private rented housing, which was the same as in 1986[68]. Despite this, published literature supports the view that older people would prefer to stay in their own homes.

In his book on residential care '*The Last Refuge*' published in 1962, Townsend concluded that there should be a greater provision of purpose built accommodation to enable older people to lead independent lives[69]. Seven years latter in 1969 Category 1 and 2 sheltered housing schemes were first described in a Ministry of Housing and Local Government Circular[70]. Category 1 schemes are purpose built dwellings for relatively independent people and a warden is not present on site, although some schemes provide a community alarm system. Estimates of provision in England indicate that there are currently around 387,000 Category 1 dwellings[71]. Category 2 schemes cater for a more vulnerable or dependent people. Typically, they are self-contained dwellings in a single block with communal facilities such as a common room and laundry room. Category 2 schemes normally have an on-site warden. There are some 430,000 of these units in England[71] with approximately 17,000 schemes[72]. The role of the warden is difficult to define but perhaps may best be described as enabling the tenant to live an independent life[16]. However, there is uncertainty over the future role of the warden. The National Federation of Housing Associations

[2] Accommodation either owned or rented in the community is referred to as ordinary accommodation[63].

has commented that the NHS and Community Care Act has undoubtedly had ramifications for the warden service, with the funding of care packages and the increased pressure on local services. They suggest that the Act's emphasis on people staying in their own homes has reinforced the case for a review of the warden service[73], while the Audit Commission of 1998 comments that the 'good neighbour' role is questionable and a review of sheltered housing and the warden is required. The reasons suggested are that new occupants of sheltered housing are relatively fit and do not need the assistance of the warden, while other longer-term tenants have high levels of dependency that wardens are struggling to cope with[71].

A further category subsequently developed, although it does not officially exist is referred to as either Category 2½, very sheltered or extra care[16]. Provision is provided for on-site care as opposed to support and the 'good neighbour' philosophy of Category 1 and 2 schemes, as such they cater for people with a greater degree of frailty[71] and falls in-between Category 2 and Part 3[3] residential care[16]. The generic term 'sheltered housing' is often applied to all three categories[71], although the Housing Act of 1985 refers to sheltered housing as having access to the services of a warden and communal facilities[74].

One of the greatest problems facing sheltered housing is that there is a decline in demand for such places since the majority of older people want to stay in their own homes. A 1994 survey in England and Wales found that 92% of local authorities and 79% of large housing associations had 'some difficulty' in letting sheltered housing[75]. In 1995 a similar survey discovered that 78% of large and 33% of small Housing Associations had 'some difficulty' in letting sheltered housing[76]. While in 1997, 87% of local authorities revealed that they had 'difficult-to-let' sheltered housing units[76, 77].

The future of sheltered housing is therefore uncertain and its role is either likely to decline or to be used to support increasingly frail tenants[71]. For instance, the average age for new tenants entering Hanover Housing Association sheltered housing schemes is now 78[78]. The ethos of the NHS and Community Care Act makes it more difficult to justify tying resources to property rather than to people; consequently the Audit Commission stated that "sheltered housing must re-invent itself as provision for older people who prefer the presence of a supportive community, or it must re-think the levels of need it is able to support[71]."

Despite funding difficulties resulting in some people being inappropriately positioned in institutional care it should be noted that assisting people to stay at home is cheaper than providing specialised housing at all levels of dependency[79-81] as illustrated by Table 1.5[79]. However, if informal care was costed and added then staying at home becomes more expensive than Category 1 and 2 sheltered housing but cheaper than Category 2½[79].

3 Sheltered housing is referred to as categories 1,2 or 2½, while residential care is referred to as Part 3

Table 1.5: *Average gross costs (£1994) per person per annum per housing type*

| | Average for all levels of dependency £'s (1994) | The most dependent £'s (1994) |
|---|---|---|
| Living at home | 7,353 | 7,890 |
| Living in Category 1 housing | 8,436 | 9,537 |
| Living in Category 2 housing | 9,618 | 11,034 |
| Living in Category 2½ housing | 14,825 | 16,378 |

A further analysis by Tinker included residential and hospital care and indicated that staying at home with a package of statutory services was again cheaper on average than all types of sheltered housing, residential care and hospitals[82, 83]. Despite the problems for sheltered housing referred to above, it is a resource that is likely to be evident for many years to come. There are over 817,000[71] units in England alone and such an investment cannot be ignored.

A final option considered by 19% of families is for the family member to co-habit[43]. Data from the Office of Population, Censuses and Surveys suggests that 2% of men and 7% of women lived with a son or daughter in 1994 with 9% of men and 4% of women living with a spouse and others[84]. Co-habiting is not necessarily the best option, 80% of older people want to stay in their own homes and limited research in Northern Europe indicates that older people do not in general want to live with family members[85]. Finally, loneliness can be higher in this group than any other sub-group[43]. This is often attributed to family relations limiting, confining and frustrating older family members[86]. This is an important issue because loneliness and isolation can lead to subsequent mortality[87].

The Relatives Association has commented that it is the personal support with everyday living which makes the difference between vulnerable people living in the community or entering institutionalisation. They suggest the everyday assistance required could be negotiating the complexities of rent payments or resolving problems with water, gas and electricity suppliers[88]. Such assistance could be provided by wardens or home carers and enable people to maintain their independence in the community. It is evident that the community is increasingly the place where care needs to be delivered and where it will continue to be delivered in the future. However, with demand likely to increase over coming years, concerns can be raised regarding the ability to deliver the appropriate services.

It could be concluded from the above that home care is an important component of the care delivery system and Halamandaris[89] gives 20 reasons for the importance of home care and states that:

> "*There is no question in my mind that home care is the wave of the future*".

Nevertheless, Van Haastregt[90] *et al* in a 2000 study commented that:

> "*No clear evidence exists for the effectiveness of preventive home visits to elderly people living in the community. The observed effects of the interventions are considered to be fairly modest and inconsistent, especially as preventive home visits are costly and time consuming...If substantial improvements in effectiveness cannot be achieved, consideration should be given to discontinuing such visits.*"

The outcomes measured in this instance were physical and psychosocial function, falls, admissions to institutions and mortality. This view would not necessarily be consistent with the evidence and cost implications expressed above.

*Increasing healthcare costs as society ages*

Due to the changes in demographics when the National Health Service began life expectancy was around 50 years and 60% of the population was under 20[34]. Today life expectancy is closer to 80 and soon 50% of the population will be over 50[34]. The healthcare costs for older people are significantly higher than those of other age groups and in 1993 people aged 65 and over accounted for only 16% of the population, but more than half, around £6.4b, of the annual expenditure on hospital and community health services[54]. Over the coming years there will be a significant increase in the number of older people, especially those aged 85 and over and it is this cohort who represent the greatest per capita spend at 5 times that of the 50 to 64 age group[54]. Tinker suggests public expenditure in England on personal social services to be as shown in Fig. 1.3[3].

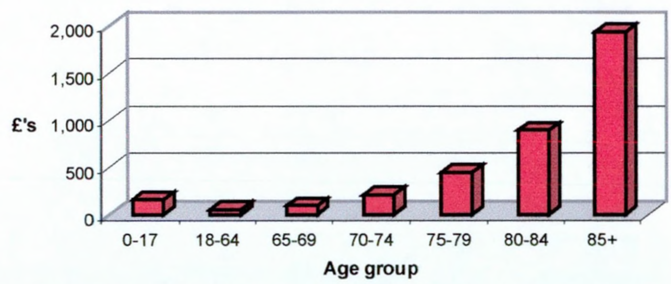


Figure 1.3: *Average per capita expenditure on personal social services by age group*

Relative to the economically active cohort of those aged 45 to 64, the per-capita expenditure on health services in the UK increases by 278% in the age group 65 to 74, by 563% in the age group 75 to 84 and by 1034% in the age group 85 over[91]. In 1992 Department of Health economists estimated that expenditure on older people would need to increase by around 0.7% per annum over the next 10 to 15 years just to keep up with demographic change[92].

This increased expenditure is evident across all budgets. In 1980 the social services and residential care budget was £18m, rising to £459m in 1986, with a staggering rise to an estimated £1.9b for 1992[93]. In total the care costs for older people in the UK amounted to £10b in 1995, and is expected to rise to £28b by the year 2030[94].

If potential difficulties can be detected earlier than at present then assistance can be provided and consequently there is move from a reactive to a preventative system that should result in a reduction in per capita healthcare costs[95]. This is an important consideration in assisting people to live longer, healthier lives but with a reduced period during which they may need support. This is termed compressed morbidity and was first introduced by Fries in 1980[96].

There is conflicting evidence about compressed morbidity. Some argue that it is not occurring; others have suggested that it is but only in respect to some illnesses and disabilities[97]. Its importance should not however be in doubt. Prophet[98] has commented that compressed morbidity should be "... *an explicit policy objective across all departments of government* ...", and added that "... *it is the greatest challenge for medical science and health education for the twenty first century* ...". She also affirmed that "...*if morbidity rates can be reduced by 1% per annum, then publicly funded care costs can be reduced by 30%, or £6.3 billion per annum by 2030.*" Assistive technologies could be used in achieving this goal.

*Older people are increasingly using technology to aid their independence*

Older people are increasingly encountering a range of technologies. For example, one survey of residents in sheltered housing revealed that 44% had their own video recorders and 45% their own microwave ovens[99]. Familiarity with a technology makes it easier to learn, but this is not solely related to chronological age[100]. With this in mind the Royal Commission for long term care expects that in future older people will be as comfortable with computer controls as the present generation are with telephones[100]. The view that older people do not want technology and cannot use it is becoming dated. Many older people are seeking to use technology and if a direct benefit can be derived from its use then there does not appear to an obstacle in acceptance. Indeed users can actually become the drivers behind the introduction of the new technology.

*Technology can improve lifestyles*

The Royal Commission report referred to above also stated that:

> "*People constantly look to modern technology to improve their lifestyles. One of the ways in which life could improve for older people is in the harnessing of new technology in new, imaginative and profitable ways*[100]."

For example through access to information, services and leisure pursuits.

## 1.5 Government Policy

Since the commencement of the research in September 1997 there has been a change in government policy towards establishing a better-integrated service between health, social services and housing. The present government, through the initiatives outlined below, recognises that there is an increasing demand on health, care and housing providers and is therefore seeking ways to help prevent, reduce, delay and/or meet part or all of these demands.

### 1.5.1 Preventive Agenda

The meaning attached to prevention is both ambiguous and changing. Within the White Paper[8] 'Caring for People' and the subsequent legislative framework in the NHS and Community Care Act, there was an explicit focus on prevention in terms of maintaining vulnerable people in their own homes and out of residential care. In 1997 the Department of Health publication[101] 'Better Services for Vulnerable

People' emphasised the development of recuperation and rehabilitation services to offer older people the opportunity to optimise their independence. A 1998 Department of Health publication[102] went further, with preventive services encompassing not only those at the boundary of institutional or acute hospital care but also those at risk of losing their independence. The shift in policy to supporting people in the community according to their needs is further highlighted by the proposed reform of housing benefit, with the separation of housing and care/support. Indeed the very title of the Department of Social Security proposals 'Supporting People'[103] underlines the policy shift. Evidently the preventive agenda is gaining momentum and clearer strategic plans are being made for the increasing percentage of older people in society[104].

### 1.5.2 New Deal for Communities

In its report 'Bringing Britain Together: A National Strategy for Neighbourhood Renewal'[105], the Social Exclusion Unit identified information technology as a key action area for tackling exclusion in deprived neighbourhoods. Social exclusion can be defined as the loss of access to the most important life opportunities that a modern society offers, particularly the ability to participate effectively in the economic, social, political and cultural aspects of that society[106]. Loneliness can result from exclusion and Table 1.6 demonstrates that at any particular time throughout Europe there are varying proportions of older people who are feeling lonely[21]. This is particularly important in appreciating that loneliness and isolation can lead to poor health and depression with some evidence suggesting a link between low levels of social contact and subsequent mortality[107].

Table 1.6: *Percentage of older people in Europe who express feelings of loneliness*

| Percentage | Country |
|---|---|
| <5 | Denmark |
| 5-9 | Germany, Netherlands, UK |
| 10-14 | Belgium, France, Ireland, Luxembourg, Spain |
| 15-19 | Italy |
| 20+ | Portugal, Greece |

It has been suggested that there is a close link between tackling social exclusion and the adoption of preventive strategies. This is centred on how future resources are likely to be allocated so that instead of providing curative services such as medicine or cash benefits, there is earlier intervention[108]. Low cost home video-conferencing systems could reduce social isolation by bringing people together virtually in their homes. However, technology could also create isolation, being used as a substitute for human contact[109].

### 1.5.3 Supporting People[4]

In December 1998, the government published a consultation document[110] that proposes widespread changes to the funding of local services to vulnerable people from April 2003, with a transitional period based on current spending levels of approximately £800m in the interim. It considers that the present funding streams are complicated, uncoordinated and overlapping.

The document proposes the bringing together of Housing Benefit funded supported housing, including sheltered housing, and certain other funding streams including Housing Corporation Supported Housing Management Grant, Home Office Probation Accommodation Grant and Department of the Environment, Transport and the Regions funding for Home Improvement Agencies, into a single "corporate" pot which will be distributed to local authorities to plan, commission and fund support services at a local level on the basis of individual need. The government's stated aim is:

> *"To enable more flexible responses to the individual needs and housing preferences of vulnerable people."*

The document recognises the important interrelationship between housing and support, but wants to ensure that provision can be made over a broad range of accommodation types. This would make it easier to respond to changes in an individuals' support needs without requiring them to move. Moreover, by giving housing, social services and probation services a joint role in deploying the resources, the government's proposals aim to produce an integrated strategy by promoting joint decision-making at the local level.

It is highly likely that this will have an affect on the funding mechanism of assistive technologies. At present, community alarm charges are regarded as an eligible cost for Housing Benefit purposes and are likely to remain so under the transitional arrangements. However, the case for the revenue funding of assistive technologies services, even if linked to a community alarm service, under these arrangements still needs to be made. Similarly, subject to eligibility criteria yet to be determined, the proposed future funding system requires clarification as to whether the costs of assistive technologies, especially if delivered through an integrated housing, care and support service will be met.

### 1.5.4 Direct Payments

From April 1, 1997, instead of an individual having to receive the local authority carers it became possible for people to organise their own carers, as long as the care package they received met their care needs as determined by a Social Services assessment. Direct payment does not have to be used, but allows the individual to organise what time the home help comes, for instance to assist in getting out of bed, instead of the time given by the social services department[111]. However, Social Services' categorisation of people over 65 as 'elderly' means that people aged 65 and over have not yet been able to access direct payments[59].

## 1.6 Conclusions

At the beginning of the project it was believed that there was a need to identify a product which could gather data about individuals within their own homes and make this data available to organisations who could respond to and assist the user. The actual data to be acquired and the market were unknown and as such several questions emerged:

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4 The section 'Supporting People' is adapted from Porteus J. & Brownsell S "Using Telecare: Exploring Technologies for Independent Living for Older People." Anchor Trust. Chapter 2.

- Can technology assist people to maintain their independence?
- If technology can be used, what form should it take, from both the end users and providers perspective?
- What are the implications for introducing advanced technology, in terms of:
  - financial considerations, and
  - service delivery

Before these questions could be considered, the potential user group needed to be identified. When investigating the present support and care system it was clear that older people would be the primary user group as they absorb the greatest resources. For example, in 1996, 83% of the recipients of home care were aged 65 and over while 64% were aged 75 and over[13]. Having identified the end user the reasons for the investigation of assistive technologies revealed:

- The current support and care system was unable to meet the demands upon it. An intensive service is being delivered where greater amounts of assistance are provided to a smaller number of people. Thus between 1992 and 1996 the total number of home care hours increased by 50% while the number of households receiving the service declined by around 7%[18].

- The UK and much of the developed world are facing a situation where the numbers of older people are expected to increase dramatically. The European Union has predicted that between 1995 and 2025 the UK will see a 43.6% increase in the 60 and over age range[23]. In line with this the proportion of people aged 85 and over who are most likely to need support increased by 22% from 1990 to 1995 and by 45% from 1990 to 2005[31].

- Informal carers are people who provide care without a charge to the government. There are currently between 6[44] and 6.8[45] million informal carers, saving the state between £15-24 billion[44] or £34 billion[46] per annum. However, doubt has been cast over the possibility of this continuing.

- The majority of people (80%) who need support would prefer to stay in their own homes for as long as possible with this being reflected in government policy. Providing assistance to people in their own homes is also the cheapest option if informal care is not included in the calculation. When the cost of informal care giving is included, care provided in sheltered housing can, for example, be a cheaper option.

- Older people absorb the greatest amounts of care and also the greatest proportion of hospital resources. The average per capita spend on services for people aged 85 and over is five times that of the whole of the 50 to 64 age group[54]. Department of Health economists estimate that expenditure on older people will need to increase by around 0.7% per annum over the next 10 to 15 years just to keep up with demographic change[92].

- Older people already use technology to aid their independence and the Royal Commission for long term care expects older people in future to be as comfortable with computer controls as the present generation are with telephones[100].

- People constantly look to technology to improve their lifestyles. One of the ways in which life could improve for older people is in the harnessing of new technology in new, imaginative and profitable ways[100].

Government policy has also influenced the debate on the use of assistive technologies as the government increasingly focuses on prevention. The NHS and Community Care Act sought to enable people to maintain their independence in the community and this position has been strengthened by the proposed reform of housing benefit with the separation of housing and care/support[103]. As a way of preventing isolation and the potential for subsequent mortality,[107] the Social Exclusion Unit could seek to use technology to enable virtual neighbourhoods, where older people could interact with others from the comfort of their own homes.

Evidently the present system may be considered as not providing the levels of support and care needed and that the situation could well worsen as society ages. Government policy would indicate that prevention is high on the political agenda, but in order to achieve this, regular information on the health and lifestyle of users needs to be acquired. Providing this information by human assessment is unlikely to be viable as there would be insufficient resources, but it would also be undesirable as it would be unlikely that people would welcome weekly or daily monitoring by a nurse or other professional with such regular visits possibly being considered as highly intrusive. However, continuous monitoring could be achieved with the use of technology and it was believed that such data acquisition would not be as intrusive. It was against this backdrop that the use of assistive technologies was investigated.

# 2 Assistive Technologies

***Chapter structure:*** *The assistive technologies currently available are described along with research and development work that started prior to this project and that which has continued since the project commenced. Particular attention is given to telecare, telemedicine and smart homes.*

Assistive technologies could be a way of lowering dependency and of enabling more people to live independently in the community. Many of those who choose to stay in their own homes also see technology as a possible way of supporting their independence, security and well being[112]. However, the use of assistive technologies to assist in the support and care of older people is not new. Physical aids such as walking sticks and bathing lifts are examples of assistive technologies but from the preceding chapter and section 1.2, the initial objectives, it is evident that the focus of this research is the ability to remotely assist people in the community. As such, there is only one assistive technology that currently fits this description, community alarms.

## 2.1 Community Alarms

These were first introduced in 1948 where residents on a sheltered housing scheme in Devon were able to activate a bell that sounded in the warden's home. The next technical development was two-way speech from a switchboard in the warden's onsite home. Then during the 1970's, small portable receivers became available and these were carried by the warden throughout the scheme. In order to communicate with residents the receiver needed to be plugged in at an intercom point located either in the warden's own flat, office, common room or another residents flat[16].

The first community alarm control centre linking a number of sheltered housing schemes together and providing cover when wardens were off duty was introduced in the London Boroughs of Hammersmith and Fulham in 1979[113]. However, despite the relatively long history of community alarms an agreed definition is still lacking[114] and the 'mainstream' equipment is very much the same as it was in 1988[115]. The structure of the current community alarm system is shown in Fig. 2.1.

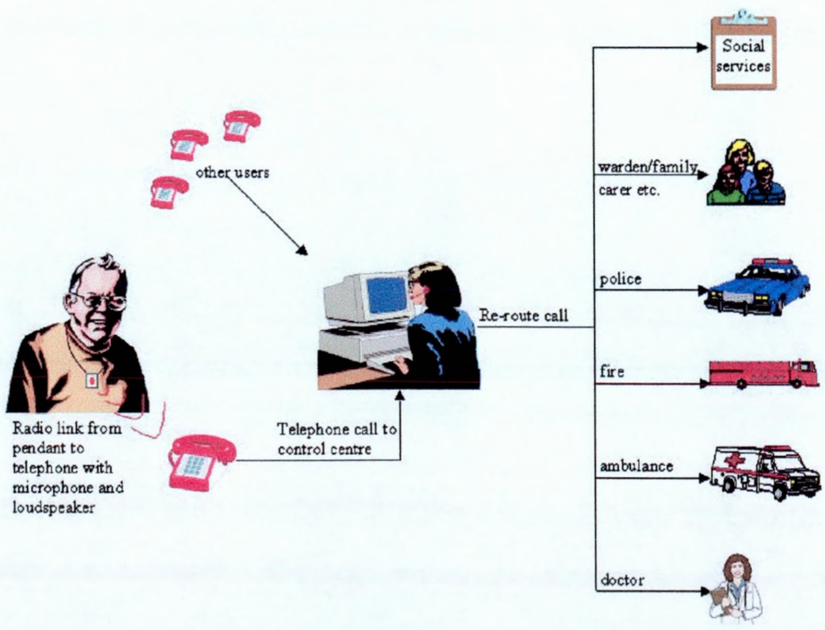


Figure 2.1: *A current community alarm system*

The system begins when a user activates their radio pendant or pulls an appropriate alarm cord. Once activated the control centre is contacted through the telephone system and an operator is available to provide assistance. If all of the operators are busy then the caller is placed on a sequential queue, as no information is gathered from the caller regarding the nature of the call the control centre cannot therefore prioritise calls. Consequently, if two calls are queued and one relates to someone requiring medical attention while the other is a request for information, the priority is based on the time these calls were received which may result in the caller in need of medical attention having to wait while a less urgent call is answered.

When the caller is answered information is retrieved from the control centres database on recognition of the callers telephone/equipment number using Caller Line Identification (CLI) and displayed on the operator's terminal. The information retrieved relates to the callers residence, details of people who will respond to a generated call refereed to as responders, services they receive, their location, doctor and warden if appropriate. Once the control centre operator has established, in combination with the caller, the nature of the call they will respond accordingly. As indicated in Fig. 2.1, the main response is to contact the social services, responders, emergency services or doctor, however anyone on the telephone system can be contacted.

The predominant providers of community alarm services are local authorities with the second largest group being housing associations[116]. In 1994, 75% of local authorities and 21% of the larger housing associations provided a community alarm service[117] totalling in excess of 260 service 'providers'[118]. It is thought that about 11% of people aged 65 and over who live independently have a community alarm[115], representing about 1,160,000 people in the UK[119]. Fisk has suggested that there might be 5 million users world-wide[120].

With the exception of the control centre operators the community alarm system has no intelligence and therefore cannot play a preventive role. No information is provided to the system until the user contacts the control centre, hence it is reactive rather than seeking to identify situations and intervene where it would be advantageous to do so.

Despite this, research on community alarms suggest that users are highly satisfied with them[100]. In a survey[121] of 2,596 community alarm users in Birmingham, 80% of respondents thought that the 24-hour operation of the control centre was very important and 86% thought that it worked well. The benefits of community alarms are considered to be[122]:

- The reduction in anxiety, from a users and their families perspective.
- A reduction in the number of hospital admissions.
- The promotion of earlier discharge from hospital.
- The potential to delay entry into nursing homes.
- A reduction in the need for home care.

Not withstanding the success and widespread use of community alarms, it could be suggested that they are under used and that many other people could benefit from their use. Local authorities have tendered to only supply alarms to older tenants in social housing and not to people living in other types of housing or other vulnerable user groups such as women and children at risk of violence, sufferers of HIV Aids or people of all ages who suffer from a mental illness[118]. The 1992 Ealing judgement commented that community alarms were a social rather than housing related service, raising doubts about the power of housing authorities that are not also Social Services authorities to provide community alarms. The 1993 Leasehold Reform, Housing and Urban Development Act tried to clarify the situation and gave local authorities the power to provide community alarms as part of the landlord function in social housing. However, in 1998 it was still unclear whether district councils can provide services other than to local authority tenants[114].

Another important issue is the importance of the alarms to users. Studies have shown that the value of alarm systems as perceived by tenants is relatively low, and considerably less significant than the nature of the accommodation occupied[123, 124]. A 1992 survey of 350 users in the UK found that 56% of respondents considered that their device was 'most wanted' by others, i.e. family relatives wanted the community alarm for an older member of the family. The same study noted that 27% of users 'never' or 'just occasionally' wore the radio pendant that is essential for remote activation[125]. A study in 1986 estimated that 40% of users did not wear their pendants[126] and a 1995 American study suggested that less than 50% of users wore their pendants[127].

An alternative way of generating an alarm call is by means of a pullcord. However, there is also evidence that people are not always able to activate them when needed. A survey[128] of Anchor Trust tenants in 1984 discovered that 59% of tenants had tied at least one pullcord up so that it no longer reached from the ceiling to the floor. Thus if the occupant fell, they may be unable to reach the pullcord and raise the alarm.

The greatest limitation of the community alarm system is that the user must initiate the call. Until the user activates the alarm call the warden or control centre is unaware of a problem and no assistance can be provided. There are two main reasons why a user may not activate an alarm call[108].

1. They are unable to activate the alarm:– They may be unable to reach the pendant or pullcord or they may be unconscious.
2. They may not consider themselves in need of assistance: They may be unsure as to whether they need assistance. For example, they may not be sure whether they should contact the doctor or not and may not call for assistance.

A further limitation of the community alarm system was identified by Thornton and Moutain[129] who refer to evidence from American studies that some community alarm users perceived themselves as more rather than less vulnerable because of the service. Fisk[130] has also highlighted this concern, commenting that the benefits obtained can be at the expense of an individual's confidence and self-esteem.

However, despite the lack of machine intelligence built in to the community alarm system, an infrastructure has been created that could be built upon. Specifically, if lifestyle and medical data could be gathered then the benefits of appropriate intervention might be considerable. The remainder of this chapter considers the developments that could be used to gather the information required to support a preventative as opposed to a reactive strategy to care provision in the future.

## 2.2 Telemedicine and Telecare

Tele derives from the Greek word for far[131], and both telemedicine and telecare allow health care to be delivered at a distance[100]. Telemedicine has been defined as:

> *"the practise of medical care using interactive audio-visual and data communications; this includes the delivery of medical care, diagnosis, consultation and treatment, as well as health education and the transfer of medical data[132]".*

Telecare is an emerging area of distance nursing and community support[133], enabling support and care remotely and gathering information so that people can be enabled to stay independent and well in the community. As indicated, this is the focus of this research.

Despite their differences the terms telecare and telemedicine are increasingly being used interchangeably, the difference being that telecare involves the patient's home or non-institutional setting[134]. Nevertheless, both seek to deliver healthcare services remotely using Information and Communications Technologies (ICTs). The qualitative benefits of telemedicine and telecare have been widely published and may consist of:

- The empowerment of patients. Obtained through the provision of information, the involvement in the management of their condition, and allowing them to make choices about their treatment[58].
- A reduction in the duration of hospital stays. By implication therefore, a reduction in the costs of hospitalisation, since the patient can be monitored remotely[135].
- The delay or avoidance of admission to nursing homes[116].
- Improved utilisation of healthcare professionals' time and the improvement of patient medicine compliance[58].
- Accelerated diagnosis and treatment[135].
- A reduction in the anxiety of patients[116], and by implication their families.

A more comprehensive list of published benefits is highlighted in Appendix A2.1.

## 2.3 Smart Homes

Smart housing, sometimes referred to as 'intelligent housing', 'domotics'[136] or 'smart homes', are terms used to describe the integration of services and technologies in the home with the purpose of automating them and obtaining an increase in safety, security or comfort[136]. Examples include door and window openers, heating and environmental controls, lighting, domestic appliances and security devices as well as telephone and video surveillance[137]. It could also include telemedicine so that the monitoring process can include daily health checks[100].

The Integer company are pioneering new technology systems alongside more efficient construction methods and green energy-saving techniques. The company estimates that its new homes, including some smart home management, would cost around 15% more to build than traditional homes. Over 30 landlord organisations are sponsoring Integer, including the Housing Corporation[138].

In the development of smart homes there have been a number of communications protocols that have been used to provide the in house infrastructure. Ensuring the compatibility of devices was a key challenge in a recent smart home project[139], and the number of communications protocols may have hindered the deployment of smart home technologies. For example, BatiBus was developed by Merlin Gerin, a French company; the European Installation Bus (EIB) is similar to the BatiBUS and was developed by several German companies; while the European Home Systems (EHS) bus was developed by Philips, Thomson and WEG[140]. However, recently a new standard has been agreed, HBES, presently known as the 'Convergence' protocol which is a merger of BatiBus, EIB and EHS. This is being led by the European Homes Systems Association with collaboration from Siemens and Schneider[140]. The range of services offered by Smart Homes is large and some examples are provided in Table 2.1[108].

Table 2.1: *Examples of the range of services offered by smart homes*

| Service Group | Examples include | | | |
|---|---|---|---|---|
| **Building**<br>Based on monitoring the performance of the building | Heating and energy management | Gas/water supply management | External and internal lighting control | Fire alarms |
| **Security**<br>Based on the safety and security of residents | Doors and window opening/closing/ locking | Selective access control | Personal alarms | Intruder alarms |
| **Home control**<br>Operated by the individual to facilitate independent living | Doors and window opening/closing | Opening/closing curtains | Turning on and off lights | Using equipment |
| **Telecommunication**<br>Provide access to information and communication services | Information on recreation and local services | Library services | Shopping services | Meals services |

Early Smart Home concepts from 1983 assumed that by last decade of the twentieth century people would live in 'electronic cottages' provided by an omnipresent artificial intelligence. Although computer and communication technologies have developed enormously over recent decades, these concepts did not become reality by the end of the twentieth century. In order to be effective a Smart Home requires considerable amounts of data acquisition, artificial intelligence, knowledge about its environment and the world, and ideally speech input technology and cheap communications. Today each of the technologies is available, but the level of system integration is still low[62]. Recent predictions suggest that all new homes in Western countries will be 'intelligent' from 2010[141].

## 2.4 Acceptability Of Assistive Technologies

Burley has commented that:

> *"community care is regarded by professionals working in the fields of social and health care as the preferred model of care. The growth we have witnessed in the residential and*

> *nursing home sectors over the last two decades will be reversed during the next two. Smart homes, assistive technologies and telecare will provide the infrastructure to support the community care model[142]".*

However, there is little evidence to support such a claim. In their November 1997 review of telecare activity in the UK, Curry and Norris observed that only a very small amount of work, carried out in the filed is ever published and suggested that literature reviews and Internet searches revealed very little. They considered that what knowledge is available is best acquired through contacts with researchers[58]. This is evident when analysing the number of publications listed on the Medline[5] database which contains details of over eight million articles in 20 languages[135]. When searching under the term's 'telemedicine' and 'telecare' in 1990-92, 47 articles were evident, with this increasing to 287 in 1993-95 and 678 in 1996- 1998[143]. By comparison over 2 million articles relating to healthcare are published annually[144].

## 2.4.1 Intrusion

It was suggested earlier that in some circumstances the benefits obtained from the use of community alarms are at the expense of an individual's confidence and self-esteem. This is associated with how intrusive the 'aid' as perceived by the end user. Fisk has argued that intelligent systems can be acceptable provided that the following issues are addressed[120]:

*Attitude to technology*

Users must not regard new hardware as an sign of dependency, i.e. a badge of dependency or disability.

*Promotion and marketing*

Attention should be given to the positive aspects of new devices and technologies rather than on negative associations of fear, anxiety, falls etc.

*Aesthetic design*

Reducing the visibility of the equipment to the point where it blends into the background or can be hidden.

*User empowerment*

Ensuring that control over the transmission of data outside of the home rests in the hands of the user.

*Automatic operation*

Limiting the need for the user to interact with the equipment so that it appears less intrusive.

If these issues can be addressed then Fisk believes that assistive technologies can benefit an individual, but for an assistive technology to be beneficial the individual has to recognise that they have a need and that it can be met. Acceptability therefore depends in part on the perceptions of the users[100]. Occupational Therapists (OTs) are well aware that certain assistive technologies are used for other purposes, for example compact trolleys being used for walking aids, bath boards becoming surfaces for a bar of soap, or simply not being used. This does not mean the original OT's decision was flawed, it will normally be the result of an older person's functional capacity having changed over time[145]. Assessment is seen to be the corner stone of high quality care but assessments are a 'snap shot in time' and older peoples needs change considerably with time[145]. It is hoped that through the use of assistive technologies, and telecare in particular, that data can be gathered over time and avoid this 'snap shot in time'; indeed Doughty *et al* have developed a protocol to automatically gather and continually assess some of the activities measured in the Activities of Daily Living (ADL) assessment[145].

### 2.4.2 Why should assistive technologies be used?

Prevention is a key goal of current government policy in the UK and present community alarm systems do not provide the necessary information to address preventable declines in a users health. Integration of home telecare data with community care information systems is essential if data captured at home is to be effectively incorporated into the care process[146]. At present, information supplied to the care system is provided by the user but there is evidence to suggest that older people are often reluctant to call for medical assistance because[147]:

- They feel that old age is a time for sickness and disability and that not feeling well is a natural part of ageing.
- The effects of depression can lead to a reduced interest in feeling well.
- The older person's perceived view of hospital is as a place to die, therefore there is a desire to carry on regardless and not call for medical assistance in case hospital admission may result.

But what information should be gathered from users? Published studies agree that assessing the relative 'risk' and predicting the onset of ill health is not currently attainable. Many of the studies conclude that, with the exception of age which can be found to be uniformly important, many of the risk factors show considerable variations[148]. Lawrence and Assmann conclude that although studies which focus on predicting ill health continue to accumulate, it is still unclear what their results mean[149]. Nevertheless, Doughty is developing MIDAS[6] with the purpose of monitoring the lifestyle and living environment of users. Processing should then enable predictions to be made and potential problems to be identified before they occur[150]. Doughty has also been instrumental in developing a fall detection unit and has attempted to generate a dynamic Fall Prediction Index which suggests when a person may be at risk[151]. Despite this work, these devices are in the development stage and are not as yet commercially available.

Although it is not yet possible to assess the relative 'risk' of individuals or predict the onset of ill health, there is however a general consensus on what should be measured to indicate the onset of ill health. Changes in mobility in particular have been identified as a key area by several authors[108, 152-155]. Other parameters where changes are considered to be important are[108, 152]:

- Sleep pattern
- Utilisation of cooking facilities

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5 An on-line medical literature retrieval service sponsored by the US National Library of Medicine, as part of the National Institute of Health.

6 Modular Intelligent Domicilliary Alarm System

- Bath and toilet usage

Williams *et al*[153] suggest that the monitoring requirements can be considered under the following headings:

- Physiological or medical
- Lifestyle or behavioural
- Personal alarm
- Environment
- Security

Physiological, lifestyle and personal alarm systems provide information concerning the well being of the user, while environmental and security systems provide information concerning the status of the user's home environment[153]. The specific medical parameters to measure have been suggested as the electrocardiograph (ECG), blood pressure, oxygen saturation, respiration and temperature[115]. Evidence increasingly shows that physiological measurements performed at home will become the gold standard of care. Monitoring of this type is preferable as clinical/hospital-based measurements are often distorted[156].

## 2.5 Telecare And Telemedicine Work Prior To 1997

The search on Medline using the terms 'telecare' and 'telemedicine' showed that since 1990-92 there has been a steady growth in the number of articles published in this area. However, many of these are concerned with specialist medical applications, for example telepsychiatry[157-159] or teledermatology[160-162]. Despite older people making the greatest demands on health care and support resources, few publications are concerned with older people and fewer refer to home monitoring. Indeed, the Journal of Telemedicine and Telecare[7] published only 12 papers relating to 'Old Age' or 'Elderly' in the period from 1995 and 1999 inclusive[163]. In this same period 20 articles were published under the headings of 'Home Health Telecare', 'Home Health Visit', 'Home Physiological Monitoring' or 'Home Telenursing' while only 1 was published on community alarms. Of these 33 papers, 19 were written before 1998.

Much of the prior published material relates to theoretical aspects rather than what was being done to assist older people in the community. Telemedicine for example, had been developing for many years, but there was little evidence of its use in the community, even in small-scale trials. This is perhaps surprising when considering that some people say that telemedicine came about with the introduction of the telephone[135]. Telemedicine was certainly practised by telegraph in the early 1900's[164] and was practised by radio in the 1920's when several countries offered medical advice from hospitals to their fleets of trade ships using Morse code[135].

Among the early telemedicine work was the research and development work into medical telemetry undertaken by the National Aeronautics and Space Administration (NASA) in the US. Scientists at

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[7] The Telemedicine Forum of the Royal Society of Medicine and the official journal of the Finish Society of Telemedicine and the Hong Kong Telemedicine Association.

NASA demonstrated successfully that physicians on earth could monitor the physiological functions of an astronaut[135]. Additional work in 1957 by Dr Cecil Wittson established the first interactive video link, between Nebraska Psychiatric Institute in Omaha and the Norfolk State Hospital, 112 miles away[165]. Yet despite this, much of the published material related to theoretical considerations. A 1996 paper by Doughty *et al*[166] defined 3 generations of telecare and suggested that developments were at the 1st generation level.

*1st generation systems*

Community alarms were considered as the basis of the 1st generation system. Technically simple, such systems had no imbedded intelligence and are entirely reliant on the user activating a call for help.

*2nd generation systems*

Second generation systems may have all of the features of the 1st generation system but would also provide some level of intelligence either locally in the home or dispersed throughout the system. For example, sensors might be positioned both on the user or in the home to detect alert situations and autonomously initiate a call for assistance if required. Second generation systems are therefore pro-active and can generate alarm calls if the user is unable to do so.

*3rd generation systems*

Third generation systems were considered to encompass the detection functions of the 2nd generation systems and to add additional capabilities. In addition, they would also contribute to an improvement in the quality of the users life by supporting teleservices such as:

- Banking
- Shopping
- Interactive exercise
- Medical diagnosis
- Integration/interaction with other people – teleconferencing/videoconferencing

The 3rd generation system focuses on the widespread use of telecommunications and introduces the concept of virtual neighbourhoods[167]. Here, irrespective of geographical location people and organisations can be linked together and the social network of an individual extended to anyone connected to the system. Services can then be delivered directly into the home and greater efforts made to reduce loneliness and isolation.

Tang and Venables have since added a fourth generation that will involve the use of the Internet to deliver telecare services[168]. However, the use of the Internet to deliver the virtual neighbourhood and teleservices could be considered as implicit in a 3rd generation system.

Fisk also suggests that community alarms are likely to evolve from their 1st generation configuration to 2nd and 3rd generation systems and suggested that a community alarm control centre is currently an under-utilisation of technology that could transmit and exchange a wider array of information regarding the users status, mobility and well being[120].

Much of the literature prior to 1998 was concerned with the ability of community alarms to assist people. For example, an American study showed that community alarms save lives, reduce healthcare costs and are well received by patients[169]. Other articles suggested that community alarms could improve home-based care co-ordination, its efficiency and quality[170]. A further Canadian study of 106 users of community alarms indicated that a year after the introduction of the alarm there was a 25% reduction in hospital admissions and a reduction from 9.2 days to 5.7 hospital inpatient days[171]. Perhaps the most comprehensive study of community alarms in the UK was performed by Riseborough in 1997, involving 2,243 users and 554 officers[118]. She commented that relatively little was known about consumers' views with most previous studies concentrating on technical aspects, were small scale or were done before the NHS and Community Care Act was introduced[118]. Her research focused on the human aspects of alarm services. The main results obtained were related to the following areas:

*Who are the main users?*

Predominantly community alarms are used by older people but other groups have appeared partly as a result of care in the community. These have included people with learning difficulties; HIV/Aids sufferers; women and children who were at risk of violence in the home and people being discharged from hospital[118].

*What is the alarm for?*

The report showed that the purpose of community alarms was unclear. For example, older users and their relatives generally believed that the service offered by the community alarm was part of the emergency services. Older people also suggested that they would use the community alarm to call someone because of actual or attempted crimes, fire and because of serious illness. There were also indications that older people thought they were in some sort of priority group because they had a community alarm[118].

*Suitability of alarms*

Most older respondents thought the community alarm was suitable for their needs but there was a general interest in having more and better placed pull-cords and being able to obtain pendants, bracelets or other devices as well[118].

In addition to the work on community alarms, some work had been published on videoconferencing and home telenursing. The purpose of this technology is to enable older and mobility impaired people to live independently and to reduce the demand on Social Service resources[172]. Much of the videoconferencing work was pioneered in the US in Kansas where they have a high bandwidth cable television infrastructure[173]. When research began in this area it was felt that a significant proportion of nurse visits did not require hands on care and that many of the activities involved in a visit could be handled by using an interactive video link and therefore saving the nurse's time spent on travelling. Trials showed a strong nurse and patient satisfaction level with the system[174]. Contrary to expectations, the trials suggested that technology was not an important issue for the participants and that the use of telemedicine technology did not appear to have any negative effects on communication[175].

Investigations into videoconferencing for doctors had also taken place in America. One trial with 25 patients and a 100-bed nursing home reduced the need for doctors to make home calls and saved many older people the inconvenience and stress of travelling to the surgery. The technology in the home was made from existing hardware, with additions such as a multi-function patient monitor into which blood pressure cuffs, stethoscopes and other medical devices could be attached. The patient's computer was fitted with a videoconferencing camera which was controlled by the doctor or nurse to ensure the health professionals view[176]. It could be argued that this does not provide enough information to the doctor, but the majority of a medical consultation is concerned with speech and not necessarily spent observing[177].

One of the largest telemedicine projects in the US used videoconferencing equipment in prisons and approximately 2,500 prisoners from Texas were treated via telemedicine in 1995. The use of integrated computer and videoconferencing systems, with specially designed medical peripherals and cameras, enabled physicians to examine prison inmates from outside of the prison. This saved time and transportation costs and avoided security problems[178]. Overall it was felt that assessment by videoconferencing was at an early stage of development, with more work needing to be done before it could routinely be employed as a clinical tool. However, it was felt that videoconferencing showed promise for the future[179].

The use of ICTs was further demonstrated in 1995 when during the unrest in Yugoslavia a solider was suffering from respiratory failure and the doctors in Macedonia sent images of the patient and data such as real-time information on blood-oxygen levels to physicians in America. The specialists were then able to prescribe drugs that saved the soldiers life[180]. The US military have also developed microchips that can be implanted under the skin to measure and transmit body temperature to a monitoring computer. Similar sensors developed at the Oak Ridge National Laboratory in Tennessee can be placed inside a patients ear[181].

One of the ground breaking studies in telecare was performed by Celler *et al* in 1995 who indicated that the functional health status of older people could be determined remotely by continuously monitoring relatively simple parameters that measured the interaction between users and their environment. These parameters were measures of mobility, sleep patterns, utilisation of cooking, washing and toilet usage[152, 182]. The study concluded that 50% of the patients had undiagnosed medical problems that could be detected by home monitoring[58]. In other trials of telemedicine systems the Israeli company Shahal[183] demonstrated a system for cardiac and pulmonary complications capable of improving home healthcare control, enabling patients to manage their own health condition and providing them with a higher quality of life[184]. In addition, other recognised companies who were developing similar technologies were American Telecare[185], Tevital[186] and Instromedix[187].

The BESTA flats in Norway investigated the use of technology in the support of 8 people with dementia in a highly staffed environment. The problems that were addressed were the danger of fire, the danger of falling and lying undetected and the danger of wandering and getting lost. Several solutions were implemented[188]:

- The lights automatically came on when residents got out of bed at night and automatically turned off when they returned to bed.
- If during the night a resident was out of bed for more than 30 minutes an alarm was sounded.
- The cooker was automatically turned off if left on by mistake.
- If a fire is detected then smoke detectors automatically alert the staff, turn the lights on and unlocks the doors.
- Magnet detectors on exit doors alert staff when doors are opened at night.

The results from the trial indicated that staff were 'very happy' suggesting it gave them the security to be able to give better and more confident care. Although an evaluation of the residents was not performed, staff and relatives claimed that the residents felt more confident and safe.

Alongside the detection of response or alert situations, some effort have also been made at gathering longitudinal data to move away from 'snap shot in time' assessments. Activities of daily living (ADL) and instrumental activities of daily living (IADLs) are assessment tools used by social services to assess older people's need for long-term care. ADLs relate to personal care tasks of bathing and washing, dressing, feeding, getting in and out of bed, getting to and from the toilet and continence management. While IADLs are concerned with domestic tasks such as shopping, laundry, vacuuming, cooking a main meal and handling personal affairs[100].

The necessary data was obtained through the use of a triaxial accelerometer (TA) and a portable data processing unit. The TA was composed of three orthogonally mounted uniaxial piezoresistive accelerometers, and measures accelerations covering the amplitude and frequency ranges of human body acceleration[189]. The energy expended is then used as a reference to indicate the task performed; the use of such a technique is widely accepted[190]. However, trials in 1997 showed differences between estimated and measured values of energy expended from –40% (underestimation) during dish washing to +33% (overestimation) during lying. Intensive activities, like stepping, carrying loads, walking, cleaning and making the bed were underestimated on average by 6.2%, whereas less demanding activities such as sitting and desk work were overestimated on average by 6.6%[189]. One of the problems with such a technique is that many of the tasks required similar amounts of energy and it is therefore difficult to differentiate between tasks. It also requires a device to be worn on the lower back that is not desirable from a user acceptance stance. A review of the online database, Medline reveals that non of the authors involved with this project have published any further work on this topic since the trial in 1997.

The assessment of gait is considered medically important as a 'good' gait measurement can reduce the probability of an accident in the home[191]. In particular the gait of older individuals who fall is often more compromised than the gait of those who do not. A poor gait measurement is characterised by a decreased speed and a shorter stride. A study of nursing-home residents demonstrated a strong correlation between abnormal gait (stride length, walking speed, and qualitative assessment) and the occurrence of falls[192]. The most common methods for measuring gait are by force plates or three-dimensional camera systems[193] with the analysis normally performed in gait laboratories. Unrestricted ambulatory monitoring of walking is more objective and is performed at the persons home. Several such ambulatory monitoring systems for recording foot pressure distribution have been developed[194-196], but problems with these devices include limited memory capacity and consequently, short recording times with a high total weight[193]. Miyazaki proposes that an angular transducer consisting of a piezoelectric gyroscope, attached to the thigh detects angular velocity and an integrator converts the angular velocity to motion angle. The maximum error rate recorded during tests was +/-15%, although for those using a walking stick, i.e. 3-point gait, was +/-25%. Miyazaki suggests that this is the first system where restraints are not imposed on subjects during long-term gait measurements. It could be suggested however that wearing a gyroscope attached to a 'rubber band' just above your knee is imposing restraints on the user.

In their 1997 review of telecare activity in the UK for the Department of Health Curry and Norris reported on current telecare activity in the UK[58]. This is reproduced in Table 2.2.

Table 2.2: *Telecare activity in the UK in 1997*

| Project Title | Organisation | Description |
|---|---|---|
| NeuroPage | Addenbroke's Cambridge | Telephone pagers to support mentally impaired in the community. |
| Fetal Home Monitoring | John Radcliffe, Oxford | Automated collection and telephonic transmission of physiological data. |
| Ithaca | South and East Belfast Trust | Development of integrated community care and telecare trials. |
| Community Antenatal Services | Edinburgh Royal Infirmary | Home and remote clinical based maternity services with backup to carers and healthcare professionals. |
| Hector | Lancashire Ambulance Trust | Use of mobile telephones to transmit patient vital signs from ambulance to A&E department. |
| RPMS | Kent Ambulance NHS Trust | Use of RAM mobile data network to transmit patient vital signs from ambulance to A&E department. |
| ACTION | University of Sheffield | Use of video communications to deliver home support to patients and their carers. |
| RISE | Calmax Communications | Use of telecommunications to deliver both health and social services to the elderly in their homes. |
| SAFE21 | Tunstall Telecommunications | Development of social alarms to provide greater facilities for users. |
| Mobile Telemedicine | Loughborough University | Development of mobile radio links to accommodate multiple channels of quality diagnostic information. |
| MORE | SNRU, University of Northumbria | Development of existing mobile telephones for use by the elderly and disabled. |
| INCA | Liverpool University | Development of intelligent sensor systems for home monitoring. |
| Anchor/BT Telecare | Anchor/BT/Shorrocks | Integration of hardware of software for home monitoring of the elderly. |
| Smart Homes | SPRU, University of Sussex | Development of a draft home monitoring specification for housing developers. |

From the above table several projects that impact upon the research area identified for this project can be identified. Personal communication with the project co-ordinators identified by Curry and Norris has led to a greater understanding of the merits of these projects and in particular:

*SAFE21*

The purpose of the SAFE21 (Social Alarms For Europe in the 21st Century) project was to develop social alarms using the existing information and communications infrastructure to deliver much broader assistive services and to enable people currently excluded, such as people with hearing difficulties, the ability to use the community alarm system. The project commenced in December 1996[197] and hoped to develop the following systems[115]8:

*Voice pendant:* Providing a pendant with a microphone to enable two way speech throughout the home.

*Multimedia interface:* A practical multimedia (text, sound, images) interface for getting community information to disabled and older people.

*Telemonitoring:* Monitoring technology (electrocardiography, non-invasive measurement of blood pressure, oxygen saturation, respiration and temperature) was to be integrated into the community alarm infrastructure.

*Shared control centre:* Access for Housing and Social Services to the same information system.

*Social alarm for the deaf:* An alarm integrating text telephone technology into the social alarm terminal.

*Mobile social alarm phone:* Through the use of cellular telephones and global positioning systems the ability to summon help and communicate with a control centre who automatically are aware of the callers location.

*Anchor/BT Telecare*

The functional health status study performed by Celler *et al* in 1995 was initially partially funded by British Telecom (BT[58]). In April 1997 BT, Anchor Trust and the Housing Corporation began a lifestyle monitoring project which was launched as the largest of its type in Europe with £400,000 injected into enlisting technology to help older people[198]. Phase One of the project would fit 60 homes in North Seaton near Newcastle[199], with commercially available sensors gathering information on movement[198], the opening of refrigerator doors, temperature and smoke monitors[200]. Phase Two would include biomedical monitoring, such as blood pressure and heart rate[198] while also providing video-conferencing for social interaction[200].

*Smart homes*

The Science Policy Research Unit (SPRU) study of Smart Homes began in October 1996 with Edinvar Housing Association and the Joseph Rowntree Foundation providing demonstration sites. The aims of the project were[201]:

- To produce a user specification for the development and use of Smart Home technologies in affordable and social housing markets.
- Consider likely markets for the Smart Home technologies.

8 Details of the SAFE21 project can be found at http://158.169.50.95:10080/telematics/disabl/safe21.html

- Evaluate supply-side issues and lessons from integration and installation from the demonstration sites.

Further details of other related projects identified by Curry and Norris can be found at the project web addresses given in Appendix A2.2.

For 8 of the 14 projects identified in Table 2.2, the European Union provided funding under either the IV Framework or the TIDE (Technology Initiative for Disabled and Elderly people) programmes. The purpose of the TIDE programme was to stimulate the creation of a single market in assistive technology in Europe and enable older and disabled people to live more independent lives[202]. The TIDE programme started in 1991 with a pilot phase of 21 projects and a major study of rehabilitation technology in Europe. In 1993 an additional phase of TIDE[203] was introduced to provide a bridge between the pilot phase and the IV Framework programme. The TIDE programme had an overall budget of 42 MECU (£29 m)[204].

The IV Framework programme operated from 1994 to 1998 and in total funded research and development across all its themes to a total of 13,215 MECU (£9,170 m). Of particular interest were the '*Telematics for Disabled and Elderly People*[9]' and '*Telematics for healthcare*[10]' themes under the Telematics Applications (TAP) Programme. A total of 69 MECU (£48 m) was made available for research and development in this area with the purpose of developing applications which provide support for independent-living, autonomy and social integration opportunities[205].

## 2.6 Research Areas Identified

A study of material at the commencement of this project indicated that the present health, care and support system had difficulty providing for the levels of support required, while the predicted increase in the number of older people is likely to make the situation increasingly difficult. The evidence from the published literature indicated that assistive technologies showed potential but there was insufficient evidence to prove that the more widespread use of technology could assist in the delivery of services.

With such a limited amount of evidence for the use of telecare and related assistive technologies the whole question of the financial feasibility of such systems had been almost completely overlooked. Curry and Norris commented that most of the projects were in their infancy and had yet to gather sufficient data to demonstrate cost-effectiveness[58]. The general research area for this project was clearly defined in the community alarm and telecare areas of assistive technologies, Curry and Norris suggested that in 1997

> *"there was an opportunity to develop rapidly the healthcare delivery side of telecare using the existing community alarm infrastructure. This infrastructure already reaches a group who have above average healthcare needs and often have difficulty accessing healthcare*[58]*."*

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9 Details of projects under this theme can be found at http://158.169.50.95:10080/telematics/disabl/disabl-proj.html.

As this area of research was relatively new, there were several areas which needed to be addressed to further understanding and help maintain older people and other users independently in the community. In consultation with the project group it was agreed that the areas identified below should be investigated in this research project:

*Users requirements*

While there had been several publications researching the community alarm system and its potential benefits, it has been acknowledged that community alarms had not significantly changed for many years[115, 206] and more could be done to aid people in the community. Risebourgh's study of community alarm users shed some light on users perceptions of the present system, but did not address future developments. This research project started 5 months after the Anchor Trust/BT project began and when their results were published in May 2000 they commented that:

> *"At the commencement of this project no-one was fully aware of what users actually wanted from an advanced system and understanding what the system should do and how to achieve this was a key element of the initial phase*[108]."

Therefore, one of the areas that needed to be addressed upon the commencement of this project was what should be included in a 2nd generation telecare system.

*System architecture*

In order to advance community alarms from their present configuration there will be a requirement for the community alarm control centre to be able to access and interface with agencies that presently they do not confer with. For example, if health information is to be gathered from users homes then this information must be used in a constructive way and new communication paths may be required. It is therefore important to define the system information flows and indicate how communication between different agencies is performed.

As a prerequisite to defining what the system architecture should be there is a requirement that the model should be obtainable. In order to achieve this consideration must be given to what users desire, what limitations there may be due to technology insufficiencies and attention must also be given to service delivery.

*Service delivery*

From the earlier part of this chapter it can be suggested that assistive technologies are likely to be beneficial to end users, but there is little evidence to suggest advanced or 2nd generation telecare systems could be delivered on a large scale. Having defined what a 2nd generation should consist of, deliberation would be needed as to 'how' the service would be delivered.

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[10] Details of projects under this theme can be found at http://158.169.50.95:10080/telematics/health/health-proj.html

*Cost-effectiveness*

As discussed, the evidence for the cost-effectiveness of such systems was negligible in 1997 and this needed to be addressed. If 2nd generation systems were to develop from the theoretical and small-scale pilot projects, evidence of the kinds of costs involved were required as there was no information available to indicate if such systems were more or less expensive than the present community alarm system. In addition, the impact of large-scale changes in the delivery of a 2nd generation system were unknown. The published literature gave no indication of the impact on community alarm control centres that the introduction of 2nd generation systems would have. Therefore, investigation of the likely impacts of introducing such systems was required.

## 2.7 Subsequent Research After 1997

Since this research project commenced in September 1997 the evidence base for the introduction of 2nd generation systems has grown but it is still not possible to purchase such a system[108]. As already indicated, prior to the commencement of this project much of the telecare/telemedicine work reported concentrated on medical specialities, rather than home care and this was still evident at the end of the project. However, some efforts had been made at addressing the home healthcare sector identified as the focus for this research. Perhaps the publication with the greatest authority was the report of the Royal Commission on Long Term Care in March 1999[100]. This bought together much of the previously published material and examined the short and long term options for a sustainable system of funding of long term care for older people in their own homes and in other settings. It sought to recommend how, and in what circumstances the cost of such care should be apportioned between public funds and individuals[100]. The evidence of an ageing population was presented and assistive technologies were considered as a way of assisting in future provision. However, despite the commission bringing together published material, it pointed to the present system and gave relatively little attention to the future[207]. It has also been criticised for missing the opportunity to flag up the full potential for reducing the cost of long term care through technical innovations that could prevent dependency[208].

Other publications have sited the importance of home telecare to help avoid expensive acute care[209-211]. Suggesting that these services can range from sending a patient's daily blood glucose readings to a control centre where the measurements are examined, or nothing more, than a simple telephone call to remind a user to take their medication[209]. This basic system is one such function of the NeuroPage system identified in Table 2.2. The reasons for introducing home telecare are now becoming widely accepted with many authors suggesting[168, 212, 213]:

*Potential Cost savings*

These must be considered from the point of view of both the health-care provider and the patient but few publications provide a numerical analysis.

*Improving the quality of measurements*

It has been suggested that the quality of medical measurements may increase if the patient is moved from their home. This is the particularly the case for blood pressure and other cardiovascular parameters, especially in older people.

*Obtaining a new kind of follow-up*

Telecare enables the levels of monitoring after hospital discharge to be increased, possible measurements include ambulatory electrocardiography (ECG) and monitoring of heart rate, blood pressure, sleep parameters and body temperature[214].

*Improving the quality of life*

If measurements can be taken or treatment can be given at home without decreasing the quality of care, there is no reason to transfer the patient to hospital. Also, retaining the home environment is often important for the success of treatment, particularly with vulnerable patients, such as older people.

A significant proportion of the published home telecare literature pertains to the use of videoconferencing as a way of reducing costs through reduced travel. Kinsella suggests there are two approaches to home telecare[209]:

- Electronic care using technology to obtain vital signs and other physiological measurements is substituted for physical in-person visits during a defined programme of care.
- Data is again collected remotely but in addition there is an educational component, based on the premise that the user will take more responsibility for their care.

A study by Allen *et al* in the US suggested that 46% of on-site nursing could be replaced by telenursing, and that this was likely to be a conservative estimate[215]. This study indicated that older people were best suited for telenursing because their problems tend to demand less hands-on intervention. A review of the ability to perform telenursing in the UK indicated that the percentage of visits was likely to be around 15% although this was likely to bias results towards underestimation of the potential rather than vice versa[216]. The reason for the differences in America and the UK were due to the greater number of hands-on consultations being carried out in the UK.

Research in Japan has also suggested that remote videoconferencing for home telecare has potential. A trial of remote respiratory care discovered that the number of unscheduled hospital visits decreased by 80% due to the advice and assistance that could be secured from a videoconference. There was also a 100% reduction in urgent or semi-urgent house calls, saving a significant number of hours of the physicians time[178].

The home monitoring equipment of lifestyle and medical signs has continued to develop since the commencement of this project. American Telecare, Instromedix and others have continued to develop their medical appliances while Shahal has developed medical and lifestyle equipment. A list of some of the more well known developers and suppliers is provided in Appendix A2.3. Two new companies developing equipment within this field are International Security Technology (IST) and Technology in Healthcare (TiH).

- **International Security Technology** have developed WristCare[217],'*The first security device in the world that continuously monitors its user's health condition. It will automatically send an alarm for help, when the WristCare user is unable to do so*'.

  In addition to a radio pendant the WristCare contains a microprocessor that analyses its user's health condition and sends evaluation data as well as analytical results to a base unit. If inappropriate readings are gathered then the base unit contacts the control centre. Inappropriate readings may be generated for instance, following a fall or becoming unconsciousness while it is suggested that conditions such as a fever will not usually trigger an alarm. The WristCare's primary role is to call for assistance when the user is unable to or is not able to identify changes in their condition requiring investigation[217].

- **Technology in Healthcare**[218] was formed in March 1998 as a spinout from the University of Wales, Bangor and claims to be the UK's first, and so far only, specialist telecare company[219]. The fall detector they developed was licensed to the Tunstall Group[219] (part of the SAFE21 consortium) and a range of other sensors is being developed to unobtrusively gather information from user's. Examples of these sensors are FLORA (flood response alarm), ANWEN (automatic night wandering electronic notifier) and MIDAS (Modular Intelligent Domiciliary Alarm System[220]).

In addition British Telecom launched a package called 'In Touch 2000' in May 2000 which consists of a pendant and receiver unit which in addition to acting as a community alarm also works as a normal telephone[221]. The telephone numbers of 3 'carers' are entered into the telephone and upon activation of the pendant the first carer is called. If a response cannot be gained then the system will circulate round the 3 numbers until a response is gained[222].

The three projects which began prior to the commencement of this project have reported their results during the duration of this project. The key results from these projects were:

*SAFE21*

The project was due to complete in November 1999[115], but it was extended until the end of May 2000 to enable completion of field trials. Results are therefore anticipated be published in the 4$^{th}$ quarter of 2000[197]. However, some of the objectives have been met, for example the voice pendant is now commercially available[223].

*Anchor/BT Telecare*

The results of this trial were published in May 2000[108]. The system used Passive Infrared (PIR) movement detectors and magnetic proximity switches on the refrigerator and entry doors to generate a profile of the users lifestyle. Deviations from the normal profile would then result in an alert being generated. The evaluation of the Lifestyle Monitoring developed and trialed highlighted a number of actual and potential benefits which is was thought made a strong case for the implementation of such technologies to older people in the future. Generally the feedback from users was positive:

- 80% were very or fairly satisfied with the system.
- 70% the system would automatically recognise a situation that required further investigation and raise an alert if they were unable to.
- The system could aid independence, one user commented:

  *"I wouldn't like sheltered accommodation. I am independent. I wouldn't like one of those homes. I do all my own cooking. I am independent. This helps me to stay at home."*
- Due to the lifestyle monitoring system early discharge from hospital could be achieved, one of the trialists commented:

  *"I had to go into hospital recently and I didn't like it very much. I think the system could help me to spend more time at home. The system is a good thing for me."*
- The system was not considered as intrusive, only 13% indicating they found it 'slightly intrusive'.

Overall the conclusions drawn were:

- The system is acceptable.
- It increases the care choices available to users.
- It enhances users feelings of safety and security in their homes.
- It supports and enhances the carers role.

Taken together, these were considered important factors that are likely to stimulate independence and help older people to remain living in their own homes.

*Smart Homes*

This project ended in March 1999 and concentrated on the establishment of the technology. The main findings were[201]:

- The smart home market, technologies and supply industries were immature. Consumers were ignorant or sceptical about potential benefits derived from smart homes, while technologies were difficult to integrate for interoperability with there was no single supplier providing a full range of bundled products and services.
- There is little standardisation across the industry and the development of common protocols to facilitate interoperability has been slow.
- There is not an affordable system for cheap appliances to work on.
- When the potential benefits of integrated 'Smart Home' systems have been proven it is likely that more people will be prepared to purchase them.

Julie Cowans of the Joseph Rowntree Foundation anticipates that the cost of a basic package of amenities, with a control system will ultimately be priced at around £3,000 per house once economies of scales have been achieved. This is based on £1,000 for the infrastructure and £2,000 for the basic devices[139]. The devices trialed in the project include central locking of doors and windows, video entry phone, key less door locks, automatic lighting controls and infra-red bathroom controls[137].

In addition to the original projects identified in Table 2.2, Curry has continued to maintain a list of relevant projects and companies with assistance from the Development Division of the Department of Health[11].

In terms of European funding for projects, the IV$^{th}$ framework ended in 1998 and the V$^{th}$ framework programme began. The total budget for V$^{th}$ Framework programmes was increased to 13,700 MECU[224] (£9,507 m), of which 483 MECU (£335 m) has been made available through the '*The Ageing Population and Disabilities*' section of '*Improving the Quality of Life and Management of Living Resources*'[225]. The programme is currently on going and is due to end in 2002.

Finally, although there has been little work on videoconferencing in the UK, remote healthcare has been delivered by NHS Direct. This originated out of the Prime Minister and the Health Minster's support for '*faster and more convenient care*'[226], and was introduced at the beginning of 1998 with nurses providing a 24-hour health advice service over the telephone[227]. The purpose was to provide easier and faster information for people about health, illness and the NHS so that they are better able to care for themselves and their families[228]. In its first four months NHS direct in the NorthEast took over 3000 calls and surveys of users showed high user satisfaction. The service proved equally popular with both men and women and also with older people who do not want to waste the doctors time unnecessarily[229]. On the 6th July 1998, £14 million was earmarked to extend the NHS Direct to 10 million people following the success of the first pilot schemes in Preston, Milton Keynes and Northumberland[230]. The Government intend to extend the service to cover the whole country by 2000[227]. Early in 2000 user satisfaction was again tested and respondents who received advice from a nurse found it very or quite helpful in 95% of cases. The most common reason given for finding the advice helpful was that it was reassuring[231].

## 2.8 Complementary Research To The Identified Areas

Of the four areas identified for consideration in section 2.6, it would be anticipated that during this project research and literature in these areas would continue to accumulate. However as indicated below this has not necessarily occurred.

*User requirements*

Risebourgh's[118] study of 1997 remains the only large-scale survey of community alarm users. Evidence from the Anchor/BT[108] has shed some light on the desires of users, but there does not appear to have been much research in this area. Indeed, in 1998 Roulestone commented that telecare and other assistive technologies was a new area of research and development and while the potential of new technologies to assist older people to live independently is acknowledged, there remained little convincing evidence about the way these systems impact upon the everyday lives of users[232].

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[11] Details of the UK National Database of Telemedicine can be found at http://www.dis.port.ac.uk/ndtm

*System architecture*

Work by Williams *et al*[153] in the development of CarerNet has shown how the technology and systems communicate within the home, but a review of the literature does not indicate any publications that have analysed the information flows from the home.

*Cost-effectiveness*

It has been said that cost-effectiveness studies are crucial to the introduction of telecare and telemedicine into national health services as no government will introduce these on a significant scale without firm evidence for cost-effectiveness[233]. However, in 1999, apparently none had been published in the UK[234]. Other authors[58, 61, 164, 235-238] have also commented on the lack of evidence of cost-effectiveness and suggested that this has militated against the further development of such services in the UK[61]. Wright has even suggested that telemedicine may not be cost-effective since it could enhance the service delivered rather than perform a process more efficiently. It may also increase demand for a previously inaccessible service and thereby increase costs[135].

Where consideration has been given to the cost-effectiveness of assistive technologies they have tended to be quiet simplistic. For example in 2000, Tang and Venables[168] took Croydon community health NHS trust, with a population of 325,000 and a budget of £17m, and assumed that 15% of domiciliary patient encounters could be performed by telehealth, saving £1.7m. The costs were assumed as £150,000 for a control centre, £250,000 for equipping the control centre, £400,000 for retraining of staff and £75,000 for technical staff to maintain the control centre. They acknowledge that the figures were speculative, but do suggest Croydon could save £1m per annum, therefore estimating the savings for the country as a whole at £200m per annum.

Although not fully related to this research, a US study on assistive technologies for older people[239] indicated significant financial benefits for intervention. On average 14 assistive technology devices were given to users, for instance walking aids, support for activities of daily living such as assistance in bathing, and hearing and vision impairment. Over an 18 month trial period the results indicated that the control group (those without any additional assistive technologies) declined more than the intervention group. When comparing health care costs the control group on average received \$433 per person in assistive technologies, compared to \$2,620 for the intervention group, but the control group required significantly more expenditure on institutional care (\$21,846 against \$5,630) and nurse visits (\$588 against \$426). In total the average expenditure for the control group was \$31,610 and for the intervention group \$14,173. The authors acknowledged that a sample small size of 52 for both the intervention and control groups, made the results more suggestive than definitive but did indicate that intervention was beneficial both from a reduction in morbidity and total cost. However, more cost-effectiveness data was still required, especially for telecare, the area of assistive technologies identified for investigation in this research.

*Data overload*

The majority of studies have concentrated on 'can' this be done rather than the impact on service delivery. Data overload is a concern expressed by many community alarm control centre managers.

They view new technology as generating many new calls and are concerned that they may not have sufficient resources to respond to the anticipated increase in calls. Although, some new technology has become available, for example fall detectors, no information has been made available about the likely impact that such technologies may have and thus the fears, of community alarm control centre managers in particular, are still evident[240].

## 2.9 Conclusions

As noted by Fisk[241], the trend towards health care at home is 'unstoppable'. His reasoning did not just relate to the potential of new technology and its application, but also the driving forces behind it with demographic change and the political imperative, shared by all western countries to enable people to live independently at home[242]. Over the next 5 to 10 years the accelerating development of computing and broadband networks could ultimately lead to a revolution in the way health care is delivered. A consequence of this will be the facilitation of a high standard of health care in the community[243]. However, as suggested by Mair *et al* in 2000, much of the research that has been conducted is aimed at answering the question "Can we do this?'' and that the next question "Should we do this?'' remains unanswered[238].

The original research question is:

**Are assistive technologies an enhancement to the present health, care and support mechanisms?**

In order to address this question four objectives have been defined:

1. **User requirements:** To define what users would like from a 2nd generation telecare system.
2. **System architecture:** To present models of the information flows in 2nd and 3rd generation systems.
3. **Financial considerations:** To undertake, based on the present and future systems as defined in objectives 1 and 2, an evaluation of the costs involved/expected.
4. **Service delivery:** To investigate the changes that will result from the introduction of the healthcare model identified under objectives 1 and 2. In particular, attention should be given to changes at the community alarm control centre.

These objectives seek to answer the questions "Should we do this?'' and "What is it we should do?" As such, it is believed that much of the research throughout this project has remained original and unique. It is hoped that the evidence presented in the remaining chapters can assist in the research and development of services for older people and other groups, and as a consequence enable many more people to have the choice, safety and independence so many of them are seeking.

# 3 User Requirements

***Chapter structure:*** *Based on a questionnaire the views of users, both current and potential, are investigated. Emphasis was placed on the people themselves and what technology they would like to maintain their independence. A questionnaire was also conducted with providers of the current technology system.*

Despite the number of telecare and telemedicine projects identified in the preceding chapters, it is perhaps surprising that Risebourgh's[118] work, identified in Chapter 2, remains the only significant work attempting to understand current user requirements. Her work sought to investigate the human aspects of the alarm service, primarily through a postal survey, while the technical aspects and views of users regarding technical developments was almost overlooked. Thus, while there is little published evidence of the views of current community alarm users, the views of future potential users appear to have been even more neglected.

Dixon[141] has suggested that user surveys only reveal how people think and feel today, users are not visionary enough to suggest what they may require from an unknown technology in the future. While it may be true that asking an open question such as: "*What would you like from technology in the future*" may not provide a significant insight it was felt that if possible technologies were described to prospective users, then meaningful indications of their potential could be uncovered. In an attempt to understand and uncover the wishes of current and potential users, qualitative research was undertaken for both groups. Providers were also questioned in order to gain an understanding of their requirements for future systems and to discover how well they understood the people they provided a service to. The results from this research together with an appreciation of the capability of technology could then be used to define what elements should be included in future generations of telecare systems.

## 3.1 Current Users Views

As discussed there is little published evidence of community alarm user views. An unpublished, internal postal survey of 2,596 community alarm users by Birmingham City Council[121] discovered that 80% of respondents thought that the 24-hour operation of the control centre was very important and 86% thought that it worked well. Similarly, 89% were satisfied with their present community alarm operation. However, it is to be expected that satisfaction would be high, as there is no alternative for comparison.

Birmingham City Council has a history of innovation in the community alarm arena having developed their own community alarm control centre in collaboration with Pentyre. Subsequently, Pentyre formed a partnership with TeleLarm Care who now market the control centre system. In an effort to further develop services, the internal survey was performed and a project established to develop the community alarm equipment.

This development project consisted of 2 phases. The initial phase would introduce a new alarm system using tried and tested technology into three vertical, warden controlled blocks in Birmingham, while the second phase aimed to develop and introduce new and novel technology not yet commercially available. Each of the three tower blocks was served by 1 full time and 1 part time warden, providing a warden service during office hours with a control centre providing assistance when the warden was unavailable/off duty.

The equipment in the tower blocks was quite dated, all of the users had pullcords but the system would only allow 6 pendant users in each block. The wardens equipment was also dated, requiring the console shown in Fig. 3.1 to be carried throughout the scheme and communication could only be achieved when the device was 'plugged in' at the wardens' office, common room, or someone's home. The initial phase of the project would remove these constraints and allow every user to have a pendant, pullcords or both. Wardens would be provided with a digital cordless telephone (DECT – Digital Enhanced Cordless Telecommunications) similar to that in Fig. 3.2, which would allow communication throughout the scheme.

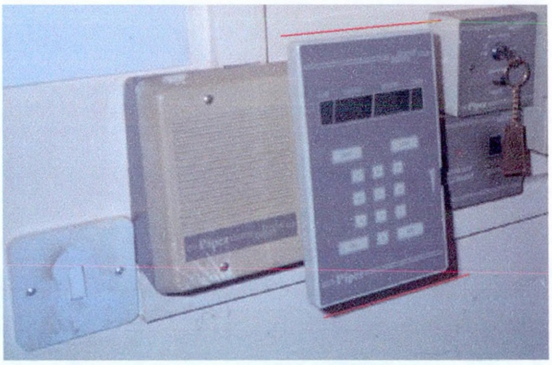


Figure 3.1: *The present wardens' console*

Figure 3.2: *The DECT warden telephone*

*Qualitative research tool*

The aims of the qualitative research were:

- To gain an appreciation of the people living in sheltered housing in respect of health requirements, social interaction and so forth.
- To discover opinions on the present community alarm system.
- To investigate requirements for the new community alarm system to be installed.
- To evaluate the potential of various technologies that could be introduced in the second phase of the project.

It was agreed with the project review group that these objectives would be best met by individual structured interviews. This would allow the accumulation of data on specific questions but would also allow the freedom of interviewees to discuss issues that were important to them. An additional benefit of performing structured interviews as opposed to a postal survey was that it allowed additional information to be given on specific technologies if users had difficulty understanding a concept.

The questionnaire developed was unique for the purposes of the research; a review of the appropriate literature revealed that no suitable tool was available. Conversations with technologists, occupational therapists, gerontologists, carers and other professionals also confirmed that no suitable tool had been formulated. Where possible, questions that other surveys contained were used in this questionnaire, enabling comparison of these control questions with other accepted results, such as the General Household survey (GHS). The questionnaire developed was verified by the review group prior to implementation and is provided as Appendix A3.1. In addition to the questionnaire, some additional questions were asked in one of the tower blocks, this revised questionnaire and the results are provided in Appendices A3.2 and A3.3 respectively. During the interviews where equipment was mentioned examples were shown, for example a new alarm unit and pendants (neck, wrist or broach based), a PIR (Passive infra-red) movement detector and a photograph of the TED unit (The Electronic Doctor) being used.

*Methodology*

Ethical approval for the questionnaire was obtained from Birmingham City Council, but the ultimate decision to be interviewed rested with the users. Ms Pauline Poole, the Careline control manager, and myself spoke at a tenants forum in order to inform the users and wardens of the research, and this information was relayed to the people in each tower block. In the interests of security, the wardens organised the appointment times and the interview took place in the users home.

Interviews were performed in the period 25$^{th}$ September to the 5$^{th}$ November 1998 and typically lasted 30 minutes for the standard questionnaire and 45 minutes where the additional questions were also asked. Although the questionnaire was voluntary to reduce the effects of a biased sample, i.e. interviewing only those people interested in new technology, as many people as possible were sought. Table 3.1 indicates the reasons why certain people were not interviewed.

Table 3.1: *Reasons why some people were not interviewed*

| Reason | Number |
|---|---|
| Wardens felt it would be unwise, i.e. distressing to interviewee | 15 |
| On Holiday, including one couple in Canada for 9 months | 3 |
| Empty | 4 |
| In hospital | 2 |
| Unavailable | 10 |
| Not completed, i.e. distress was being caused | 2 |
| Declined to be interviewed | 7 |

The three tower blocks contain a total of 204 flats. For the first four reasons indicated in Table 3.1, during the interview process this reduced the sample size to a possible number of 180 flats. From this only 7, (4%) declined to be interviewed, 10, (6%) were unavailable for various reasons including refusing to answer the door to the warden or anyone else unless a family member was with them. A further 2, (1%) were interviewed but it was felt that the questions were causing distress and the interview was terminated. Only those people benefiting from the services of the warden were interviewed, therefore sons and daughters living with their parent(s) or live-in carers were not included in the sample. Where there was shared occupancy, all parties benefiting from the warden services were interviewed if available. This resulted in a complete sample size of 176 people, an 89% response rate.

## 3.2 User Survey Results

The results obtained from the questionnaire are presented as an Access database on the accompanying CD. Discussion of the results is under four headings:

- *Control questions*: Comparison with published figures and investigation of general measures, for example how people perceived their own health.
- *Present system*: Examination of the use, knowledge and operation of the community alarm system.
- *Phase 1 alarm technology*: Requirements of the new community alarm system.
- *Phase 2 alarm possibilities*: Investigation of elements that could be included in a 2nd generation telecare system.

### 3.2.1 Control questions

*Demographics*

The average age of the 176 people interviewed was 75.5 with a dispersion indicated by Table 3.2. It could be suggested that the average age of people in the tower blocks will increase over the coming years as the life expectancy of someone reaching the age of 70 is currently 81.5 years[244]. People entering the scheme are also likely to be above the average scheme age, for example the average age of people entering Hanover sheltered housing schemes is 78[78]. The scheme average is lower than this figure because the tower blocks were not originally sheltered housing schemes. In the 1970's they housed people of all ages and the warden services were not introduced until the late 1980's when many of the occupants were ageing and required some additional assistance.

Table 3.2: *Age dispersion of interviewees*

| η=sample size | **Proportion** η=176 Percentage | η |
|---|---|---|
| Less than 60 | 2% | 3 |
| 60-70 | 18% | 32 |
| 70-80 | 49% | 87 |
| 80-90 | 30% | 53 |
| Greater than 90 | ~1% | 1 |

Of the 176 people interviewed, 127 (72%) lived alone and the gender dispersion was 125 (71%) female and 51 (29%) male. The results reveal that 28 (16%) of men and 99 (56%) of women live alone and this would agree with the General Household Survey 1994[84] who suggest figures of 24% and 49% respectively.

*Informal care*

Of those interviewed 24 (14%) currently receive regular informal care for an average of 4.2 hours per week with the sources of informal care shown in Table 3.3. Clearly women provide the majority of the care and this agrees with published data[39]. Table 3.3 indicates that the greatest provision was provided by children however, it has been suggested that caring is not completely reserved to children, others such as brothers, sisters, nieces and nephews can all fulfil the role[42] and this was observed in this questionnaire. Of those surveyed receiving regular informal care only 4 (17%) receive formal care.

Table 3.3: *Sources of informal care*

| | **Provider** η=24 | |
|---|---|---|
| | *Percentage* | *η* |
| Daughter | 63% | 15 |
| Son | 13% | 3 |
| Granddaughter | 8% | 2 |
| Niece | 8% | 2 |
| Nephew | 4% | 1 |
| Friend | 4% | 1 |

*Formal care*

A 1996 MORI poll concluded that 10% of older people received home care services, rising to 36% for those aged 80 and over[245]. The 1994 General Household Survey observed that most domiciliary services are used by people aged 75 and over, by women and by people living alone[12]. While figures specifically for local authorities indicate that they were 6 times more likely to help people living alone in 1994[246]. The questionnaire results would agree with these publications, indicating that overall 22% received formal home care. Those aged 80 and over received the greatest proportion with 38% receiving home care while this reduced to 16% for those aged 60 to 80. Of those receiving formal care 87% were female and 87% live alone. Overall people living alone were 6.6 times more likely to receive home care, slightly higher than the 1994 figure but may be explained by the intensifying of services over recent years. For those in receipt of formal home care on average 6.6 hours per week were provided, however 4 people received full time care i.e. 35 hours a week. Discounting these people suggests a weekly average of 3.2 hours.

In terms of nursing care 10 were in regular receipt, at an average of 0.7 hours each week. However 1 person received 3.5 hours a week, which is slightly higher than the totality of the other 9. Discounting this person gives an average of 0.37 hours a week. As identified in Chapter 1, the domiciliary care service is very intensive and this is highlighted with 9 of the 10 people receiving nursing care also receiving formal home care.

*Doctor consultations*

A 1992 Department of Health publication suggests that the average number of doctor consultations for people over the age of 75 is 6 per year[10]. The Office of Population Censuses and Surveys suggested two years later that those aged 65 to 74 have 6 consultations per year and those aged over 75 have 7[12]. Assuming people under the age of 75 have 6 consultations and those over 75 have 7, then a national figure of 6.6 would be anticipated as indicated by Equation 3.1. Interviewees were asked how many times they thought they had seen the doctor in the last year, thus the information is reliant on the interviewee rather than formal health records, but this indicated 6.8 doctor consultations. Reflecting the level anticipated.

$$\frac{(\text{no. of people} < 75 * \text{no. of consultations}) + (\text{no. of people} >= 75 * \text{no. of consultations})}{\text{total no. of people}} \qquad 3.1$$

$$= \frac{(70 * 6) + (106 * 7)}{176} = 6.6$$

In 1994 the proportion of doctor consultations performed in the older persons own home was 13% for those aged 65 to 74, and 31% for people aged 75 and over[12]. Consequently, the number of home visits can be calculated using Equation 2, suggesting a figure of 1.6 per annum. Using the same procedure the number of surgery based consultations is calculated at 5.

$$\frac{[0.13 * (\text{no. of people} < 75 * \text{no. of consultations})] + [0.31 * (\text{no. of people} >= 75 * \text{no. of consultations})]}{\text{total no. of people}} = 1.6 \qquad 3.2$$

The questionnaire results indicate an average of 4.74 surgery based consultations and 2.07 home visits. It would seem reasonable that the slight increase in home visit consultations could be explained by 22 (13%) expressing that they did not go outside of the scheme on an average week. For these people, they indicated that they received 1.59 surgery based consultations and 5.05 home based consultations during the last year.

The questionnaire indicates that 11% of those interviewed had not seen their doctor in the last year, while 10% had seen their doctor more than 15 times. Therefore, this sheltered housing scheme, which generally reflects anticipated levels of occupancy, home care and doctor consultations, has an equal proportion of people who have not seen the doctor in the last year and people who have seen the doctor more than twice the national average.

*Medication*

There appears to be no consensus on the number of prescription medications older people regularly take. Reports vary between the average older person requiring 3 to 4[247] or 6[248] drugs on a daily basis. The results from this questionnaire would agree with the first estimation as interviewees used 3.7 drugs per day. It should be noted that 18% did not take any prescribed medication, while 4% take more than 10 drugs a day. Most interviewees, 41%, take their medication just once during the day, while 27% take medication at two different times and 32%, 3 or more times during the day.

Attempts have been made at assisting users to take their medication[249, 250] and aids may provide assistance to many if available. However, users had their own way of remembering when to take medication, a technique used by many was before going to bed placing their medication for the next day into egg cups, jars or piles. This would then inform them whether or not they had taken their medication. Remembering when to take medication often revolved around cups of tea, with many taking their medication with their cup of tea after meals. Thus only 16% acknowledged they forget to take medication and on average this would happen a little over 6 times a month. However, 3 people indicated they forgot to take medication more than 10 times a month; a reminder system for these people could be beneficial.

*Hospital admissions*

During a 'normal' year it would be anticipated that 32% of older people would be admitted to hospital[251]. Those interviewed, not including those in hospital when the questionnaire was performed, revealed that 41 (23%) had been admitted to hospital in the preceding year. However, on average they had been admitted 1.8 times, therefore multiplying the two suggests a figure of 42%, 10% higher than the national average. Results specifically for older people in Birmingham would indicate a figure of 46.8%[252]. The reason why the figure is higher in Birmingham than the national average may be due to some socially deprived areas in and near to the city centre.

The 1994 General Household Survey suggests that the duration of a hospital stay depends on age and gender, those aged 65 and over spent on average 11 nights (men) and 12-14 nights (women)[253]. Equating this as a general figure, independent of gender by apportioning the ratio of females to males[27] indicates an average duration of approximately 12 days. However, generated figures from Hospital Episode Statistics[251] suggest a mean of 10.03 days for Birmingham and a mean of 9.5 on a national scale. The questionnaire results obtained from people remembering the duration, indicates an average stay of 12.6 days. Once again the results obtained from the questionnaire are generally in line with accepted published figures.

*Peoples own health*

Table 3.4 presents how people perceived their own health. The results disclose that most people perceived their own health as good, closely followed by poor. In total 59% considered their own health as good or better with the reminder as fair or poor.

Table 3.4: *How people perceive their own health*

| | **Male** $\eta$=51 | | **Female** $\eta$=125 | | **Total** $\eta$=176 | |
|---|---|---|---|---|---|---|
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Excellent | 10% | 5 | 8% | 10 | 9% | 15 |
| Very good | 14% | 7 | 20% | 25 | 18% | 32 |
| Good | 35% | 18 | 31% | 39 | 32% | 57 |
| Fair | 31% | 16 | 25% | 31 | 27% | 47 |
| Poor | 10% | 5 | 16% | 20 | 14% | 25 |

How health is perceived is clearly a subjective measure, thus for the purposes of comparison people with excellent or very good health can be categorised as having above average health. Those with good health as average, and those with fair or poor health as below average. A comparison with the number of doctor consultations in the last year, reveals that people with above average health saw the doctor on average 3 times, people with average health 7.7 times and people with below average health, 9 times. A similar trend is observed for the number of hospital admissions.

*Falls*

A fall has been defined as:

> *"Inadvertently coming to rest on the ground or other lower level with or without loss of consciousness and other than as a consequence of sudden onset of paralysis, epileptic seizure, excess alcohol intake or overwhelming external force*[254]."

The percentage of people aged 65 and over who fall at least once each year is approximately 33%[255-258]. Of those interviewed, 42 (24%) acknowledged that they had fallen at least once during the last year in their home, hence this is lower than generally accepted figure of 33%. The difference may be explained by embarrassment and a reluctance to acknowledge a fall. Equally the questionnaire only refereed to falls inside the home, including falls outside of the home could reduce the difference. However, there does not appear to be consensus; Campbell *et al*[259] suggest 24% of women and 31% of men who fall, fall away from the home environment while Lord *et al*[260] suggests a figure closer to 50%.

For the 42 people who acknowledged they had fallen in their home, on average each person fell 3.8 times. Investigation of these people reveals that 19 had only fallen once during the year with one person falling 10 times, another 18, and a one some 40 times. Discounting these 3 extreme cases indicates an average of 2.4 falls during the past year. Of the 42 people who acknowledged they had fallen, 23 (55%) fell more than once during the year and this is slightly less than would be expected. Nevitt *et al*[261] suggest that two thirds of people who fall will do so again in the next 6 months. The discrepancy may be explained by some people falling once in the preceding 2 or 3 months before the questionnaire, and therefore such people would have a further 3 months in which they could fall again and be included in the figure calculated by Nevitt.

*Physical activity*

On average people went outside of the scheme into the surrounding area 5 times a week, Table 3.5 reveals the dispersion.

Table 3.5: *How often interviewees go into the surrounding area (per week)*

| | **Proportion** $\eta$=176 | |
|---|---|---|
| | *Percentage* | $\eta$ |
| <1 | 13% | 22 |
| 1-5 | 36% | 63 |
| 6-10 | 48% | 85 |
| >10 | 3% | 6 |

The majority of people went into the local environment regularly, with many stating they try to get out as often as possible to maintain their mobility. Nevertheless, 22, (13%) do not go out of their homes during the week, indeed 20, (11%) stated that they never get out of their homes. Nolan *et al*[9] suggests that 5% of people aged 65 to 69 cannot go out alone, rising to 47% in those aged 85 and over. The results obtained do not indicate the people who cannot go out alone, but rather the general question of how often people go out. Using such criteria reveals that 19% of people aged 65 to 69 do not go outside of the scheme, while the identical figure was observed for those aged 85 and over.

*Interaction with family and friends*

In the UK a study by Tunstall Telecom on interaction with family revealed that 33% of older people had not been visited by relatives in the last week[41]. The results from this questionnaire revealed that on average, 31% were visited by family less than once a month, 31% were visited in-between 1 and 5 times a month, 11% in-between 5 and 10, and 27% more than 10 times a month. In total 43% suggested a family member did not visit them on a weekly basis.

The Tunstall study[41] also suggested that 50% of older people are not visited by friends in a normal week. In this study the figure was 57%. However, a common room is available where people often meet and some choose to meet friends here as opposed to their own homes. Nevertheless, it should not be presumed that this accounts for everyone. Many commented that they never went into the common room, reasons such as "... *the same group are always there.....*" or "*....it's a health risk just walking through the door....*", referring to the amount of cigarette smoke, were suggested. For those having friends visiting them in their own homes this occurred on average 2.6 times a week.

Analysis of the results reveals that 52 (30%) suggested that friends or relatives visited them less than once a week. Indeed, 17 (10%) suggested that they were never visited by friends or relatives in their own homes. This has implications such as loneliness, isolation, motivation and well being, and it may be assumed that these people live in isolation in their homes. However, as discussed, on average interviewees indicated they went outside of the scheme 5 times a week, while for the 30% without weekly interaction in their homes this rose to 5.5 times; only 2 people went outside of the scheme less than once a week. It may be that many of the people without interaction in their homes meet friends in the locality rather than interacting with others on the scheme. Equally, 32 (62%) of the 52 people in this group went out 6 or more times a week, and they may be doing this in order to interact with someone else. More research would be needed to clarify this observation.

*Control questions summary*

The results from the above questions are comparable with other published figures as summarised in Table 3.6. Consequently the views concerning the introduction of telecare services may well reflect not only those people in sheltered housing, but also the views of the older population as a whole.

Table 3.6: *Comparison of control questions with published figures*

| Control question | Comment |
|---|---|
| The percentage of people who live alone | The GHS suggests 24% of men and 49% of women live alone, of those interviewed 16% of men and 56% of women lived alone. |
| Providers of informal care | Published studies indicate most carers are female and primarily children, the results of this questionnaire would agree with these findings. |
| The quantity and provision of formal care. | The GHS witnessed that most formal care was given to women aged 75 and over and people living alone. This finding was observed in the questionnaire results obtained. It has also been suggested that people living alone in local authority accommodation were 6 times more likely to receive formal care. The results from this questionnaire suggested a figure of 6.6. |
| Doctor consultations | Analysis of published figures suggested that on average each participant in the questionnaire should have had 6.6 consultations in the previous year, with 1.6 of these being performed in the participants home. The results from this questionnaire suggested there were on average 6.8 consultations of which 2.07 were performed in the home. |
| Prescribed medication | One study suggests that on average each older person takes between 3 and 4 prescribed drugs on a daily basis. A further study suggested the figure to be 6. This questionnaire revealed a figure of 3.7. |
| Hospital admissions | The DoH suggests that 32% of older people are admitted to hospital each year. These results indicate a figure of 42%, 10% higher than the DoH. However, Birmingham City Council Social Services suggested a figure of 46.8% for Birmingham, which is similar to the result obtained in this questionnaire. |
| Hospital duration | The GHS suggests for older people an average hospital stay of 12 days, while the DoH suggest a stay of 10.03 days for Birmingham and a stay of 9.5 days on a national figure. This questionnaire revealed a stay of 12.6 days, which would agree |

| | |
|---|---|
| | with the GHS results. |
| Falls | It is generally accepted that 33% of older people fall at least once each year. Nevertheless, these results indicated a lower figure of 24%. For those people who have fallen, published figures suggest that 66% fall again in the next 6 months. Again this indicator was slightly less with a figure of 55%. |
| Interaction with family and friends | It is has been suggested that 33% of older people are not visited by relatives in their own home during a normal week, a figure of 43% was obtained from these results. In terms of interaction with friends, the same survey suggested that 50% of older people do not have friends visiting them in their own home during a normal week. The results from this questionnaire would agree with this finding as the figure was 57%. |

Despite many of the results obtained agreeing with published figures it should be appreciated that those interviewed represent a wide diversity of people and it would be unfair to group them as dependant people in sheltered housing. For example, 22 people indicated they would go out of the scheme and into the surrounding area less than once a week, while 11 indicated they went out more than 7 times. Investigation of the number of doctor consultations and the levels of prescription medication also indicated a wide array of people with 11% not having any contact with their GP during the last year, while 10% had seen their doctor more than 15 times.

## 3.2.2 Present system

*Common home based technology*

In addition to the community alarm technology that interviewees were familiar with, investigation of the presence of common home based technologies was also sought. Table 3.7 indicates the percentage of users who had certain technologies and the ease with which they could use them.

Table 3.7: *Community alarm users experience with common home based technology*

| | **Have the technology** | | **Of those with the technology the proportion who can use it** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **without help** | | **with help** | | **cannot use** | |
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Cooker | 98% | 172 | 92% | 161 | 2% | 4 | 4% | 7 |
| Microwave | 45% | 78 | 95% | 74 | 1% | 1 | 4% | 3 |
| Washing machine | 52% | 93 | 95% | 88 | 1% | 1 | 4% | 4 |
| Vacuum cleaner | 98% | 173 | 71% | 123 | 4% | 6 | 25% | 44 |
| Telephone | 89% | 157 | 99% | 156 | 1% | 1 | - | - |
| Television | 100% | 176 | 100% | 176 | - | - | - | - |
| Radio | 98% | 173 | 100% | 173 | - | - | - | - |
| Video | 44% | 77 | 84% | 65 | 9% | 7 | 7% | 5 |

Clearly the vast majority of people have and can use a cooker. Perhaps surprisingly 2% or 4 people did not have their own cooker, instead they had hobs and or a grill, with one of the four having a microwave also. Those who indicated they were unable to use the cooker received an average of approximately 12 hours of informal or formal care per week and thus it could be assumed that others cook for them. For older people it has been suggested that 63% of couples and 41% of people living alone have a microwave[262]. The findings from this questionnaire would suggest that 32% of people living alone and 13% of co-habitants had access to a microwave. In total 45% of interviewees had a microwave but many of those currently without one indicated it would be unlikely that they would ever have one because they believed them to be unsafe. Of the 4 people encountering difficulty or indeed unable to use the microwave, 1 was male and was unable to use it because his wife had always cooked for him, whilst the 3 women lived alone and received on average almost 19 hours of care each week.

It would be perhaps surprising that only 52% had their own washing machine with some washing by hand or using the local laundrette. However, this figure would agree with a 1994/95 publication[263] suggesting a figure of 59% for older people living alone mainly dependent on state pensions. It could be assumed that it would be the oldest people who did not have a washing machine, as these people may not have used one during their lives. However, the average age of people without washing machines is 76.4, less than 1 year higher than the scheme average. It could also be assumed that people without a washing machine were likely to have minimal contact with other technologies yet of these people, 48% possessed a microwave or video recorder and 19% both. It would appear that the real reason was due to many using the on-site washing machine. Each tower block had their own washing machine and discussions with the wardens revealed that many would use this and avoid paying for the electricity even if they had their own washing machine. It is unclear exactly how many people this accounts for.

Table 3.7 indicates that 3 people do not have their own vacuum cleaner, in order to keep their houses clean these people used a manual carpet sweeper. Of the 25% of people indicating they were unable to use a vacuum cleaner 82% received an average of 8 or more hours per week of informal or formal care, with cleaning being one of the duties performed during this time.

Around 80% of older households own a video recorder, but this reduces to a third of single older people[262]. The results from this questionnaire suggest figures of 26% and 18% respectively, considerably lower than expected. However, the financial limitations of people living in local authority accommodation may explain the difference. In total 30% of those interviewed had a video and microwave, consequently the assumption that older people are technophobes and unable to use, or willing to accept, technology is not upheld. Only 42% do not own either a microwave or video, with this figure possibly lower if financial limitations were removed. Many did not have a washing machine, however this may be due to people being astute and saving money, not rejecting technology. Table 3.7 also highlights that those who have technology had few difficulties using them, with the exception of the physical limitations of vacuuming. Furthermore, 3 (2%) possessed their own computer with all commenting that they had no difficulties using such equipment.

*User satisfaction*

In addition to previous community alarm studies[118, 121] the results from this questionnaire suggest that there is universal acceptance and satisfaction with the present community alarm system, indeed 89% were content with the system as indicated in Fig. 3.3.

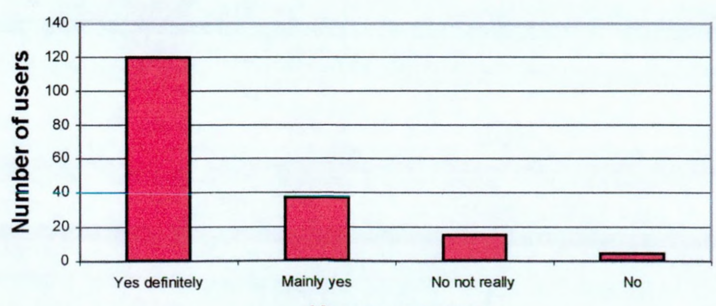



Figure 3.3: *Results when asked - do you like having a community alarm?*

The 4 people indicating they were unhappy were of this opinion, not because they dislike the concept, but rather believe the alarm system is not as good as it should be with 'crackling' on the intercom and having to rely on pullcords.

*Alarm usage*

Throughout the previous year 54% indicated they had used the alarm on average of 1.9 times. Despite the inadequacies of the community alarm identified in Chapter 2 such as, the user being unable to generate an alarm because they were not wearing their pendant or could not reach a pullcord, only 4 people indicated they were unable to raise an alarm during the last year. Three of them lived alone and all used the alarm more than the schemes average, indeed approximately double, at 4 times. Another similarity was that they had all experienced at least one fall in their home during the last year with one person falling 10 times during this period. These people were also more reliant on the doctor, with the average number of consultations set at 23, compared with the scheme average of 6.8.

*Contacting services*

Despite many people indicating they were familiar with common household technologies and suggesting they had no difficulties using them, Table 3.8 would suggest that many were unsure of the purpose of the community alarm. This table indicates how users would contact various services, only including the responses from people with both a telephone and community alarm, giving a sample size of 157 people in this instance. As such, 19 (11%) did not have their own telephone and this would be anticipated from other studies. In 1994/95, of pensioners mainly dependent on state pensions and living alone, 14% did not have a telephone[263] while a 1997 publication suggests a figure of 10%[118].

Table 3.8: *Contacting services by community alarm or telephone*

| $\eta$=157 | **Community Alarm** | | **Telephone** | |
|---|---|---|---|---|
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Repairs | 74% | 116 | 26% | 41 |
| GP | 9% | 14 | 91% | 143 |
| Ambulance | 59% | 92 | 41% | 65 |
| Police | 52% | 81 | 48% | 76 |
| Fire | 44% | 69 | 56% | 88 |

Riseborough suggested that community alarm users had difficulty deciding whether or not a situation is an eligible emergency and whether to use the alarm or telephone[118]. The results shown in Table 3.8 agree with her observation as in all of these circumstances the telephone should normally be used. Discussions with interviewees revealed that many would use the alarm because they thought the alarm would generate a quicker response. They also believed that the police were more likely to attend if the control centre called on their behalf. Education would therefore be beneficial, however a significant proportion understand that the telephone would be quicker but preferred to speak to the warden or control centre operators who they were familiar with. Quantifying the number of people this accounted for has not been possible.

The high percentage using the alarm when seeking repairs to their home may be higher in sheltered housing than for users dispersed in the community. The scheme had its own caretakers and using the alarm during office hours will result in an almost immediate response form a caretaker. When wishing to contact the GP only 14 (9%) indicated they would use the alarm. It may be suggested that these people would prefer others to make decisions for them, further analysis shows that 13 of the 14 would also use the alarm when wishing to contact all of the emergency services. It would appear that even if users were fully educated, there would always be a proportion of people who would always use the alarm.

It may be presumed that those suffering from ill health would prefer to use the community alarm as they may be more vulnerable and comfortable with the community alarm control centre, but the evidence would not support this hypothesis. When wishing to contact all 3 of the emergency services, 43% of users perceiving their health as good or better would use the alarm, while this figure reduced to 41% of those perceiving their health as fair or poor. What appears to be the only parameter indicating a possible trend is the number of times interviewees went out of the scheme into the surrounding area, as presented in Table 3.9. An explanation may be that people who frequently interact with others in the local environment are more confident and willing to use the telephone. While those more inclined to stay within the 'safety' of the scheme are more apprehensive when encountering unfamiliar situations and prefer the assurance provided by the community alarm system with which they are familiar.

Table 3.9: *How interaction affects contacting the emergency services (inc. those with an alarm and telephone)*

| **Weekly number of times interviewees went outside of the scheme surroundings** | | **Percentage of people who would use the alarm rather than telephone** | |
|---|---|---|---|
| *Percentage* | *η* | *Percentage* | *η* |
| <1 | 20 | 65% | 13 |
| 1-5 | 53 | 49% | 26 |
| 6-10 | 78 | 33% | 26 |
| >10 | 6 | 17% | 1 |

Table 3.10 analyses users with access to their own telephone and who had activated the alarm during the previous year. It is noticeable that when an alarm situation arose in every measure the option of using the alarm was higher than that indicated in Table 3.8. It is therefore clear that when assistance is required the comfort that the community alarm system provides to users can be substantial.

Table 3.10: *Contacting services by community alarm or telephone (based on alarm usage in the past year)*

| η=83 | **Community Alarm** | | **Telephone** | |
|---|---|---|---|---|
| | *Percentage* | *η* | *Percentage* | *η* |
| Repairs | 84% | 70 | 16% | 13 |
| GP | 10% | 8 | 90% | 75 |
| Ambulance | 69% | 57 | 31% | 26 |
| Police | 61% | 51 | 39% | 32 |
| Fire | 49% | 41 | 51% | 42 |

*The acceptance of pullcords and pendants*

A survey by Anchor Trust in 1984[128] discovered that 59% of users had at least one pullcord tied up so that it no longer reached from the ceiling to the floor. The results from this questionnaire suggest a lower figure of 43% with a worrying 21% of interviewees having all of their pullcords inaccessible. Fig. 3.4 presents these figures and indicates where one pullcord was tied up which room this occurred in.

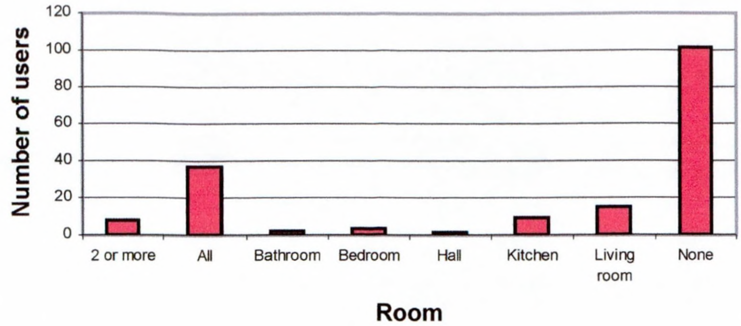



Figure 3.4: *The number of pullcords deactivated*

Occupancy has a significant impact on the accessibility of pullcords. Where occupants co-habited only 33% had all of their pullcords accessible compared to 67% for people living alone. A common theme throughout interviews with people living with someone else was that if they lived alone their response would be different. Many of those interviewed whom had all of their pullcords deactivated suggested that if they lived alone they would ensure all of the pullcords were accessible.

Analysis of the results for each of the 3 tower blocks highlights the important role of the warden. Where all of the pullcords were deactivated 76% were in one tower block, with 16% and 8% in the others. Part of the reason for this is that there are more people of shared occupancy in this block than the others, indeed there were 21 people in shared occupancy, compared to 12 and 16 respectively. However, this does not explain the considerable difference, the real reason is likely to be in the way the warden perceives their role. Where the figure was highest the wardens viewed their role as providing information for users to come to their own conclusions, whilst the wardens in the other blocks believed their role was to ensure that pullcords were available. Both methods have their strengths but what is perhaps required is clear direction to ensure a uniform service delivery, independent of a particular warden.

As previously highlighted, due to the limitations of the hardwired system installed, the system could only function with 6 pendant users per tower block. In total, 11 people had a pendant with 7 (64%) not wearing them when interviewed. This is slightly higher than the published figures of 27%[125] and 40%[126] identified in UK studies and the approximate 50%[127] identified in an American study. There does not appear to be a reason for this higher figure, although the sample size in this instance raises doubt over the reliability of the findings.

*Present system summary*

This section of the questionnaire investigated the use of everyday technology. In addition to the community alarm, many interviewees were exposed to common household technologies with 58% having access to their own microwave or video. An important finding suggested that interviewees were happy to use the various technologies they were exposed too, and few had difficulties using them. Nevertheless, examination of the community alarm system revealed that pullcords and pendants were often inoperable and users were unsure whether to use their alarm or the telephone. Many knew the consequences of inoperable pullcords but would rather live with their own level of risk and this again was a significant finding. For some developers there may be a requirement for a system that would detect everything immediately. The majority of those interviewed would be content with a more basic, and hence cheaper, system; prepared to live with some 'risk'. Removing the risk element may result in a loss of dignity that could be detrimental. Such a basic system would be a lifestyle monitoring system and the results from this section would indicate that there would be a significant interest in this element.

### 3.2.3 Phase 1 alarm technology

*Alarm architecture*

The system in place prior to the completion of the questionnaire was based on pullcords, however the replacement system would allow users to have a pendant, maintain their pullcords or have both. The responses are provided in Fig. 3.5 and perhaps not surprisingly 60% choose to keep their pullcords and have an additional pendant. No charge was involved; therefore many opted to maintain their present system configuration with the addition of the pendant. Although not quantified, many commented that they would only wear their pendants when they were ill, the remainder of the time they would rely on the pullcords. Acceptance of a community alarm system was high, as indicated 89% were happy with their present system, but people would prefer to have the system without them having to wear a device, an important discovery for the development of future systems.

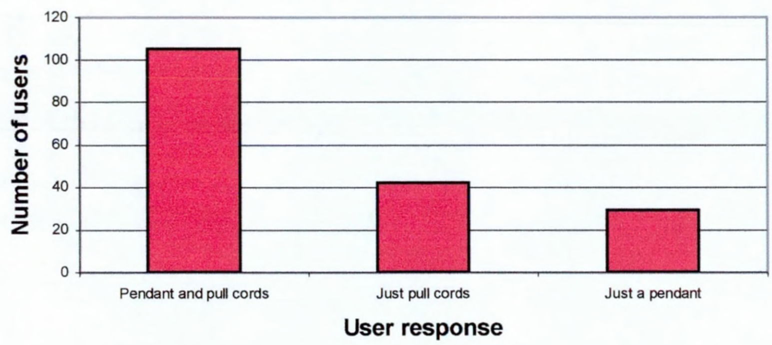



Figure 3.5: *Preferred user system configuration*

Interestingly, 16% preferred to have a pendant and have their pullcords removed. Many of these people suggested that they found the pullcords more intrusive than the pendant, which they felt they could hide under a jumper. Conversely, 24% preferred to stay with their pullcords and declined a pendant. Many of these suggested that they did not find the pullcords intrusive as they had become accustomed to them, while the pendant with the necessity to be worn was more intrusive to them.

Of those with all of their pullcords inaccessible, 62% choose to keep the pullcords in addition to a pendant, 14% choose to have just a pendant and 24% choose to maintain their present system configuration. Users were aware that the removal of pullcords would not result in redecoration, so this is perhaps a surprising result, with 86% wishing to keep their inoperable pullcords.

Risebourough's study[118] concluded that people aged 75 and over were most interested in obtaining a pendant and other 'gadgets' and this was observed in this study. Of those under the age of 75, 70%

requested a pendant while for those aged 75 and over, this rose to 80%. In addition to age, gender would also appear to influence the decision with 61% of men and 82% of women choosing to have a pendant.

*The pendant*

For those people choosing to have a pendant 3 different options were available as indicated in Fig. 3.6

Figure 3.6: *The possible positioning of pendants*

The first option available was the traditional neck cord, the second was worn like a wristwatch, while the final option was a broach that could clip onto jumpers or belts. The choice of which pendant was related to gender with 59% of women requesting the wristwatch, 34% the neck cord and 7% the broach. Males had a preference for the broach with 48%, the wristwatch 39% and the neck cord 13%. The deciding factor was often concerned with how easy people thought they could hide the pendant.

A feature of the replacement system was the ability to answer the telephone by using the pendant. A hands free system would then ensure communication with the caller. For those people for whom such a feature could be used (i.e. chose to have a pendant and have access to their own telephone), 64% indicated that this would be beneficial to them. It would be assumed that mobility would affect the desire to use such a feature. However, when comparing the number of people who went out into the surrounding area less than once a week, the same 64% response was obtained. People who may be defined as having mobility problems indicated they had additional handsets, with one next to where they normally sit and one next to their bed. Therefore, to many this feature was no more beneficial than for other users. An impression was gained that people would prefer to use their telephone but in circumstances when they could not get to the telephone, this would be a benefit. As no charge was made for this service responses may be artificially high.

*The 'box'*

The community alarm 'box' to be installed into the homes of users is indicated in Fig. 3.7.

Figure 3.7: *The replacement community alarm*

This 'box' was noticeably smaller than that currently used and as such many (59%) indicated that they were content with it. However, 41% indicated that they would like to disguise it. Two options were given to achieve this, the alarm could be incorporated into a standard telephone, or it could be made as a clock. The majority, 81% choose the former.

*Phase 1 alarm technology summary*

The previous section highlighted that people were comfortable living with 'risk'. This theme is again evident here where many of the 60% of users welcoming a pendant indicated they would only wear it when they felt ill. Choosing to live with the inadequacies of the pullcord system but making this choice aware of the limitations and as such their views should be respected.

It is clear from the chosen system configuration and the 'box' that users were looking to disguise the fact that they had a community alarm. The approach taken differed between people some reduced intrusion by having a pendant, while others declined a pendant as they considered it to increase intrusion. There is however a clear message that despite the 'success' and acceptance of the community alarm system the visible impact of the equipment needs to be recognised, users do not want others to easily recognise that they have a community alarm.

### 3.2.4 Phase 2 alarm possibilities

*Generated speech*

Amongst service providers[240] it has been remarked that recorded messages can cause confusion and distress to older people. The present system uses recorded or 'comfort' messages when calls are queued at the control centre and there have been occasions where the caller has thought the recorded message was an operator. However, the 'comfort' message is a person speaking naturally and there are cases where it is an operators voice. Using an unfamiliar voice, perhaps with some background music would be beneficial, as this is unlikely to result in the same confusion.

It is common for pendants and pullcords to be mistakenly activated and the control centre contacted[264]. This is an area of concern, not just for the control centre who when dealing with such calls cannot answer higher priority calls, but also for many users who do not want to be seen as a 'nuisance' or 'burden'. It was suggested to interviewees that it could be possible for the community alarm to speak to them and inform them that they have activated the alarm. Therefore there would be the opportunity to cancel the call before the control centre was contacted.

Despite the concerns of some service providers this proved to be acceptable with 78% positively seeking such a possibility. A few, 5% were undecided and 17% were uncomfortable with this possibility. For those who rejected this option their average age was 79.2, 3.7 years more than the scheme average. Overall it can be concluded that generated speech is acceptable to the majority of users if a clear benefit can be derived.

*PABX functionality*

The PABX or Private Branch Exchange is a local communications switch that enables all of the local telephones to be connected together with a reduced number of 'trunk' lines[265]. In practice instead of people having their own telephone line to the telephone exchange, people have a telephone line to the PABX and the PABX connects to the exchange. Because not everyone is on the telephone at the same time, the PABX does not require as many telephone lines to the exchange. It also enables telephone calls within the PABX network to be free of charge.

The questionnaire concluded that 22% regularly telephone others on the scheme and on average this would be done 3 times a week. These people suggested that if the PABX system were introduced they would call others approximately 6 times a week. It would be expected that if no charge were involved people who do not currently telephone others on the scheme may find this helpful, but only 10% indicated they would use this possibility if it were available.

Parry *et al*[16] has suggested that the installation of community alarms may have contributed to a decline in tenants willingness to be neighbourly towards one another and may explain why only a third would be interested in telephoning each other even if no charge were involved. Any enhancements to community alarms must be carefully monitored to maintain or preferably increase tenant involvement and reduce isolation. Fisk[266] has suggested that when speech systems were first introduced in sheltered housing they were accused of being liable to abuse and would result in a loss of social contact with the warden, yet few would argue with the benefits today. Nevertheless efforts must be made to ensure that developments do not divide tenants.

*Gas detection*

Fig. 3.8 testifies that many (65%) were concerned that others could leave gas appliances on by mistake. Many of those interviewed suggested that gas appliances should be prohibited, as a gas explosion in the tower block would impact upon many people. However, many of the interviewees suggested they had cooked on gas all of their lives and to prohibit this could be very intrusive.

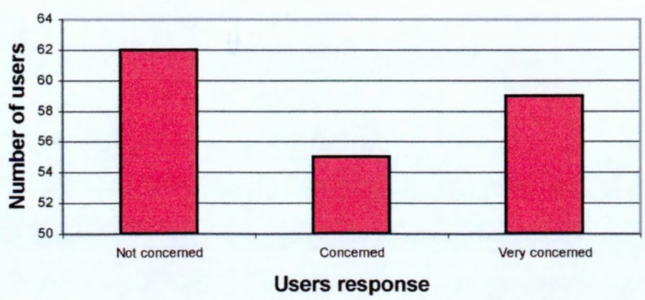



Figure 3.8: *The level of concern over others leaving gas appliances on by mistake*

A more acceptable solution may be to detect the level of gas and if above a dangerous level generate an alarm. This alarm could be internal, perhaps using generated speech, and if the gas level did not decline the gas could be turned off. This would address the safety concerns expressed by interviewees and allow people to continue to use gas appliances. Such technology is already commercially available[188].

In addition to gas monitoring a significant proportion of users raised the issue of monitoring water usage. Several commented they had experienced flooding when occupant(s) above them had accidentally left the bath taps on. Again, devices and systems are being developed to address this issue[137, 219].

*Automatic lights*

Automatically turning lights on and providing better visibility when getting out of bed may help to prevent some falls. It may also be beneficial to automatically turn lights on and off when moving in-between rooms. However, Fig. 3.9 indicates that such a possibility was not welcomed by many.

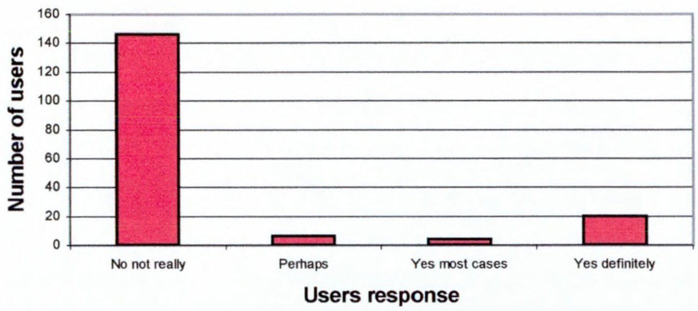



Figure 3.9: *The number of users interested in automatic lights*

This result may not be representative of users in other sheltered housing schemes or dispersed in the community. A considerable proportion commented that automatic lights were irrelevant because light from the floor hallway eliminated their passageway. Others commented that they had their own strategies for example, always putting the bedside light on before getting out of bed or using a torch. One lady also suggested that the shock of the lights automatically coming on could give her a heart attack! People without external hallway light may find this function more beneficial; nevertheless in a similar fashion to people taking their medication individual strategies are providing the solution.

*Automatic fall detection*

The fear of falling and lying on the floor undetected was prevalent in many interviewees minds. A system was proposed that would automatically detect a fall and if that person had not regained their feet 2 minutes latter, an alarm would be raised. In total, 75% commented that they would definitely welcome such a possibility with a further 2% indicating they were interested in this development.

Surprisingly, 9 (21%) indicating they had fallen in the last year rejected this possibility and it is unclear why this would be so. Two of the 9 had fallen 6 times during the last year and commented that because they fall regularly without harming themselves, such a system would be intrusive. Some also commented they were uncomfortable knowing that others would be informed they had fallen and therefore would rather do without such a device. They believed that if necessary they could raise the alarm with their pullcords or the soon to be acquired pendant.

*Lifestyle monitoring*

Each interviewee was shown a PIR and it was explained that each room would require one. Consequently if they became unable to get out of a chair or the bath, this would be detected and an alarm generated. It would also ensure that if they normally got out of bed at 08:00, but were still in bed at 11:00 for example, an alarm would be generated. In the first instance the alarm would be internal with generated speech and then externally to the control centre if no cancellation was received.

Many who expressed an interest in this possibility wanted to ensure that they did not encounter false alarms and would rather wait for the alarm to be raised than encounter false alarms. Many also wanted reassurance that 'they' – the warden or control centre operators, could not see them. The general concept of monitoring and analysing daily activity levels were not discussed, hence there was no mention of monitoring the usage of the refrigerator as has been suggested[267] or creating a detailed pattern of habits[200]. Only the specific benefits were discussed.

Of those interviewed, 65% declared they would welcome such a system in their home, with a further 3% interested in this development. All of the interviewees expressing an interest had no objection for a PIR being placed in the bathroom; indeed many saw this as the main source of potential benefit.

It would be anticipated that physical activity would affect the acceptance of such a possibility. Those with mobility difficulties would be considered to benefit the most as they would be more likely to have difficulties getting out of a chair or bath and therefore the system could detect this and raise an alarm. Table 3.11 indicates the acceptance rate when compared to how often interviewees went into the surrounding area.

Table 3.11: *How interaction with the surrounding area (per week) affects acceptance of lifestyle monitoring*

| **Outside of scheme** | | **Accept lifestyle monitoring** | |
|---|---|---|---|
| | $\eta$ | *Percentage* | $\eta$ |
| <1 | 22 | 55% | 12 |
| 1-5 | 63 | 76% | 48 |
| 6-10 | 85 | 60% | 51 |
| >10 | 6 | 50% | 3 |

Evidently the more often interviewees went outside of the scheme the less likely they were to accept this possibility. Nevertheless, the obvious deviation from this hypothesis is those who go outside of the scheme less than once a week. Such people were only slightly more receptive than those who go into the surrounding area more than 10 times a week and there does not appear to be a satisfactory explanation for this result. Approximately half of those most likely to benefit from lifestyle monitoring accept it, while for those who go outside of the scheme between 1 and 5 times a week, three-quarters welcomed such monitoring.

*Telemedicine*

Interviewees were shown a photograph of TED, The Electronic Doctor, developed by the University of Wales, Bangor[147], and described in Fig. 3.10.

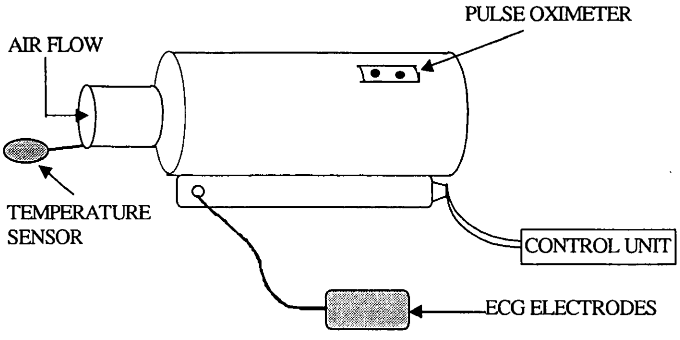



Figure 3.10: *TED – The Electronic Doctor*

It was explained that TED would measure blood pressure, heart rate, body temperature and breathing characteristics and that their doctor would define particular parameters for them. If outside of these parameters they would be informed and the doctor contacted. The doctor would therefore be able to assist, hopefully before greater intervention would be needed. Cancellation of the automatic call to the doctor would be provided, therefore giving control to the user.

In total 52% indicated they would value such equipment with a further 5% suggesting they would use it if their doctor suggested it. With such a device it would be assumed that health dictates the response and indeed this is true both for perceived health and the other health measures identified in section 3.2.1. The level of interest of users perceiving their health as above average was 43%, whilst this rose to 54% for those deeming their health as average and 68% for those below average. The number of prescriptions also affects the relative benefits of the device as depicted in Table 3.12, while the number of doctor consultations in the last year also indicated the same trend.

Table 3.12: *How the number of prescriptions affects interest in telemedicine*

| | **Accept telemedicine** | |
|---|---|---|
| | *Percentage* | $\eta$ |
| 0 $\eta$=32 | 44% | 14 |
| >0 & <=2 $\eta$=57 | 58% | 33 |
| >2 & <=4 $\eta$=48 | 58% | 28 |
| >4 & <=6 $\eta$=21 | 57% | 12 |
| >6 $\eta$=18 | 72% | 13 |

Clearly as health deteriorates the greater the level of interest in telemedicine almost independent of the health indicator used. Only hospital admission did not indicate this trend, where of those admitted to hospital in the last year 56% were interested compared to 57% of those who had not. Of those receiving nursing care only 30% were interested in telemedicine. It is believed that interviewees thought the telemedicine equipment would ultimately replace the nurse and hence in this circumstance some may have seen it as a choice between the nurse and an electronic device, with the resulting scepticism.

*Video conferencing*

To ensure that the user was in control, the system described consisted of a small camera positioned on top of their television that they would physically have to activate to enable videoconferencing. Many were interested as to how this would be achieved, as they were concerned about potential damage to their television. In total 44% sought this functionality, with a further 2% possibly interested. A significant, but unknown, number of interviewees declined this option, as they believed the aforementioned enhancements were more important. Interviewees were aware that the second phase of the project would develop some of the enhancements, but there was limited finance and the results from the questionnaire would influence developments. It could therefore be suggested that if videoconferencing were available it would be used, but to the interviewees it was of less importance than the other enhancements discussed.

Nevertheless, a significant proportion did not perceive that any benefit could be derived from videoconferencing and would not be interested in this functionality if it became available. These people perceived it more as a toy than a positive enhancement to their community alarm. Surprisingly, of those people who get outside of their home less than once a week only 41% would be interested in this possibility, slightly less than the scheme average. This may be due to a lack of confidence with unfamiliar circumstances, previously expressed when contacting services, section 3.2.2.

In addition to being able to see people on their television screens, it was also suggested that by activating their camera the person they were conversing with could see them. Of those indicating they welcomed videoconferencing, 83% were content with this possibility, while a further 4% were interested in this possibility.

In order to investigate social video conferencing, i.e. with other people, in Block A the question asked was:

> '*When talking with friends, as well as speaking to them through the alarm unit would you like to be able to see them on the television*?'

While in the remaining blocks, videoconferencing with service providers was discussed in the form:

> '*When communicating with the warden, control centre or GP, as well as speaking to them through the alarm unit would you like to be able to see them on the television*?'

Table 3.13 indicates the difference this makes, thus if there is a clear and personal benefit there is greater enthusiasm for the technology. In this case, the effect of the personal benefit increases the acceptance by 18%.

*Variation between tower blocks*

In order to have confidence in the results the three tower blocks should produce similar findings. Table 3.13 presents the results, on an individual block basis, for the 4 main technology enhancements discussed.

Table 3.13: *Interest in the four main technology enhancements, specific to each tower block*

| | Tower block | | | | | |
|---|---|---|---|---|---|---|
| | **A** $\eta$=55 | | **B** $\eta$=55 | | **C** $\eta$=66 | |
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Automatic fall detection | 75% | 41 | 76% | 42 | 79% | 52 |
| Lifestyle monitoring | 67% | 37 | 69% | 38 | 68% | 45 |
| Telemedicine | 51% | 28 | 53% | 29 | 65% | 43 |
| Video conferencing | 58% | 32 | 36% | 20 | 44% | 29 |

Evidently, there is similarity between the tower blocks with indicates that the responses obtained could be representative of people in similar situations. Automatic fall detection and lifestyle monitoring had a range of under 5%, indicating a reliable response. Telemedicine had a larger range, 14% and it is difficult to explain why interviewees in block C were more receptive. It could be assumed that block C contained a greater proportion of people with health needs and as previously identified, these people would be more receptive. However, analysis of the health measures such as, GP consultations, prescribed medication, or perceived health, indicates that there were equal proportions of people with significant health needs in all three blocks.

A possible explanation is the influence of the wardens who in this block were the only ones receptive to telemedicine monitoring. As previously indicated the wardens organised the interviews and were interviewed after the questionnaire had been completed with the users. However, by the time the wardens were interviewed users had informed them of the technology discussed and therefore they may have influenced users that had yet to be interviewed. The influence wardens have is substantial. Where comparison can be made for videoconferencing, namely blocks B and C, there was a range of only 8%.

*Occupancy*

As previously discussed couples living together indicated they would answer questions differently if they lived alone. Analysis of the different responses is presented in Table 3.14.

Table 3.14: *Interest in the four main technology enhancements, specific to living arrangements*

| | **Shared occupancy** $\eta$=49 | | **Live alone** $\eta$=127 | |
|---|---|---|---|---|
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Automatic fall detection | 69% | 34 | 80% | 101 |
| Lifestyle monitoring | 73% | 36 | 66% | 84 |
| Telemedicine | 65% | 32 | 54% | 68 |
| Video conferencing | 61% | 30 | 40% | 51 |

Of the 4 main technology enhancements discussed it is noticeable that co-habitants were more receptive with the exception of the automatic detection of falls. When performing the questionnaires it was evident that falling and lying undetected was a concern to many. Co-habitants have the comfort and assurance that their partner can assist them and raise an alarm, while people living alone would be more isolated and therefore may be more receptive to this possibility.

It is difficult to appreciate why people living alone, who may be considered as more vulnerable and therefore potentially gain more, were less enthusiastic to the technology possibilities than co-habitants. During the course of the questionnaire co-habitants often indicated that if they lived alone they would have been even more receptive, so overall it would be assumed that co-habitants would be the less receptive group. This is also validated by the use of pullcords where 67% of co-habitants did not use the pullcords, i.e. had all of them tied up, compared to 33% for single occupants. The only plausible suggestion for co-habitants being more receptive is that because the questionnaire was performed on a flat basis, co-habitants could confer and find support from each other. People living alone had no such 'safety net' and therefore if they were unsure, perhaps the safer response was to decline the technology enhancement. Such a hypothesis cannot be assured from the results of this questionnaire.

*The affect of age on acceptance*

Riseborough's study[118] of community alarm users suggested that those aged 75 and over were most interested in pendants and 'gadgets'. The results from this questionnaire would agree with her conclusions for age being a qualifier for the acceptance of pendants, but suggests that for the acceptance of what she termed, 'gadgets', it cannot. Table 3.15 indicates that for 3 of the enhancements it was those under the age of 75 who were most receptive. However, the results do not overwhelmingly fall into one group or another and therefore would suggest that the acceptance of the enhancements was not dependent on age. The use of common home based technology also does not clearly support Riseborough's hypothesis. Of the 102 users in this questionnaire having either a microwave or video machine only 54% were aged 75 and over.

Table 3.15: *Interest in the four main technology enhancements, specific to age*

| | **<75** $\eta$=70 | | **>= 75** $\eta$=106 | |
|---|---|---|---|---|
| | *Percentage* | $\eta$ | *Percentage* | $\eta$ |
| Automatic fall detection | 69% | 48 | 80% | 85 |
| Lifestyle monitoring | 70% | 49 | 67% | 71 |
| Telemedicine | 64% | 45 | 52% | 55 |
| Video conferencing | 47% | 33 | 45% | 48 |

*Those rejecting the four main technology enhancements*

Nineteen, (11%) were not interested in any of the 4 main enhancements. As indicated in section 3.2.2, contacting services, approximately 8% looked for others to make decisions for them, choosing to use the community alarm to contact the GP and emergency services rather than the telephone, yet none of these people rejected all of the enhancements.

Comparison of the people rejecting the four main technology enhancements does not indicate a clear reason as to why this should be so. The average age of these people was 76.5 and using Riseborough's hypothesis of people over the age of 75 being most receptive, it would be presumed the average age would be below 75. The only clear characteristic common to all was that 12 of the 19, 63% also indicated that they would stay with their pullcords and declined a pendant.

There were situations where it would appear that an individual could greatly benefit from some of the enhancements discussed; yet they declined. It may be that some could not comprehend what was being discussed and therefore declined, since they were satisfied with what they had already. These people would fit into the stereotypical view of frail older people in sheltered housing and are heavily reliant on the warden for advice and assistance. Such people are part of sheltered housing and the wider community and when introducing such technology every effort should be made to include these people. Several people wanted to change their opinions on enhancements after discussions with others and the wardens. This was especially true of block C where the wardens were very enthusiastic. This again highlights the significance of the warden.

*The acceptance of multiple enhancements*

The results from this questionnaire revealed that 89% were happy with their present community alarm system, yet 57% were interested in at least 3 of the 4 main technology enhancements and 25% interested in all 4. This casts doubt over the validity of user surveys that purely seek to discover the 'success' of current systems as no comparison can be made with an alternative. This questionnaire reveals that despite a high level of satisfaction with the current community alarm system there is a desire for development. The acceptance of multiple enhancements can be seen to be related to how often the current alarm is used as presented in Table 3.16.

Table 3.16: *How alarm usage in the previous year affects the acceptance of multiple enhancements*

| | **0** η=81 | | **>0 <=4** η=73 | | **>4 <=10** η=16 | | **>10** η=6 | |
|---|---|---|---|---|---|---|---|---|
| | % | *η* | % | *η* | % | *η* | % | *η* |
| Interested in any 3 | 59% | 48 | 52% | 38 | 69% | 11 | 50% | 3 |
| Of which, definitely want any 3 | 57% | 46 | 45% | 33 | 63% | 10 | 50% | 3 |
| Interested in all 4 | 22% | 18 | 27% | 20 | 31% | 5 | 17% | 1 |
| Of which, definitely want all 4 | 21% | 17 | 26% | 19 | 19% | 3 | 17% | 1 |

It is noticeable that users who have not used the alarm in the last year recognise there are benefits with the enhancements discussed. The general trend indicates the more the alarm is used the greater the acceptance of new technology, until the alarm is used more than 10 times during the year. At such point there is a noticeable decline, which is perhaps surprising, as it may be that these are the people who would most benefit from the enhancements. Tables 3.17 and 3.18 show similar trends comparing perceived health and the number of doctor consultations throughout the previous year and both show the same trend.

Table 3.17: *How perceived health affects the acceptance of multiple enhancements*

| | **Excellent** η=15 | | **Very good** η=32 | | **Good** η=57 | | **Fair** η=47 | | **Poor** η=25 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | *η* | % | *η* | % | *η* | % | *η* | % | *η* |
| Interested in any 3 | 33% | 5 | 38% | 12 | 60% | 34 | 70% | 33 | 64% | 16 |
| definitely want any 3 | 20% | 3 | 31% | 10 | 56% | 32 | 68% | 32 | 60% | 15 |
| Interested in all 4 | 13% | 2 | 9% | 3 | 25% | 14 | 38% | 18 | 28% | 7 |
| definitely want all 4 | 7% | 1 | 9% | 3 | 25% | 14 | 32% | 15 | 28% | 7 |

Table 3.18: *How the number of GP consultations in the previous year affects the acceptance of multiple enhancements*

| | 0 | | >0 <5 | | >=5 <=10 | | >10 <=15 | | >15 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | η=19 | | η=68 | | η=53 | | η=18 | | η=18 | |
| | % | η | % | η | % | η | % | η | % | η |
| Interested in any 3 | 47% | 9 | 50% | 34 | 51% | 27 | 89% | 16 | 78% | 14 |
| definitely want any 3 | 42% | 8 | 47% | 32 | 43% | 23 | 83% | 15 | 78% | 14 |
| Interested in all 4 | 26% | 5 | 28% | 19 | 15% | 8 | 33% | 6 | 33% | 6 |
| definitely want all 4 | 21% | 4 | 28% | 19 | 11% | 6 | 33% | 6 | 28% | 5 |

Whether it is a fear of the unknown, embarrassment, an insufficient understanding or some other measure those who could reap the greatest potential benefits, those in the last group of the above tables have a reduced interest in the enhancements. It is also clear that the majority of people were clear in their own minds if they wanted an enhancement, as there is little variation between those interested and positively wanting enhancements.

It may also be considered that previous technology exposure would increase the desire to embrace the enhancements. Of those possessing a microwave and video player, 62% were interested in any 3 of the enhancements, while this only reduced by 10%, to 52% of those who did not posses either. Therefore, there would be some evidence to support the hypothesis that previous technology exposure increases the acceptance of an enhanced community alarm system, but the results from this questionnaire would suggest the impact is slight.

*The freedom of information*

An important component of automatic fall detection, lifestyle monitoring and telemedicine is that they could be used in a preventative as well as reactive way. Thus, if unusual behaviour occurred, perhaps several falls within a small time scale, the reason for this should be investigated; ultimately perhaps avoiding future falls. Monitoring lifestyle behaviour and medical parameters over time can also be used to indicate potential difficulties. To achieve this personal information must be stored and analysed and as Table 3.19 indicates the majority of interviewees were prepared for this to happen.

Table 3.19: *How interviewees responded to being asked if personal information could be stored*

| | No objections | | If GP thought wise | | Don't know | | No | |
|---|---|---|---|---|---|---|---|---|
| | % | η | % | η | % | η | % | η |
| Automatic fall detection η=135 | 92% | 124 | 1% | 1 | - | | 7% | 10 |
| Lifestyle monitoring η=120 | 98% | 118 | - | - | 1% | 1 | 1% | 1 |
| Telemedicine η=100 | 97% | 97 | - | - | - | - | 3% | 3 |

Evidently, 10 (7%) expressing an interest in automatic fall detection would prefer that if they fell this information was not kept, with 2 of these experiencing a fall in the last year. It is unclear why there should be a higher proportion of people preferring fall information not to be stored. A possible suggestion may be that if a fall did occur these people may believe that the fall would not be substantial, and they would be able to regain their feet; thus to remove any possible embarrassment they would prefer this information not to be stored.

*Video door entry system*

The final technical enhancement discussed was a remote door entry system that would allow people to see who was at the front door to the tower block on their television screen. This was the most well received enhancement with 92% indicating they would find this beneficial. It would appear that the high acceptance rate was due to local children causing a nuisance in the tower blocks. To gain access to the tower blocks someone has to let the caller in and this is achieved by activating a switch in any of the flats. Some interviewees commented that some of the "....*confused older ones*...." would let anyone in and that being able to see the caller on the television could help to alleviate this problem.

*Technology or residential care?*

In order to investigate the possible acceptance of technology enhancements, interviewees were asked to choose between having technology enhancements or moving into residential care and 93% indicated they would prefer to stay in their own homes with technology. Although this may indicate that technology would be welcomed if such a situation arose it is difficult to know if this is an accurate picture. Many may have chosen to stay at home whether or not they had technology as they did not want to leave their home or go into residential care. A Department of the Environment[268] report has indicated the 80% of people want to stay in their own homes for as long as possible and it is known that people enter residential care as a last resort[10].

*Phase 2 alarm possibilities summary*

Several technologies were discussed and a positive response was gained by many. Generated speech, which was previously thought to be unwelcome, was shown to be acceptable. The acceptance of the 4 main technologies discussed namely, automatic fall detection, lifestyle monitoring, telemedicine and videoconferencing was previously unknown. The questionnaire clearly indicates where efforts should be made with the automatic detection of falls, lifestyle monitoring and a vision door entry system the enhancements users were most interested in. The use of telemedicine and virtual consultations were welcomed by those with poor health and would therefore indicate that the use of such equipment would be most welcome by people suffering from particular illnesses rather than all of the community alarm users.

A summary of the findings were provided to each interviewee is available in Appendix A3.4

## 3.3 Future Potential Users

A voluntary questionnaire was performed at the 8th retirement association chairpersons' conference of Boots. All retired Boots staff have the option of joining regional associations and the conference gathered together the chairpersons of these regional associations. Therefore, the people gathered represent a wide diversity; some were recently retired while others had been retired for some time. They were geographically spread from Edinburgh to Sussex and appeared to have no bias towards accepting or rejecting the technology discussed. The only common link was that they previously had worked for Boots.

*Methodology*

The questionnaire immediately followed a presentation on advancing home care technology and was completed individually. Information was given on each question (the questionnaire is provided in Appendix A3.5) and time given for the participants to fill in the form. In total all 22 chairpersons' participated in the questionnaire. Investigation of future technologies, such as lifestyle monitoring etc. was on the assumption that they had been assessed as needing a community alarm.

### 3.3.1 Future potential user results

*General*

The majority of participants (21) owned their own homes with 1 being a tenant. Thus compared to the previous questionnaire with users in local authority owned sheltered housing, these participants could be considered as more affluent. Seven people lived alone, 11 lived with one other, while 4 lived with 2 others. The average was therefore 1.8 occupants per home.

Currently, 11 (50%) of participants have a home security system, with a further 2 (9%) indicating they may obtain one in the future. It may be assumed that people living alone and therefore often leaving the home unoccupied would be the group most likely to have a security system. However, the findings would not support this hypothesis with 7 of the 11 (64%) living with at least one other having a security system. As in the previous questionnaire co-habitants were the most receptive group. For people living alone there was no distinction between having a security system or not with approximately equal proportions in both groups. For those living with two others only 1 from 4 (25%), had a security system.

*Lifestyle monitoring*

The explanation for the lifestyle monitoring system was the same as that in the aforementioned current user questionnaire. Of the 22 people questioned, 9 (41%) indicated that if they needed a community alarm, they would find lifestyle monitoring beneficial. A further 9 also indicated that they would consider this option with the remaining, 4 indicating that they were unsure. Although these findings do not show that lifestyle monitoring should be an integral part of the community alarm system, it is evident that no one indicated that they did not want this option. The previous questionnaire revealed that those with good mobility, going into the local environment frequently, were the least receptive group to lifestyle monitoring. Therefore, as mobility was not currently a difficulty for the participants in this questionnaire it may have been difficult to appreciate the benefits at this stage.

It was observed earlier that co-habitants were more receptive to the 4 main technology enhancements than people living alone. This trend was evident again where 53% of co-habitants indicated they would welcome lifestyle monitoring as part of their community alarm, while this reduced to 14% of those living alone. Previous technology exposure also impacted upon acceptance in the current user questionnaire and this trend was observed again. Of those with a home security system 55% welcomed lifestyle monitoring, with this reducing to 27% of those without such technology.

*The acceptance of cameras*

When the community alarm is activated in some circumstances it may be helpful for the community alarm control centre operator to see inside of the home. However, it has been suggested that such a technique is '....*recognised as being intrusive*'[269]. The system described would only use the camera when the control centre was contacted and the camera would be hidden, perhaps in the PIR used in the lifestyle monitoring system. The response indicates that all participants would have at least 1 camera in their home with Table 3.20 indicating the acceptance of cameras in specific rooms.

Table 3.20: *The acceptance of camera's in the home*

| | Living room | | Hall | | Kitchen | | Bathroom | | Bedroom | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | $\eta$ | % | $\eta$ | % | $\eta$ | % | $\eta$ | % | $\eta$ |
| Accept | 59% | 13 | 59% | 13 | 50% | 11 | 41% | 9 | 36% | 8 |
| Reject | 41% | 9 | 41% | 9 | 50% | 11 | 59% | 13 | 64% | 14 |

Despite the results suggesting that participants would allow cameras into their homes, intrusion was evident especially where people were likely to be in a state of undress in the bedroom and bathroom.

On average participants indicated they would have 2.5 camera's in their homes, 8 indicated they would have only 1 while 5 indicated they would allow cameras in all of the rooms. The exposure to technology again impacted upon the acceptance with 3 of the 5 people indicating they would have camera's in all of the rooms currently having a security system and 1 suggesting they may have one in the future. All 5 lived with someone else and occupancy again impacted upon acceptance, where people living alone indicated an average of only 2 cameras.

*Automatic fall detection*

Eighteen (82%) welcomed the automatic detection of falls with a further 2 (10%) unsure. Of those living alone 86% indicated they would welcome a fall sensor while this dropped slightly to 80% of those living with at least one other. Again this trend was observed with the current users, where of the 4 enhancements discussed the only one which was better received by people living alone was the fall detector.

*Telemedicine*

The results from the current user questionnaire suggested that 52% welcomed medical monitoring. This questionnaire of potential users suggests a similar figure with 12 (55%) indicating they would welcome such a possibility. A further 7 (32%) indicated they would use telemedicine if their doctor suggested it.

Again, people living alone were less receptive, 3 (43%) of the people living alone indicated 'yes' and 6 (86%) indicated either 'yes' or 'if doctor decided', while those people living with someone else indicated 9 (60%) to 'yes' and 13 (87%) to either 'yes' or 'if doctor decided'. Regarding a home security system, no real significance was observed, 89% of those without a security system indicated either 'yes' or 'if doctor decided', whilst this reduced to 82% of those with a security system.

*Virtual consultations and videoconferencing*

The prospect of performing doctor consultations virtually was suggested as an alternative to physical consultations in some instances. In total, 36% declared they had no objections to their consultation being performed remotely with a further 27% indicating they would be happy to use such a method if their doctor suggested it. Twenty-three percent would prefer to have a physical consultation, with the remaining 14% undecided. Again, co-habitants were more receptive with 67% compared to 57% prepared to use virtual consultations.

Thirteen (59%) indicated that videoconferencing with friends and relatives, in effect a video telephone, would be welcome with 5 (23%) unsure. The remaining four (18%) indicating that they would not like this, preferring to use the standard telephone. Of those suggesting they would welcome virtual consultations, 5 of the 8 (63%) would also welcome videoconferencing when speaking with friends and relatives. Evidently, 3 of the 8 (37%) were content to use videoconferencing with their doctor, but would prefer to use a telephone when speaking with friends and relatives. Interestingly, of the people positively welcoming videoconferencing all of them lived with someone else and it is unclear why this should be so. Comparing those with and without a home security system is inconclusive.

*Equipment costs*

Because the majority of participants were likely to be affluent and not eligible for statutory funding they are likely to have to purchase their own community alarm. As such an idea of the price participants would be prepared to pay if assessed in need for a full system, incorporating lifestyle monitoring, fall detection, virtual consultations and videoconferencing was investigated. Participants were asked to suggest a one-off figure for equipment and a weekly monitoring charge. Four participants were unable to suggest a figure as they were unsure what 'technology' costs, but the remaining 16 suggested an average of £925 for the one off equipment charge. However, Table 3.21 suggests there is a significant variation between what participants would pay for the technology.

Table 3.21: *How much participants would pay for a one off equipment charge*

| Amount | **£50** | **£100** | **£350** | **£500** | **£750** | **£1,000** | **£1,500** | **£2,500** | **£3,000** |
|---|---|---|---|---|---|---|---|---|---|
| Frequency | 2 | 1 | 1 | 3 | 1 | 5 | 1 | 1 | 1 |

This is obviously a subjective measure and is difficult to suggest a figure when the technology is not currently needed. However, Table 3.21 indicates that a figure of £1,000 was most frequently suggested. By eliminating the two extreme cases, i.e. £50 and £3,000, the average reduces to £900. Analysing the results indicates those who would pay the most were the most receptive to the technology. Focusing on those who would pay a minimum of £750 reveals that they all indicated an interest in lifestyle monitoring, while all positively welcomed the automatic fall detection system. In addition telemedicine was welcomed by all, while 6 of the 9 welcomed virtual consultations and 7 videoconferencing.

Before the questionnaire was completed it was mentioned that the BCC Careline system charges under £2.00 a week for monitoring of the present system. Nevertheless, it would appear that many would pay far in excess of this for a 2$^{nd}$ generation telecare system. Table 3.22 indicates the range of weekly charges for the 17 participants suggesting a figure.

Table 3.22: *How much participants would pay for a weekly monitoring charge*

| Amount | £1 | £2 | £5 | £10 | £20 | £25 |
|---|---|---|---|---|---|---|
| Frequency | 1 | 3 | 2 | 3 | 4 | 4 |

The average weekly charge suggested by participants was £13.35, while removing the two extreme cases suggested a figure of £10.50. Analysis of those prepared to pay £750 or more for the equipment suggests a weekly monitoring charge of £14.33.

Currently the community alarm costs approximately £175 with a 5 year maintenance contract, while the weekly monitoring charge is less than £2.00[240]. Clearly if the participants needed a community alarm they were prepared to finance, from their own resources, the necessary equipment to maintain their health and allow them to stay in their own homes. This clearly demonstrates that if there is need, people are prepared to use technology and invest considerable sums for it.

*Accuracy of the results*

The results presented do not represent the whole population fairly, all but one of the participants owned there own home and from subsequent information obtained from Boots 85% held a middle management position, 5% were union representatives and only 10% were operational staff. They may therefore be well educated and reflect a financially affluent group. It should also be noted that with a sample size of just 22 this is insufficient to be able to generalise the results obtained. However, the results gathered indicate a similarity with the current user results as can be seen in Table 3.23, and therefore add to the evidence base for 2nd generation telecare systems.

Table 3.23: *Comparison between present and potential community alarm users*

| | Current users | | | Potential users | | |
|---|---|---|---|---|---|---|
| | Yes | Perhaps* | No | Yes | Perhaps* | No |
| Automatic fall detection | 75% | 2% | 23% | 82% | 13% | 5% |
| Lifestyle monitoring | 65% | 4% | 31% | 41% | 59% | 0% |
| Telemedicine | 52% | 5% | 43% | 55% | 40% | 5% |
| Virtual consultations | 44%† | 9%† | 47%† | 36% | 41% | 23% |
| Videoconferencing | | | | 36% | 23% | 41% |

* = Includes all options except 'Yes' or 'No'.

† = Virtual consultations and videoconferencing were combined in the current user survey.

## 3.4 The Providers Prospective

In order to successfully develop the community alarm system investigation is required of both users and providers. Having gained an appreciation of the needs of users, and understood the arguments behind their thinking, the common ground acceptable to users and providers can be sought. The providers perspective was analysed from the wardens and control centre operators viewpoint and sought to investigate:

- Their requirements for any future system.
- Their understanding of the user.

In order to measure the providers understanding of community alarm users, the wardens and control centre operators who provide a service to the users surveyed in the current users questionnaire were questioned. The warden's were questioned on an individual basis after the survey of the users whereas the control centre operators completed a questionnaire by themselves and without additional information. The involvement of participants in both of the questionnaires was voluntary with consent provided by Birmingham City Council.

### 3.4.1 The warden's requirements

All 6 wardens participated in the questionnaire presented in Appendix A3.6.

*Is the present system meeting requirements*

Three of the wardens thought the current alarm system met their requirements 'most of the time', whilst the remaining three commented that the present system was ineffective as their equipment was in need of repair. Generally the wardens were content with the system specification, but due to the age of equipment and its unreliable nature they were keen for a replacement system.

As indicated in Fig. 3.1, the wardens can currently only receive alarm calls when physically connected to the alarm system and this was seen as a disadvantage, especially when doing their morning visits to each home on the scheme. Two of the wardens working in the same tower block also expressed a desire to be able to converse with one another through the intercom, something that currently is not possible. These two wardens also commented that it would be useful if they could carry personal details of everyone living on the scheme on a computer. Therefore in an emergency they could inform the ambulance crew of medical information and contact relatives without leaving the 'patient' alone.

*Pullcords and pendants*

In terms of the effectiveness of raising an alarm, half of the wardens thought the pullcords were effective, while half thought they were ineffective. The reason suggested for the ineffectiveness of pullcords was that so many users deactivated them and that you needed to be near one to raise the alarm. Particular reference was given to the placement of the pullcords, especially in the bathroom where the pullcord was positioned near to the toilet but at the tap end of the bath where it was difficult to reach when bathing. All of the wardens believed the pendants would be effective, however they recognised that users would need to wear them.

*Alarm activation*

Based on a 5 day week with 40 users the wardens suggested that during office hours the alarm would be activated 11.2 times. However, there was a large dispersion in the results, 2 of the wardens suggested the alarm would be activated 3 times a week, while another suggested 25. During non-office hours an average figure of 18 was suggested, again with a large dispersion between 2 and 35. Seemingly the wardens believed there would be more alarm calls during non-office hours when they were not available. The current users suggested they would activate the alarm 1.5 times per week while the wardens suggested an average figure of 29.

The variation may originate from a reluctance by users to truthfully admit to how many times they have used the alarm through embarrassment or forgetfulness, while the wardens may exaggerate the number for issues of job security. Over recent years the warden service at this scheme had been reduced by 25%

and the uncertainty of a new system being introduced with the technical possibility of reducing morning visits, may have intimidated the wardens. The wardens may also have included the number of times they provide assistance without the alarm being activated, while the users only included alarm activation.

The current user questionnaire revealed that during the last year there were 6 occasions where assistance was required but the alarm could not be activated. Three of the wardens commented that in their experience there had never been an occasion where the alarm could not be activated when required, while one warden remarked in his 11 years as a warden this had occurred 3 times. The remaining 2 wardens commented that this could happen as much as 14 times a week on the scheme as they would not always know when assistance was needed. Evidently there is again a large range in the results and the experience of different wardens.

*Future alarm possibilities*

The wardens were receptive to enhancements if they felt the users would benefit. All of the wardens believed that the automatic detection of falls and lifestyle monitoring would be advantageous to users and would also assist them in their role. The role telemedicine could play was not greeted with such enthusiasm with just 2 wardens believing this could help users. One warden felt some users could gain from it, while the three remaining wardens suggested that it could actually be harmful. They felt that providing telemedicine options to a select few would be divisive and that some would find it stressful, using it continually to ensure their well being. There was also concern that the device could be relied upon and that medical attention would not be sought because the telemedicine equipment did not support the feeling that they were unwell. Clearly there is some uncertainty as to the value of telemedicine and its appropriateness in sheltered housing and this trend was observed with the current user questionnaire where the split was just over half (52%) in favour.

Being able to speak and see users through the alarm system was seen as advantageous by 5 of the 6 wardens with the remaining warden suggesting there would be little benefit. Of the current users only 44% were interested in this possibility, suggesting the wardens would benefit more than the users. This may be because they may be able to decide whether or not to visit a user based on the additional information provided by the videoconference. British Telecom have suggested that less than 10% of the effectiveness of any encounter comes from the words used, the body language is more important[270].

A door entry system with a video camera enabling users to see who is at the front door to the block was welcomed by 5 of the wardens with 1 warden undecided. However, all would like the door entry system, with or without a picture, to be linked to the control centre, therefore enabling the emergency services and anyone else access to the block when the warden is off duty. Due to operational issues, at present, the Birmingham City Council system does not provide this function although others such as Orbit[271] or Chichester[272] have done so since 1997/98.

### 3.4.2 The control centres requirements

From a possible number of 18 control centre staff, 10 participated in the voluntary questionnaire reproduced in Appendix A3.7.

*Pullcords and pendants*

There was a large range of responses regarding the effectiveness of pullcords as indicated in Table 3.24.

Table 3.24: *The control centres perspective of the effectiveness of pullcords*

| | Effective | Effective most of the time | Not really effective | Not effective |
|---|---|---|---|---|
| Frequency | 2 | 4 | 3 | 1 |

Some 40% of users did not consider pullcords as an effective way of raising the alarm, which was similar to the response obtained from the wardens where half thought they were ineffective. Pendants were seen as a more reliable way of raising a call for help with 9 of the 10 control centre staff commenting pendants were effective when worn. The remaining operator suggested they were effective most of the time.

*The warden service*

The operators were asked to rate the value of the warden service to them. Positive feedback was gained from all participants with 3 suggesting it was invaluable, 1 very good and 6 suggesting the service was good. The value of the warden service to the control centre staff was similar to that of the users where 92% valued the warden service in the 3 categories mentioned. The value of the warden service to users is provided in the additional information presented in Appendix A3.3.

*Communication*

The quality of the communication with users was investigated, with 8 of the 10 participants directly involved with answering calls. Five judged the communication as good and 3 satisfactory. Occasionally difficulties were experienced when the caller was not in the same room as the community alarm. Manufacturers claim alarm units can detect sound through closed doors but in such circumstances it is often faint. Amplifying the sound at the control centre also amplifies background noise such as the television, and the common 'hiss' of the telephone line.

*Future alarm possibilities*

In a similar fashion to users and the wardens automatic detection of falls and lifestyle monitoring were seen as the most beneficial enhancements with 9 of the 10 control centre staff welcoming these developments. The remaining participant was undecided for lifestyle monitoring; while a different participant suggested only certain users should have automatic fall detection.

A greater degree of variation was observed for the introduction of telemedicine. Only 2 (20%) were positively in favour compared to 33% of the wardens and 52% of the current users. Six thought certain users should have this capability, 1 believed that no one should have a telemedicine device and 1 was undecided.

The use of videoconferencing technology indicated that there was uncertainty as to the benefits of being able to see and hear callers. Three were in favour, 2 thought it would be useful for certain users, 2 rejected this, 2 were undecided and 1 did not answer. Such a position was observed with both the wardens and current users. Evidently both users and providers do not envisage being able to see each other in an emergency as an important consideration.

Being able to see who was at the main front door to each tower block was seen as important to 92% of current users and all of the wardens suggested that the control centre should be able to see whoever is at the front door and allow entry to the block during non-office hours. The findings from the control centre staff reveal that 4 were in agreement with the wardens with 6 indicating this would be advantageous when limited to the emergency services only. It would appear there is concern about an increase in workload and answering door entry calls whilst 'real' emergencies are left unanswered on a queue. Call line identification (CLI) could be used to prioritise calls but would undoubtedly result in an increased workload. However, the service provided should be the consideration and every effort made to meet users wishes.

### 3.4.3 Understanding the users

As previously indicated there has been little investigation of the wishes of users in respect to the development of their community alarms. What developments there have been have originated from manufacturers and service providers. Therefore, if the providers cannot accurately estimate the responses of the people to whom they provide a service, manufacturers may develop unnecessary equipment and systems. In order that the wardens and control centre staff did not feel threatened by a comparison of their understanding of the users, the questions referred to what the majority of users indicated, rather than specifically as to what percentage of users responded to particular options. The findings are provided in Table 3.25.

Table 3.25: *Comparison of the providers understanding of current users*

| Topic | **Percentage of Providers who successfully indicated how the majority of the current users responded** | | |
|---|---|---|---|
| | *Current users response* η=176 | Wardens η=6 | Control centre staff η=10 |
| Satisfied with the present community alarm system | *89%* | 100% | 90% |
| Would use the alarm rather than the telephone when contacting: | | | |
| Repairs | *74%* | 100% | 67% |
| GP | *9%* | 83% | 33% |
| Ambulance | *59%* | 100% | 67% |
| Police | *52%* | 17% | 67% |
| Fire | *44%* | 0% | 67% |
| Preferred user system configuration: pendant and pullcords | *60%* | 67% | 80% |
| The level of positive acceptance of: | | | |
| Generated speech | *78%* | 33% | n/a |
| Automatic fall detection | *75%* | 100% | 70% |
| Lifestyle monitoring | *65%* | 100% | 80% |
| Telemedicine | *52%* | 66% | 30% |
| Videoconferencing | *44%* | 33% | 0% |
| No objection to historical data being stored on: | | | |
| Falls | *92%* | 100% | 40% |
| Lifestyle monitoring | *98%* | 100% | 50% |
| Telemedicine | *97%* | 100% | 20% |
| Interested in attending an exercise class on the scheme | *39%* | 33% | 0% |

Overall the analysis reveals that the wardens and control centre staff had a fair understanding of the people they provide a service too. Both the wardens and control centre staff demonstrated they were aware of the satisfaction users had with the present community alarm system however, their grasp of other measures was less accurate. The understanding of the use of the community alarm indicated that the majority of wardens believed users would contact the fire brigade and police directly when in fact the alarm would be used. While the majority of the control centre staff believed the alarm was used to contact the GP, when in reality the telephone was the primary source.

A particularly interesting result was the acceptance of generated speech. The majority of users welcomed this, as there was a direct benefit (reduction in false alarms). However, the majority of wardens believed users would reject this option as they would be against '*....a computer speaking to them....*'. The acceptance of telemedicine and videoconferencing were also misunderstood, however these options would be difficult to predict with the users indicating a near 50% acceptance rate. What is surprising is that, to some degree, all of the control centre staff indicated the majority of users would accept videoconferencing when this view not upheld by the users. The control centre staff also misunderstood the extent to which users were prepared for information about them to be stored.

With the physical contact and friendship of the warden it is not surprising that overall they had a better understanding of the users. Nevertheless, the analysis suggests that despite an overall apprehension they could not predict all of the outcomes and consequently indicates the importance of conducting questionnaires with users.

## 3.5 Conclusions

It could be said that the questionnaire with current users generally represents the views of older people as a whole. An 89% response rate is likely to include those both receptive and against technology, while responses to the control questions indicated anticipated results. However, due to insufficient resources one researcher performed all of the interviews and although an unbiased approach was sought it is possible that the researchers prejudices may have influenced the results.

The exposure of everyday technology to current community alarm users revealed that 58% had a microwave, video machine or both. Many users expressed they had few difficulties using the technology but the operation of the community alarm indicated that users were unsure when to use it. When wishing to contact the emergency services they would often use the alarm as opposed to the telephone. Indeed, when wishing to contact the ambulance service 59% indicated they would use the alarm. The alarm had been used by only 54% of users in the previous year and education of what the community alarm system achieves and its purposes could be useful.

The introduction of commercially available community alarm enhancements was generally welcomed. Pendants were requested by 76% and the choice of pendant centred on how it could be best disguised or hidden. Many users indicated they would not wear the pendant unless they felt ill, as they perceived it as intrusive. It is known that pendants are often not worn with 64% not wearing their pendants when interviewed in this survey and figures of 27%[125] or 40%[126] have been suggested in other surveys. It may therefore be advantageous that future technologies do not rely on the user having to wear a device.

The acceptance of technology not commercially available when the questionnaire was performed also indicated a high acceptance rate. Indeed, 57% were interested in 3 of the 4 enhancements discussed namely, automatic fall detection, lifestyle monitoring, telemedicine and videoconferencing. In addition being able to see who was at the main door to the tower block on the users own television was welcomed by 92% and generated speech by 78%. Other technologies would also be beneficial with 65% indicating they were concerned with others leaving gas appliances on by mistake. Several interviewees also mentioned flood detection.

An important finding was that users choose to live with risk. Over 40% of users had at least one pullcord deactivated with 21% indicating they were all deactivated. The consequences of being unable to activate the alarm were often known yet the choice was made to live with a level of risk with which they were content. The setting of parameters for lifestyle monitoring also indicates that users would rather wait for the technology to discover they needed assistance than encounter possible false alarms. This suggests that a foolproof telecare system, monitoring every situation may not be required and may result in a loss of dignity that may be detrimental to users. A modular system is therefore required that can change the level of monitoring required. For example, Table 3.26 indicates a possible three levelled system based on the findings of the user survey.

Table 3.26: *Possible modular community alarm system – based on current user questionnaire*

| Level | Description |
|---|---|
| One | Current community alarm system with generated speech for false alarms and a security system |
| Two | In addition to the above system automatic fall detection and lifestyle monitoring |
| Three | In addition to system two, telemedicine and video conferencing |

A modular system is also suggested by the ways in which users found means of coping. Automatic drug dispensers have been suggested[249, 250] but users had their own methods for remembering when to take their medication. The use of automatic lights was also not seen as particularly beneficial as lamps or torches were placed next to beds. Financially contributing towards the cost of equipment and support services is important to many older people to maintain their core sense of independence[145]. Therefore, providing functions that the user feels are not required, even if provided without charge, may be detrimental.

Nevertheless, there were clearly people who could benefit from technology enhancements, yet they declined them. Automatic fall detection was declined by 21% of users who had fallen in the last year, 65% of users welcomed lifestyle monitoring but only 55% of users who go outside of the scheme less than once a week welcomed it. This theme was observed several times, and perhaps because of a limited understanding these people rejected enhancements that could benefit them. If 2$^{nd}$ generation telecare systems are introduced such people must be targeted and informed of what the technology can do and the benefits they could derive from its use. However, if after discussion they still decline their views must be respected.

There appears to be no published research on the thoughts of future potential community alarm users and the research conducted to address this issue revealed that they would welcome enhanced technology. Similar findings to the current users were observed for automatic fall detection, telemedicine and videoconferencing. The only significant deviation was for lifestyle monitoring where fewer potential users indicated they would definitely want it (65% compared to 41%). However, non of the remaining 59% were against this monitoring. The acceptance of cameras throughout the home was also high with all participants indicating they would have at least one camera in their home. It has been suggested that the use of cameras is intrusive[269], yet the results from potential users indicates they would accept them. Intrusion may not be as significant as suggested for both current and potential users.

Another significant result was the amount people were prepared to pay for an enhanced community alarm if they needed one. Participants indicated an average of £925 as a one off equipment charge and £13.35 for weekly monitoring. The results from both user questionnaires indicate that people are receptive to technology enhancements if a benefit can be derived from it use. They are also willing to pay substantial amounts to ensure their well being.

Thornton and Mountain[273] have commented that there is little evidence of the views of service providers on technology with many unaware of the potential of community alarms. The findings from wardens and control centre staff would not necessarily agree with this statement, as both groups were receptive if they felt the community alarm user would benefit. Both groups welcomed the automatic detection of falls and lifestyle monitoring, while for telemedicine and videoconferencing these were not seen as beneficial. Indeed, the wardens suggested that telemedicine may be harmful if users relied on the equipment and did not seek medical attention because of it. Overall the service providers had a fair understanding of the people they provide a service too, with wardens finding it easier to judge the majority of the users responses.

It may be said that the views of users and providers are under researched. The findings from these questionnaires have attempted to understand and discover what users and providers desire. A clear message has resulted with automatic fall detection and lifestyle monitoring being key areas for future developments. Having identified some of the key areas, the technology requirements for these and other enhancements can now be investigated. Such an approach ensures that the systems envisaged are needs led and not technology driven.

# 4 Meeting The User Requirements

***Chapter structure:*** *In order to develop the present community alarm system and move to advanced or 2nd generation telecare systems an understanding of the technological possibilities is required. This chapter therefore considers what technology is currently available and what may be available in the future. Based on this review and the findings of Chapter 3, a target system for implementation within 15 years is defined.*

In order to provide the monitoring functions suggested in the previous chapter, community alarm technology or 2nd generation telecare systems need to be developed. However, a key finding from the user questionnaire was that users were prepared to live with a degree of 'risk' and did not want technology to do everything for them or provide a completely safe environment. Smart homes could do too much as many functions are controlled by the home system. Closing curtains either automatically or via some form of control panel may be beneficial for mobility impaired people but in other circumstances this may be harmful. To some it may be another function they can no longer perform and may increase any feelings of depression. To others, although difficult, the exercise obtained from such tasks may be enabling them to stay in the community rather than entering residential care. Finding the correct balance so that assistive technologies actually assist and do not bring forward a move 'up the care ladder' is not currently understood, as many of the technologies required are not available. However, when developing the systems and technologies required in the future, appreciation must be given to need and a plug-and-play or modular system is essential to ensure that technologies can be added when they are needed.

From the preceding chapter it would appear that a 2nd generation system needs to detect situations that require investigation and automatically call for assistance if necessary. Ideally, the technology should not impose upon the user and therefore a system is required that does not rely on the user having to wear a device. In addition, reliable and easy to use home based medical monitoring is required to provide medical professionals with data that can be used in prevention. In the development of home based medical monitoring equipment Warren and Craft[274] identified three key areas where implementation is hampered by insufficient technology:

1. Messaging standards that are secure and allow patient identifiable medical information to be communicated both inside and outside of the home. (i.e. internally within a home network and externally to a medical professional.)
2. Information architectures that allow various suppliers equipment to communicate together.
3. Low cost plug-and-play medical devices that can be incorporated to match an individuals care needs.

In essence they are suggesting that standards are not in place to allow lifestyle and medical monitoring data to be effectively communicated, while the actual devices and sensors used to obtain the data are not readily available. In order to identify the areas where technology developments are necessary the ultimate purpose of the technology and the current state of the technology must be identified.

## 4.1 The Target Telecare Aim

For the purposes of this investigation the target aim is a system that could be available in 10 to 15 years time. The stated aim of such a system would be:

> *To reduce morbidity through the detection and prevention of the onset of ill health and to automatically detect when and where emergency situations have occurred raising an alarm if necessary.*

In order to meet such an aim several areas can be identified:

1. The detection of emergency incidents both inside and outside of the home: Falls, intruders, physical abuse.
2. Continuous gathering of lifestyle monitoring data: Looking for deviations in the normal pattern of behaviour that could indicate areas of concern, i.e. the onset of dementia. This could be linked to some form of automatic Activities of Daily Living (ADL) assessment, providing information over a long time scale and alerting occupational therapists when reassessment may be beneficial.
3. Continuous measurement of medical data: For example ECG, breathing characteristics and any parameter that may be beneficial in detecting and preventing illness. Virtual consultations to be performed when necessary.
4. Predictive and preventive systems: For example, fall indices to suggest that a person may be at a high risk of falling and therefore suggest hip protectors should be worn.
5. Provide information to user: Medical conditions and treatments, bus timetables, benefit entitlements, etc.
6. Motivational aspects: Virtual neighbourhoods and interaction with other individuals, educational groups and entertainment systems.
7. Obtain provider information: When professionals interact with users details of the interaction should be stored for future analysis and checking. Thus, when carers are present the tasks they perform should be recorded along with the time they arrived and departed.

This implies that in the home environment an intelligent system is available which is capable of[275]:

1. Receiving information from a number of sources, such as medical and environmental sensors.
2. Analysing this information.
3. Communicating both internally, for instance within a 'smart' home environment, and externally to provide access to the health-care and emergency services.

Current community alarm technology falls a long way short of this target aim, but the technology may exist in other fields. It is therefore necessary to identify the technologies currently existent and those being researched that may be available in the future.

## 4.2 Technology Trends[12]

As indicated, telecare is an evolving area of research and development, with only a relatively small amount of research having previously been performed. However, research into other 'tele' disciplines has been more substantial. One such example is telepressence or telesurgery where remote human expertise is transferred via the communications network to a remote location[276]. In the 1950's this was termed 'teleoperation' and allowed hazardous materials to be handled safely at a distance while being monitored by television[277]. More recently, it has allowed a surgeon to perform operations by controlling a robot many miles away. Such systems have performed open-heart surgery with greater precision than the human hand[278]. The difficulty with such operations is that the surgeon cannot currently 'feel' what the robot is touching, however by 2015 it has been suggested that synthetic skin with all the tactile qualities of human skin will be available to address this deficiency[279].

The technology currently used in telecare and telemedicine projects was identified in Chapter 2. In order to meet the aim set out above the technology requirements can be identified under three headings as presented in Table 4.1[154].

Table 4.1: *Technology requirements for an advanced health and community care system*

| Technology area | Comments |
|---|---|
| Personal | At the personal level the role of the deployed technology is that of providing all the necessary information about the user and of communicating this onwards within the system.<br>Applications at this level include the monitoring of a persons vital signs, for instance during the recovery period following discharge from hospital, the detection of falls and similar events, the monitoring of therapeutic systems such as drug dispensers and the control of embedded systems such as pacemakers and drug pumps. |
| Lifestyle | Lifestyle technologies are concerned with the ability of an individual to function effectively within their local environment including the home, their place of work and public areas such as stores. Lifestyle technologies therefore include:<br>▪ Monitoring systems capable of building up a profile of behaviour and of detecting and responding to anomalies in that profile.<br>▪ Environmental monitoring covering aspects such as temperature or air quality.<br>▪ Security systems<br>▪ Mobility and access support systems including wheelchairs and manipulators.<br>▪ Dwelling design.<br>▪ User interface design. This is a particularly important area given that a range of interfaces will be required covering a wide range of user capabilities.<br>▪ Communications within the local community, for instance through the use of the internet to place people in contact with resources such as libraries or even to talk to their neighbours and to expand the range of social contacts available.<br>▪ Local intelligence and decision making capabilities to control system operation.<br>▪ Mobile communications systems such that when a user is within an appropriate environment; home, work or public, they are still connected to the system. Ultimately it is envisaged that the system would become fully mobile, for instance by using satellite technology, enabling all monitoring at the personal level to continue wherever the user might be.<br>'Smart' or 'Friendly' home technologies to support the operation of a wide range of devices. This would allow individual items of equipment, cookers, heating systems, therapeutic and physiotherapy equipment to be given individual internet addresses for remote communication and control. |
| Support | At this level the technologies are concerned with ensuring that the user has access to the support they require as and when they require it. The technologies are therefore concerned with the management of information to ensure that it is presented to the necessary agencies in as up to date form as possible as it is required. This implies some form of intelligent data filter to maintain privacy while still ensuring that the information required to generate the appropriate response is supplied. |

12 This section is based on: Brownsell SJ. Williams G. Bradley DA. Bragg R. Catlin P. Carlier J. "Future systems for remote health care." Journal of Telemedicine and Telecare. 1999. 5:141-152.

In order to satisfy these technology requirements developments are required in three areas:

1. Physiological and medical.
2. Lifestyle and security.
3. Environmental.

### 4.2.1 Physiological and medical

Though a great deal can be achieved in respect of lifestyle monitoring with systems based on passive infra-red sensors, such sensors do not respond directly to changes in an individual's physical condition. For example, during the recovery period following a heart attack changes in cardiac function need to be detected and responded to directly rather than indirectly while patients with dementia, though capable of being supported by conventional sensors, would perhaps benefit from additional sensing to monitor their movements directly.

Chapter 3 suggested that individuals would be prepared to use a range of personal physiological and medical sensors to maintain their well being and enable earlier release from hospital. The early release of patients would also have the advantage of freeing hospital spaces, but is not possible at present because appropriate sensors are not available.

Table 4.2 identifies some of the sensors that may be considered for a personal monitoring system. However, many of these sensors are not currently available in a form which would make them suitable for a telecare application, and where they do exist they are generally too intrusive or cumbersome. Other sensors which are not included in this table and for which there would be significant application include those for the real-time analysis of blood chemistry, including levels of drugs, the provision of a warning of the possible onset of an epileptic seizure, breath and breathing analysis and motion analysis.

Table 4.2: *Examples of physiological and medical sensors*

| Sensor type | Function |
|---|---|
| ECG | Pulse rate and variability |
| Photoplethysmograph | Pulse rate and blood velocity, profile, blood oxygen content |
| Spirometer | Respiration rate, peak flow, inhale/exhale ratio |
| Sphygmomanometer | Blood pressure |
| Thermometer | Basal temperature |
| Galvanic skin response | Sweating |
| Colorimeter | Pallor, throat inflammation |
| Pupilometer | Light response |
| Accelerometer | Fall and tremor |
| Polarimeter | Blood glucose level |
| Stethoscope | Heart and breathing sounds |

In order to meet the target aim of continuous medical monitoring it is likely that a device must either be worn or implanted in a manner similar to a pacemaker. Fisk suggests that sensors that are worn or implanted under the skin are 'secondary' sensors while, sensors installed in or about the home are 'primary'[61]. An example of the possible trends in worn 'secondary' sensors is the *WristCare* system developed by IST International[217] and sold through Vivatec[280] in the UK. IST suggest that this monitors the general physical activity of the wearer together with pulse rate and temperature. The resulting signals are analysed and compared with the so-called normal condition and automatic alarms are triggered by acute or major deviations[217]. Other companies involved in medical research of this type were provided in Appendix A2.3.

Developments on implanted 'secondary' sensors are likely to be driven by biotechnology and nanotechnology. It has been suggested that biotechnology and implanted sensors will have a major impact on the delivery of health care[281], through the delivery of new drugs and products for diagnosis and monitoring. Nanotechnology refers to the creation of systems and devices with dimensions in the 1 to 100 nanometer range[282] and some have suggested it will radically transform computing, biotechnology, and medicine[283]. Chip based systems incorporating power source, transmitter and receiver have been produced which can be injected into the body to measure body temperature[284] and blood gas constituents[285]. Dixon suggests that the use of secondary sensors will become widespread by 2010[141]. However, Block[283] has said that '..... *biologists and nanotechnologists need to figure out how nature's machines work before trying to manipulate them or develop their own.*' So although this area of research may yield valuable results in the future, such technology is not currently available or likely to be so in the immediate future.

The requirements for 'secondary' sensors suggest the deployment not only of microsystems technologies but also of novel materials to produce a new generation of sensors. There would also be a need to ensure that any such sensors were robust, highly reliable and, ideally, of sufficiently low cost to be used on a 'throw away' basis.

A possible alternative to secondary sensors is the use of primary sensors to derive the same information. Such sensors could be used in a non-intrusive way as the measurement can be obtained without the user having to wear a device[286]. A technology that may meet the requirements is thermography which is defined as the registration of the distribution of human skin temperature[287]. Any object above absolute zero radiates electromagnetic energy, the intensity of which is such that a human can be detected with standard infrared technology[286]. Skin temperature dynamics measured by infrared thermography seems to reflect the overall condition of a human being, as well as the condition of several regulatory systems. The overall condition includes personality and emotional state, as contrasted to specific physiological function[288]. In addition thermoregulation is a clinical value and results from dynamic telethermometry[289]. Temperature changes are most easily observed in the thermoregulation regions: hands, feet and face and the result obtained depends mostly on peripheral blood flow dynamics. Factors that determine this blood flow can thus be investigated. Anbar has suggested that '.... *provided appropriate hardware and software are available, infra-red telethermometry offers an utterly harmless, inexpensive diagnostic technique*[289]'.

### 4.2.2 Lifestyle

Improving or enhancing the ability of older people to live independently in their own home by providing improved security and by ensuring that they have ready access to assistance when needed is seen by many older individuals as a major factor in enhancing their quality of life. As indicated in Table 4.1, lifestyle sensors monitor behavioural patterns and changes in those patterns; for instance to detect a fall or a lack of activity as well as supporting security systems and communications.

A lifestyle monitoring system would recognise that an individual had deviated from an established pattern of behaviour and would first check by asking the user if there was a problem, autonomously summoning assistance if no appropriate response was obtained. Lifestyle sensors therefore include functions such as room occupancy and use, together with behavioural monitoring covering the use of appliances and security systems. While much could be achieved using currently available sensors for this purpose, the need is to integrate the data more effectively to achieve the necessary responses with minimum interference for the users.

For example, the Anchor Trust and BT lifestyle monitoring trial[108] looked for deviations from daily routines but did not link this with living habits. If, for instance, a person regularly went to bed at 21:00 and on a particular occasion was still up at 22.30 then this would have triggered an unusual behaviour alert. However, several reasons may justify this behaviour and would indicate that no alert was needed. For instance, visitors could be present or the persons favourite television program, normally shown between 20:00 and 20:30, was moved to 22:00. In these examples, the system should have detected the presence of visitors or that the television program had moved, perhaps by using the video plus code unique to every program.

The example of a 'favourite' television program moving its time slot requires the intelligent home system to recognise:

- A certain program is normally watched.
- That the program has moved from its normal time to a new time slot that must be identified.
- That the person is moving after the time they would normally be in bed because they are watching their favourite program and not because they are unwell.

To move to this level of monitoring from the relatively simple level performed in the Anchor Trust/BT trial requires a complete system approach together with Artificial Intelligence where the computer perceives, reasons and acts[290]. For a telecare system this could mean that habits of a person are learnt and parameters altered according to received information. It has been suggested that a viable telecare system must ultimately make use of these techniques[291].

### 4.2.3 Environmental

Environmental sensing would cover factors such as the monitoring of room temperature and humidity and would integrate with lifestyle sensors to adjust room temperatures according to use. This integration would allow for the autonomous setting of the temperature of a shower, the time at which an electric blanket is to be turned on and off or ensuring that gas cookers are properly turned off after use.

Other aspects of environmental sensing may well overlap with physiological and medical sensing such as the provision of air quality indication for asthmatics or the detection of carbon monoxide. As is the case with the other sensors considered, all environmental sensors would need to be robust and reliable and it is again envisaged that there is scope for significant novelty in the achievement of low cost solutions to the problems raised.

As with lifestyle sensing, sensors currently exist such as, carbon monoxide detectors[292] or temperature sensors, which can be used as the basis for an environmental sensing system provided the problems of data management, analysis and security can be resolved. However, in other areas such as air quality there remains scope for improvement in sensor performance.

In addition to the sensor developments identified above there is also a requirement for technology developments in other areas as set out in the following sections.

### 4.2.4 System intelligence

The role of system intelligence is that of analysing and interpreting information from a wide variety of sources and providing the control and operational support required. Chapter 3 indicated that users were prepared for information derived from the sensors to be stored. However, privacy and security of data are likely to be major elements in the acceptance of telecare systems and it is therefore essential that information leaving the users home is agreed.

If data is analysed locally then the parameters for an external call to a third party such as the control centre or a carer can be agreed with the user. However, if processing takes place remotely for instance at a control centre, then all of the data must be forwarded. This second approach was used in the Anchor Trust/BT lifestyle monitoring project[108] where data was retrieved periodically, analysed and alarm calls generated where necessary. This involved significant additional telephone charges and required an additional telephone line to be provided to each user. It has been suggested a pound a day in telephone costs would not be an unreasonable charge as this may remove the need for hospital admission[293]. Performing the processing in the home would effectively reduce the use of the telephone to emergencies only.

Regardless of the financial position it is believed that there is also a duty of care to enable the emergency call to be generated as soon as possible. Batch or remote processing at the control centre introduces a delay as the home data may indicate an emergency situation but until this data is retrieved and processed no action can be taken. If the data were processed in real time in the home then such a delay would not be evident. In order to reduce telephone costs associated with the remote processing of data it has been suggested that data retrieval could be carried out less frequently during the night, perhaps only on three occasions[293]. This presumes that 'risk' is reduced at night, however, evidence from the current user survey in Chapter 3 indicated that 77% regularly got out of bed at least once each night and on average they got up 2.2 times a night. It has been commented that about 20% of falls occur during the night[259] and batch processing may therefore result in a person in need of help having to wait, perhaps for several hours, until the data is analysed and assistance provided. If the data were analysed locally the response would be much more immediate. The speed of response can also be critical as a confusion, dehydration and pressure sores can start to develop from falls in as little as 30 minutes[114].

Nevertheless, batch processing has advantages, particularly for the provider. Such a system requires less intelligence in the home and by implication less equipment, making maintenance easier and cheaper. However, there is still a need for the data gathering sensors and equipment in the home, which would be subject to failure and maintenance requirements. The greatest advantage of batch processing is the ease of modifying the processing protocols, particularly relevant when creating a workable system. Batch processing could provide analysis that is almost in real time if a dedicated telephone line was available solely for the telecare system. The choice of where to analyse the data then can be made on the basis of system cost.

Remote system intelligence is likely to be a combination of both human and machine intelligence and is concerned both with the management of the flow of data between the various external groups involved in care provision and the emergency services, and with the interpretation of that data. Thus, a district nurse could automatically receive an update of the user's behaviour pattern and the results of any physiological monitoring prior to a visit which may be either 'real' or 'virtual' using videoconferencing. Similarly, a GP might conduct a virtual consultation from their office and use the results to remotely adjust the drug dosage as delivered by a dispenser in the user's home. The achievement of a system of this form will require the breaking down of some of the barriers, both real and imagined, that currently exist between different agencies in order to support information sharing and the targeting of limited resources.

Expert systems could become commonplace to analyse data and aid experts, especially medical experts. in their diagnosis and call handling. Medical expert systems have been developed over recent years and CEMS – Clinical Evaluation and Monitoring System[294] installed in a psychiatric hospital in Hartford, Connecticut has been successful in assisting doctors. CEMS generates an alert by comparing the information in its knowledge base (about medications, diagnoses, treatment protocols, and hospital procedures) to clinical data in the hospital information system. Clinicians can alter what they have prescribed or inform the system that CEMS's advice has been noted but not implemented. In 72% of cases CEMS alerted clinicians as it felt treatment was incorrect, not all of the alerts were responded to by the clinicians but a change in clinical practice was made in 15% of cases. In 49% of cases non-standard treatment was continued but only after entry of the rationale for the decision and the medical directors review and approval of this practice. Both clinicians and patients welcomed the system.

Diagnostic expert systems are also available on the Internet. CAPSULE is a programme designed to advise doctors on prescribing and was developed by the Imperial Cancer Research Fund. It is expected to be used in British surgeries by 2002 at the latest. In trials, decisions by doctors using the system were estimated to be 70% more accurate. It has been suggested that in some countries by 2010 it will be necessary for doctors to consult their computer before beginning a wide range of treatments[141].

### 4.2.5 Communications

Effective communications are essential to achieving an effective system. Inside the home it is necessary for all suppliers to use compatible standards so that users can utilise a plug-an-play approach for the devices that best meet their requirements. However, as identified in Chapter 2 suppliers have tended to use their own communication standards, the 'Convergence' protocol which is a merger of BatiBus, EIB and EHS will hopefully address this problem[140].

In order to enable sensors to be installed in several rooms without the need for a hard-wired system wireless communication will be required. The 802.11 Local Area Network access standard is one such standard but it has been plagued with interoperability issues, poor data transfer rates and prohibitive costs[295]. The Infra Red Development Association (IrDA) standard is another wireless standard that has been used in notebooks for sometime and supports a transfer rate of 4Mbps with 16Mbps under development. However IrDA only works up to distances of 1 metre[295]. An alternative could be Bluetooth which was developed by a group led by Ericsson and Intel, offering transmission speeds of 721,000bps[296] over distances of 10 meters[295]. Bluetooth is a radio frequency specification for short-range data transfer and with a range of 10m is likely to be acceptable for the majority of users homes. However, because it operates on an unlicensed band there may be some noise problems[295]. TDK were the first to launch a Bluetooth device in July 2000 and suggested the combined network and Bluetooth PC card would connect other Bluetooth devices up to distances of 100 meters[297].

The majority of community alarm and potential future telecare users currently have a Plain Old Telephone System (POTS)[298] connection from their home to the 'outside world'. The transmission speed of the fastest modem link on a POTS line is up to 56 kbps[299] and this is not sufficient for the requirements of future telecare systems and videoconferencing in particular. In trials of transmission speeds it was found that the difference in quality between 56 and 64kbps was substantial while 384kbps was recommend for videoconferencing[300]. High transmission speeds are also desirable when sending still images which typically are 1Mbyte, a stress ECG which is 3Mbytes, or an EEG which is 15-40 Mbytes[135]. Table 4.3 indicates how long it would take to transmit a 15Mbyte file at varying transmission speeds[135].

Table 4.3: *Transmission times through various telecommunications networks*

| Transmission speed | Time |
|---|---|
| 28.8 kbps | 1 hour 30 minutes |
| 64 kbps | 40 minutes |
| 2 Mbps | 1.25 minutes |
| 10 Mbps | 15 seconds |

Image compression could be used and for X-ray images would reduce the amount to be transmitted by a factor of 30:1 without significant loss of information[301]. However, such techniques could only be used with store-and-forward and not real time videoconferencing. Therefore, in order to meet the videoconferencing aim of the target telecare system a minimum transmission speed of 64kbps is required with this ideally being set at 384kbps. Various technologies could be used to meet this requirement:

1. Integrated Services Digital Network (ISDN) operates at 64Kbps and is already available. ISDN6, linking 6 ISDN's together, would provide the sought after 384kbps.
2. TensorTech have developed software which can group 2 or more standard telephone lines together for transmission, therefore 2 POTS lines would provide up to 112kbps, while 4 would provide up to 224kbps[302]. The costs of the telephone lines would be prohibitive at present.
3. Asymmetric Digital Subscriber Line (ADSL) transforms the POTS into a digital connection[303]. By March 2001, 6 million households will have access to this with transfer rates between 512kbps and 2Mbps. Costs are estimated to between £40 and £150 per month[304].
4. Norweb and Nortel have suggested that the mains socket will be the communication media of the future. This technology affords greater flexibility, as in theory any 3-pin socket can be used as a telephone point with a transmission rate of up to 1000 kbps. Trials in the North West of England began in April 1998 and if security issues could be resolved costs were estimated as a one off payment of £100 and a fixed monthly charge for access to an Internet provider[299]. Further details of this technology have not been forthcoming and it has been suggested that the security issues cannot be resolved at present[305].

Evidently there are various technologies that may be used to provide the necessary transmission speeds both inside and outside of the home. The possibility of using the Internet as a means of communication must also be explored. By incorporating a microprocessor with its own IP address in an appliance such as a washing machine, refrigerator or a central heating controller it could become possible to interrogate the refrigerator as to its contents or set the central heating from any internet site. Supported by appropriate access codes to ensure security, this would allow the user to make adjustments to their home environment as required or to update their shopping list.

Internet 2 is being developed by a group of more than 100 universities, mainly from the USA, and is likely to be 100 times faster than the current net. To increase the speed a new set of nodes, called Gigapops (points of presence) is being developed and these offer sufficient routing and switching capacity for such multimedia applications as streaming video. Estimates suggest Internet 2 will be available sometime in 2000-2002[306].

### 4.2.6 User Interface

One of the keys to an effective telecare system is a successful user interface. While it is clear from Chapter 3 that older people are not technophobes, they quite rightly dislike the thought that the technology is in control of them rather than the other way round. The user interface is perhaps the primary way of ensuring that the user retains the control that they seek. As the primary users of telecare systems are likely to be older or vulnerable people there is a need to cater for a large number of different user skills, manipulative abilities, dexterity, levels of vision and so forth. This suggests that there is not one single user interface, but rather a range interfaces that can be used to meet particular users requirements.

Speech and vision are the most natural forms of communication between humans and these are therefore obvious targets for an interface. At present the majority of smart home or device controllers are controlled through a button and screen controller such as the SRS 100 (Merlin)[307] or Environmental Control Unit (ECU)[308]. These allow the user to call for help, turn electrical appliances on and off, make or receive telephone calls, and control entertainment devices such as TV's, VCR's and stereo equipment. Nevertheless, over recent decades speech technology has evolved so that it is now common place on many PC systems and could be the most appropriate interface for many. The majority of the early work was performed on speech synthesis[309], or generated speech. These systems are so successful that research is now taking place on the variability of output speech, for example the mood of speech[309]. If speech is to be a viable medium for data input then accurate Automatic Speech Recognition (ASR) is essential. Despite several decades of research, accuracy much above 90% is only attained when the task is constrained in some way, for example only receiving numbers. For large-vocabulary speech recognition of different speakers accuracy is no greater than 87%[310]. In order for the system to be effective and accepted by users, it is likely that a figure close to 100% would be required. If ASR was sufficiently accurate it could be used to give verbal instruction along the lines of:

> *"I am going to see Mrs Jones at number 18. Please lock up the house. I expect to be back at about 10 o'clock".*

This set of commands could then trigger the following sequence of events:

1. The system would check that it had all the relevant data for Mrs Jones such as address and telephone number. If there were a conflict the system would ask for clarification as appropriate.
2. The house would be locked and secured.
3. The system would check that all appliances were in a safe state, for instance that the cooker hob was turned off.
4. The temperature levels would be adjusted for energy saving.
5. If required to do so the system would, after an appropriate time, contact Mrs Jones to confirm arrival.
6. Prior to the anticipated time of return the heating would be turned up.
7. If the occupant had not returned after a predetermined delay from the established time then Mrs Jones would be contacted automatically. The system could then be given a new arrival time or an indication that the person was on their way or had left some time ago.
8. If the delay in arriving home then fell outside defined limits, emergency action would be taken including a call for assistance, perhaps in the first instance to a warden in the case of sheltered housing or a nominated neighbour.

An alternative interface may be direct control of devices by thought alone. Controlling a switch by the mind is already possible and needs no special training as the EEG electroencephalogram signals of the brain are detected. However, noise caused by the brain's intense activity and by the presence of the scalp makes control of numerous devices difficult. It has been suggested that by 2010 such brain pattern recognition software will be pre-installed on computers[311].

Vision and display systems must be simple and adjustable to persons with different levels of eyesight. Information provided should be as clear as possible and should be structured to guide the user through the required sequence of actions. Other forms of interface include Braille systems, push buttons, physical and optical pointers, joysticks and so forth. Whatever form of interface is chosen it must be suited to the needs of the particular individual for which it is intended.

### 4.2.7 Security and safety

Safety must be a primary requirement of all systems and the definition of appropriate 'fail safe' conditions and system degradation paths will therefore be a feature of any implementation. Increased information raises questions of security in two aspects[312]:

1. End-to-end communication – ensuring accurate communication between computer 1 and computer 2
2. Access to communication – ensuring the user of computer 1 is authorised to use it.

Ensuring that the control centre or GP has access to the data obtained from the user without others being able to access this could be achieved through cryptography. One of the most common methods is the public-key encryption that was introduced by Diffie and Hellman in 1976. Each person has a private and a public key and messages are encrypted using the recipients public key. The message can only be decrypted using the recipients private key[313]. Security is becoming so effective that government agencies are concerned they may not be able to monitor illegal activity[314].

Verification that the correct person is using the computer or terminal in the users home could be performed by various methods. Smart cards and passwords could be suitable methods but biometrics offers new solutions that are user friendly and secure. They work by inspecting the distinct biological features of a person such as the fingerprints, hand geometry, voice recognition and iris recognition. Iris recognition has some advantages over the other biometric solutions in terms of speed, hardware simplicity and accuracy[315].

The possibility of using the human iris for identification purposes was first introduced by ophthalmologists who noted that the pattern of the iris remained unchanged in clinical photographs taken over several decades[316]. As the iris is internal to the eye, it is difficult to change surgically, even if criminals considered this as an option. Security, with regards to error rates is extremely low with such systems, typically in the order of $10^{-40}$[315]. Hence, the system is difficult to cheat and when validating an eye the probability of recognising the wrong person is almost negligible. An alternative method could be to recognise the whole face and such systems are becoming available[317].

The advantage that both of these methods have is that much of the technology will already be in the home. A camera will be present for virtual consultations and the virtual neighbourhood, some sort of computer will also be there to gather and/or analyse data and the computing power required for such security systems is not substantial. For example, a face recognition system by eTrue can compare 500 faces per second on a Pentium 200MHz PC[318]. There may therefore be little additional cost in using such methods as a security device. Access to the telecare system for GP's and carers could therefore be secured, while users may also use one of these methods in order to gain access to their personal settings, perhaps when turning some monitoring function on or off. Evidence for the affect of users with cataracts on an iris recognition system was not forthcoming and trials may therefore be required to ensure that such users are not refused access.

## 4.3 Communication Barriers

Despite the considerable amounts of technology identified above, some of which are already available, it is surprising that community alarms have not significantly changed for many years[115, 206]. However, the wishes of users have not been known, while many of the possible advances are likely to save money for the health service that rarely funds the community alarm system. Another reason may be that technological developments are likely to impact upon service delivery and until health, social services and housing organisations can work together, technological advances could be ineffective. It has been commented that telemedicine will impact upon every aspect of health care delivery[276] and collaborative working between these organisations to date, has been poor. Barriers exist between the hospital and community occupational therapists[145], while the gulf between health and social services has been refereed to as the 'Berlin Wall'[319].

The example of hospital discharge demonstrates these barriers with the House of Commons Health Committee suggesting that in 1995, 20% of all patients over the age of 75 were waiting to be discharged and a third of these were waiting for a placement in a residential or nursing home[320]. Barriers and communication difficulties are also evident within the three main organisations of health, social services and housing. For example, when a patient is discharged from hospital medical summaries should be sent to the GP but in one survey a third of GP's thought they arrived too late to be of any use[321]. Discharge summaries should arrive within 1-2 days of discharge[322] with 90% of GP's preferring they arrived within a day[323]. In a study of discharge communications, 67% of charge nurses or sisters sent written information to the GP on the day of discharge[321]. However, in a further study 11% of GP's had received no communication from the hospital 2 months after discharge[324]. The clarity of what is sent is also bought into question with a third of GP's complaining that the writing on the discharge summary was 'illegible'[325].

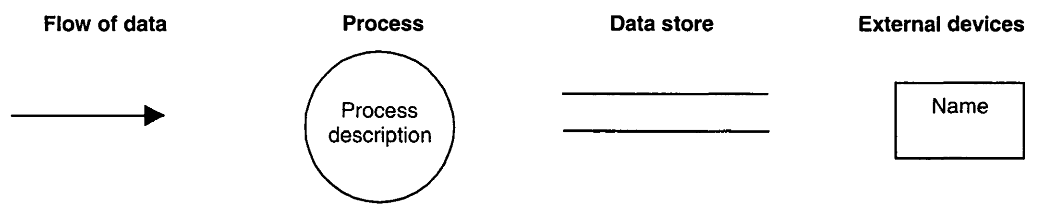
## 4.4 System modelling

The review of technology reveals that achieving the stated aims for telecare could be a possibility in the future. However, in order for such a system to be successful it suggests that information within the health care delivery system must be more readily available and that the barriers between organisations are removed or reduced. In order to move forward from today's first generation system incremental steps will be required that build upon previous system generations until the target system is reached. These incremental steps are required for the technology to be developed in a suitable format while it also allowing cultural, political and management infrastructures to be developed to gather and use the additional information such telecare systems provide. The community alarm technology in the present system has been described in Chapter 2. However, the required information system has yet to be formally defined and this is needed to form a base from which the impact of future telecare systems can be developed.

One of the main tools for systems analysis and design is the data flow diagram (DFD). DFD's show how input data is transformed to output results through a sequence of transformations. They are an integral part of a number of design methods and are an intuitive way of describing a system[326]. The diagram shows the various processing elements in the system, the data flows between the processing elements and the major stores of information within the system. In order to obtain more information each processing element can be decomposed onto further diagrams to indicate greater levels of detail[327]. In addition to the DFD, a context diagram indicates the system as a single process and shows how it interacts with the real world[328]. As such it can be regarded as a high level DFD[329].

There are various notations and layouts for DFD's such as MASCOT[330], or Gane and Sarson[331]. However, Yourdon[332] is the most widely used notation in use today[328] and therefore is used throughout this work. The notation is defined in Table 4.4.

Table 4.4: *The Yourdon notation used on DFD's*




## 4.5 DFD For The Current System

### 4.5.1 Context diagram

In order for a community alarm user to gain help they must first initiate a call for assistance. This can be achieved through activating a pullcord or radio triggered pendant, or by contacting the control centre through the normal telephone system. This is depicted in Fig. 4.1 and it is noticeable that at the centre of the system is the community alarm control centre. This relates to Table 3.10 in Chapter 3 indicating when a situation required attention, with the exception of contacting the GP, the majority of users would contact the control centre as opposed to contacting services directly themselves. It is also due to the control centre facilitating the interaction of all parties involved once a call for assistance has been received. The control centre is therefore pivotal but it also is a bottle neck, as it does not provide assistance until a call is first received.

When the control centre has been called an operator can provide or facilitate the necessary assistance. Primarily this involves emergency contacts, such as the ambulance service, warden or other responder if the caller requires assistance. In other circumstances social services may be contacted if, for instance, the caller is requesting a reassessment of their care package. It is noticeable that there is little feedback within the system. When the control centre operator has requested an ambulance, or informed a responder that assistance is required, the only feedback is that of the operator informing the caller of the actions undertaken. After the attendance of the ambulance, warden or responder, no information is provided back into the system of the outcome. For example, if the caller requested an ambulance the control centre is not informed whether the user was taken or admitted to hospital or whether they have remained in their home.

Whenever a user makes personal contact with social services or emergency contacts this information is not relayed to the control centre. For example, if a care package begins or changes the control centre are unlikely to be informed, while admittance or discharge from hospital is unlikely to be registered by the control centre. Indeed in a 1997 survey of wardens attending the Charted Institute of Housing sheltered housing conference, less than 10% indicated they were regularly informed or consulted about hospital discharge arrangements[16]. Such information is particularly useful when the control centre contacts a GP or the ambulance service, which may seek to discover the status of the callers health and their medical history. Decisions may be made based on this information and at present the information relayed to these parties may be unreliable.

The only automated information flow is an equipment or warden call into the control centre. The equipment call is used to ensure that equipment is working correctly. For example, in sheltered housing schemes the main equipment will often automatically call the control centre every 25 hours if it has not been used within this period[240]. The warden call again originates from sheltered housing schemes and is an automated call to the control centre informing the system when the warden is on/off duty. These calls occur without any involvement from the control centre operator and occur without their knowledge.

Equipment checks for the community alarm equipment installed in users homes is normally the responsibility of the user with some providers suggesting that the user should activate their alarm and speak to the control centre every month[240]. Such a call therefore requires the involvement of the operator but many users ignore or forget to do this, as indicated by the current user survey in Chapter 3 only 54% of users had activated their alarm in the previous year.

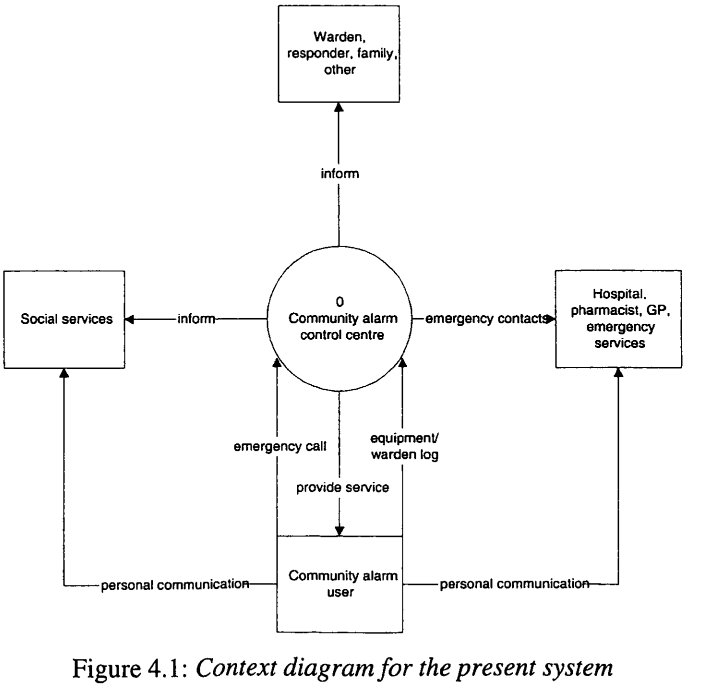



Figure 4.1: *Context diagram for the present system*

## 4.5.2 Data flow diagrams

The overall structure of the community alarm system is represented in Fig. 4.2. The system commences with a community alarm being installed in a users home and upon activation the destination of the call varies upon the location of the user. If the users are dispersed within the community then the call will go directly to the control centre. However, if the users are located in sheltered housing, the call will first go to the server on the scheme. If the warden is on duty then they will receive the call, in some circumstances the warden may be unable to answer and if the call is not answered within a given time period, often 5 minutes, then the control centre will be called as a default. If the warden responds, no information of the wardens activities are recorded within the system, nor that the alarm was activated. It is also possible that users will not use the community alarm, but rather use the telephone to contact the control centre; such calls are rare and normally relate to requests for information.

When an alarm call is observed at the control centre the equipment there will decide upon the nature of the call. If the call is an automatic call, such as the equipment or warden log then this will be dealt with by the system. If the call is from a community alarm the operator will be informed that their assistance is required. After discussion with the caller they can then facilitate action with other services, such as the emergency services, or end the call if it was a test call or activated by mistake. The system is completed by recording where the call originated from and what actions the operator took.

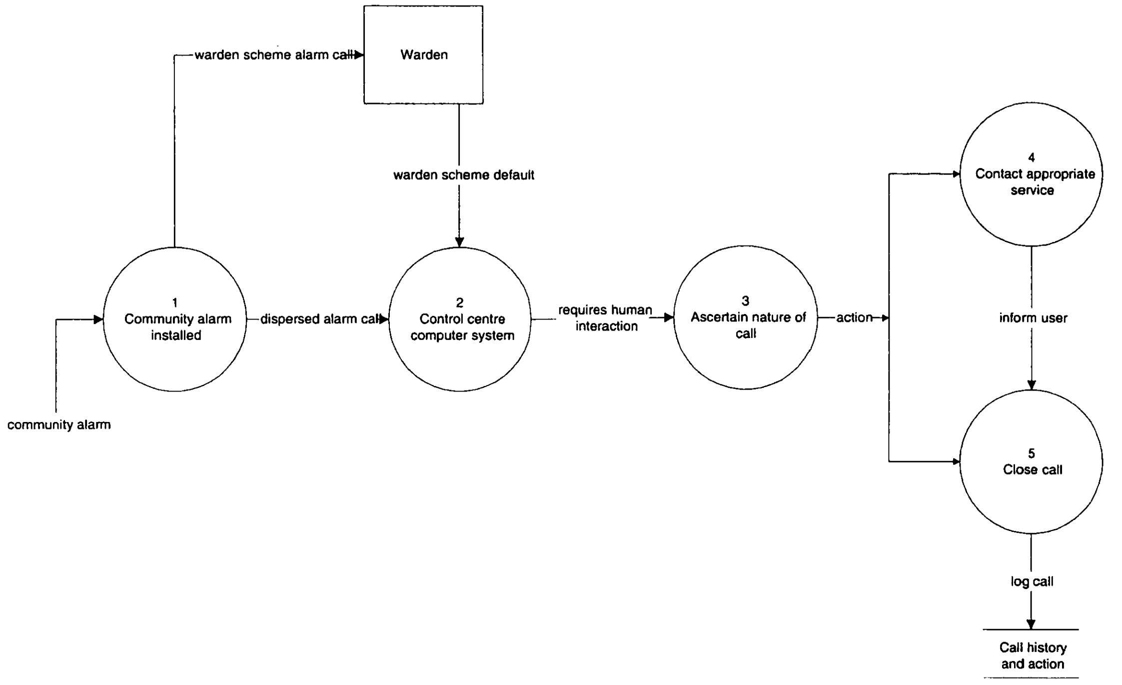



Figure 4.2: *The overall community alarm structure (level 0)*

*Process 1: 'Community alarm installed'*

Fig: 4.3 provides further detail of the first process 'community alarm installed'. Acquirement of a community alarm will often begin with the potential user becoming aware of the benefits of the alarm system and seeking further information. Awareness may originate from:

- Relatives, friends, wardens or neighbours who currently use the alarm or are aware of its benefits.

- Self awareness, through advertisements in the press or by contacting social services for an assessment.
- Hospitals, who may advice as part of the discharge process.

Having gained an awareness of the community alarm system procurement can be made through several routes:

1. As part of a social services assessment it may be recommended that a community alarm would be beneficial. As such, procurement through this route is eligible to means testing which may result in obtaining one without charge.
2. Charities may assist people and provide the alarm. Charges for such an option vary from free to the full price depending on the charity and procedures in place.
3. The potential user, family or friend may procure the alarm through a private purchase.

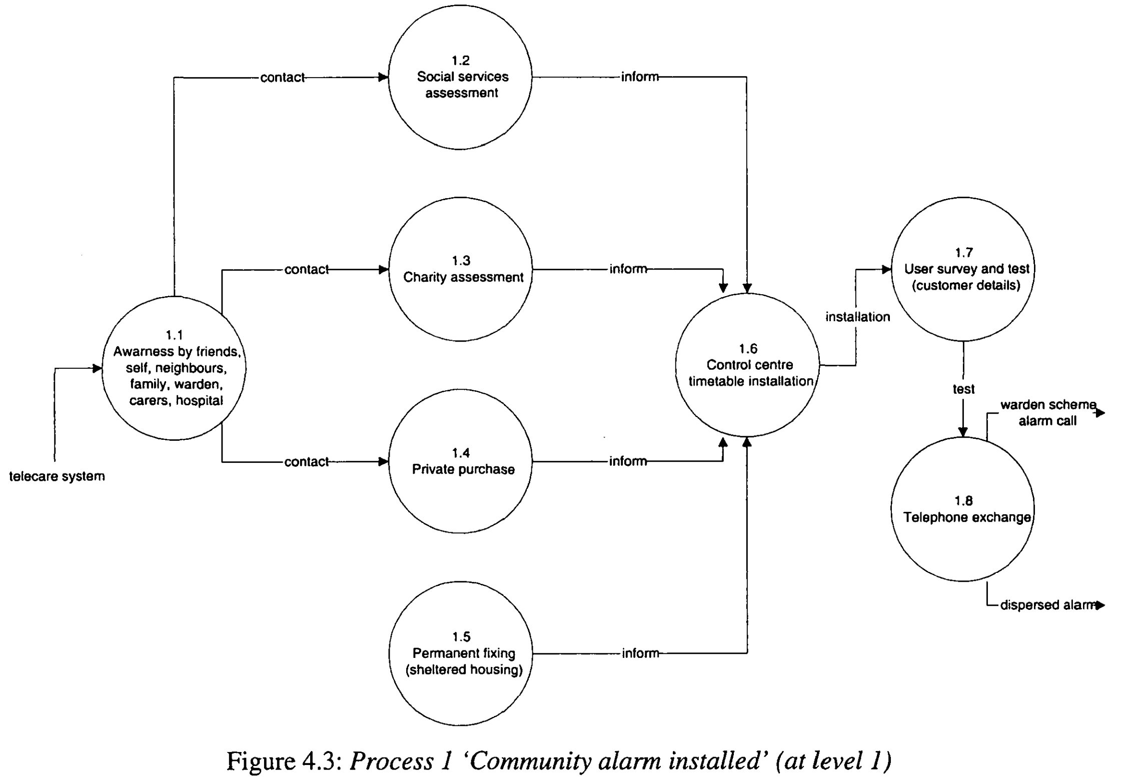



Figure 4.3: *Process 1 'Community alarm installed' (at level 1)*

In addition an alarm may be acquired because it is a permanent fixture in a sheltered housing scheme. It is normal practice for the installation to be organised and performed by staff at the community alarm control centre and as part of the installation process a user survey would be performed to obtain background information[240]. Such information would typically include:

- Long term medication – particular medication used over an extended period.
- Medical history – such as heart complaint, osteoporosis etc.
- Next of kin and responders – people to contact if the user requires assistance.
- Key holder – indicates who has a key to the property that may therefore alleviate the need to force entry in an emergency.

Having performed the user survey and connected the community alarm it is then tested. This test involves activating the pendant or a pullcord if appropriate and speaking to the control centre to familiarise the user with the operation. As previously discussed, upon activation of the alarm the telephone system is utilised to connect the warden server or dispersed community alarm to the control centre. Having successfully completed the installation the alarm is now fully operational and can be activated when assistance is required.

*Process 2: 'Control centre computer system'*

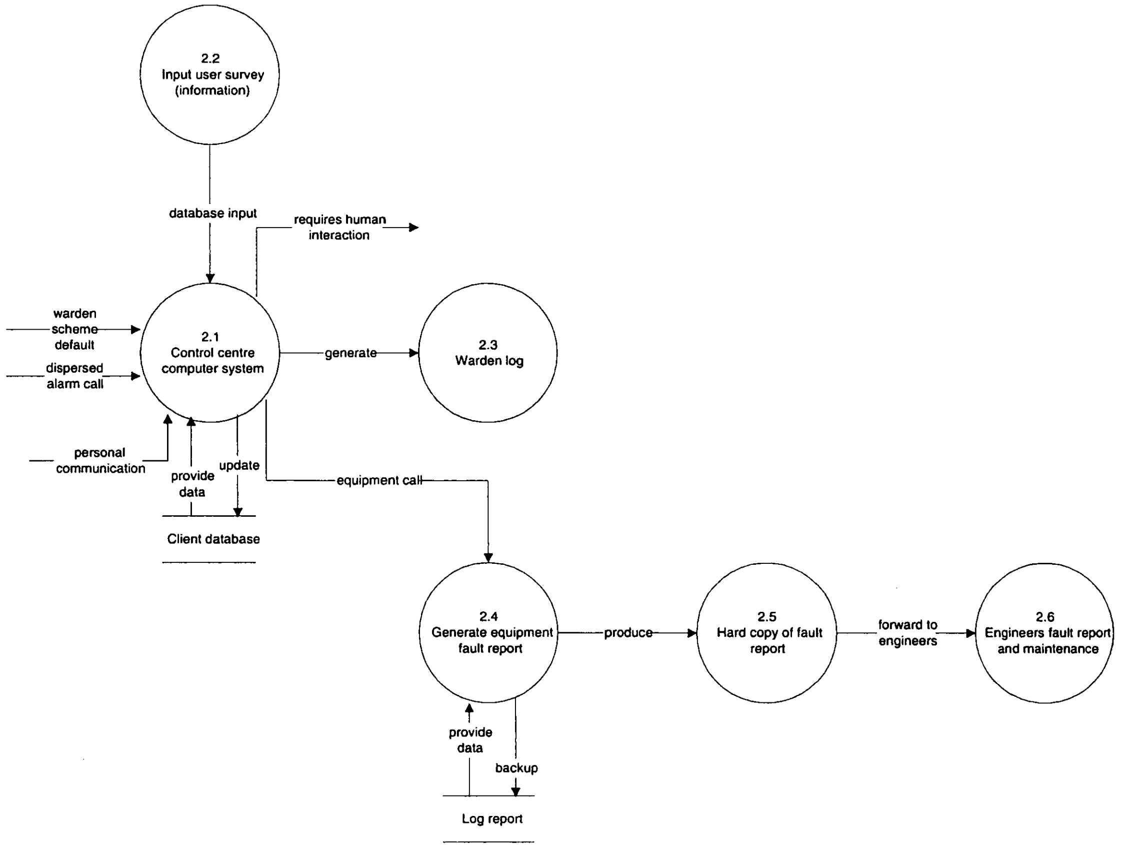



Figure 4.4: *Process 2 'Control centre computer system' (at level 1)*

The control centre computer system receives inputs from a range of sources. Process 2.2 on Fig. 4.4 indicates that the information obtained during the user survey in process 1.7 is entered into the computer system, while the other inputs are from users, either by the telephone or community alarm. As previously indicated, information from hospital discharge, GP's and social services is not provided to the control centre computer system.

Process 2.1 generates various outputs; the user survey information entered into the computer system is recorded for future use, while process 2.1 will determine whether an operator is required and if necessary retrieve the callers details from the client database as an input for process 3. Alternatively, if it is an automatic call, the system can respond without the operator being involved. Automatic warden calls, indicating a warden logging on and off duty, are stored for monitoring and accountability purposes, such as monitoring the hours a warden works. While equipment calls are performed in process 2.4. Sheltered housing schemes will contact the control centre, typically every 25 hours, with these calls being recorded in the log report database. Periodically process 2.4 will analyse this database and generate a fault report for any sheltered housing scheme servers which have failed to contact the control centre within the 25 hour period.

*Process 3: 'Ascertain nature of call'*

When an operator is required the caller will be identified by Caller Line Identification (CLI) and a screen similar to Fig. 4.5 will result.

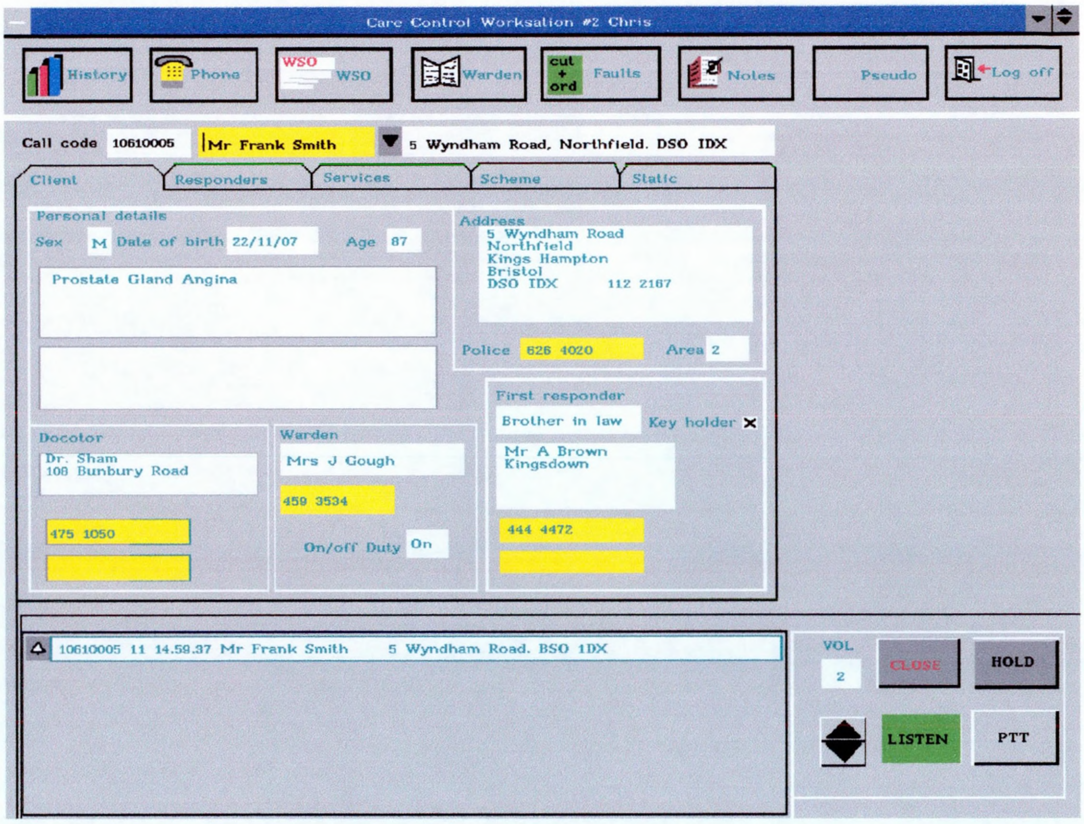



Figure 4.5: *A typical operator screen*[13]

The bottom of the screen maintains a list of calls which are waiting to be answered. When an operator answers a call, the callers details are retrieved from the database and displayed. The only information obtained from the community alarm is the fact it has been activated, calls are therefore answered on a First In First Out (FIFO) basis. For fire alarms the call icon is different and allows priority in this instance. The information retrieved from the community alarm database and displayed for the operator relates to:

- Client – personal details, name, address, doctor, warden etc.
- Responders – a list of the people and their contact details who have acknowledged they will respond in an emergency.
- Services – any community care package the caller may be receiving.

[13] Typical control centre screen of a Pentyre/TeleLarm CareControl system.

- Scheme – contains details of the community alarm equipment of the caller and sheltered housing scheme equipment if relevant.
- Static – is used by managers to provide information on calls, client age analysis etc.

The section at the bottom right hand corner of Fig. 4.5 allows the operator to control the communication link to the caller. The close button ends a call, while the hold button will place the caller on hold. The two buttons 'LISTEN' and 'PTT' (Press To Talk) are used with half duplex communication, when only one party can talk at any one time. Full-duplex communication, similar to a telephone conversation, is becoming more widespread with new technology such as the Horizon unit supplied by TeleLarm[333] (Fig. 3.7).

The buttons at the top of the screen relate to:

- History – indicates previous calls made by the current caller, any health history and comments entered by operators after previous calls have ended.
- Phone – is a directory of telephone numbers that the operator may call to assist them.
- WSO – Work Service Order, contains the job numbers for repairs.
- Warden – details of the warden and scheme, planed leave, contact details, scheme television licences etc.
- Faults – any technical faults are logged and a record kept.
- Notes – similar to a notebook for general notes.
- Pseudo – search facility for obtaining details of particular users or clients.
- Log off – used when an operator logs off at the end of their shift.

When the above screen is displayed, operators can ascertain the nature of the call. Because no information is provided with the alarm, this information must be derived by verbal communication with the caller. In some circumstances, such as people with speech disorders like dysarthria, communication can be problematic. It therefore requires a skilled operator to quickly converse with the caller in order to accurately determine the requirements of the caller. Having gained the necessary information in consultation with the caller, the appropriate action can be agreed.

*Process 4: 'Contact appropriate service'*

Having obtained the necessary information and decided that external assistance is required, the particular organisation must be identified. As indicated in process 3 anyone on the telephone system can be contacted but the main organisations are identified in Fig. 4.6.

If communication with social services is required then they can be contacted and information provided to the caller. Such calls primarily relate to a request for an assessment of the callers care package, in this case social services are informed and the responsibility for action transfers to them. Alternatively, contact with social services will be sought to investigate the current care package. This is more common at holiday periods and after a caller's care package has changed. These calls will often concern the arrival of a carer or nurse and the caller is seeking conformation of when they can expect their visit. Social services can confirm the current care arrangements and these can be relayed to the caller.

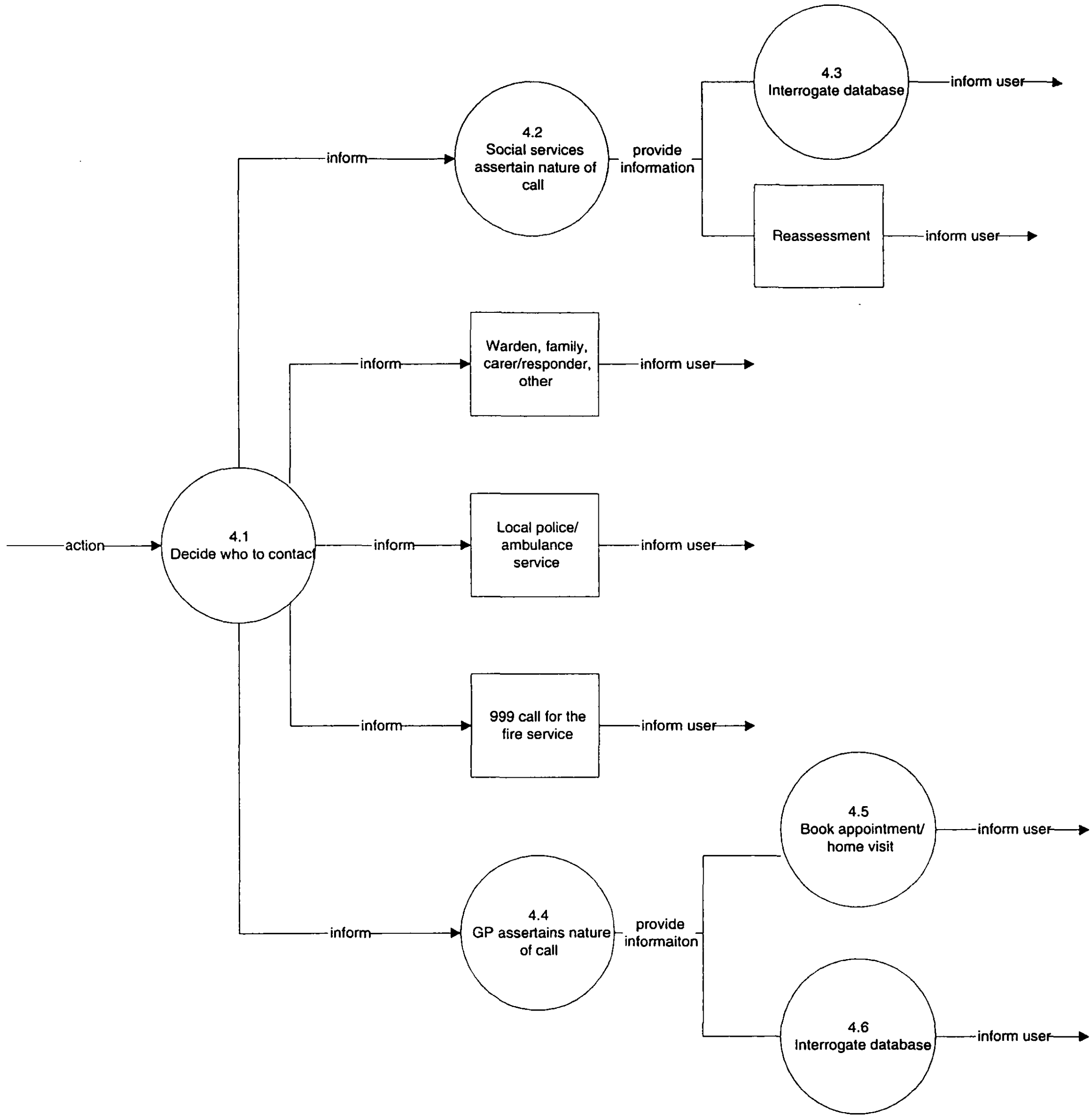



Figure 4.6: *Process 4 'Contact appropriate service' (at level 1)*

The most common cause of action undertaken by operators is to contact the warden, family members, carers or responders because the caller needs assistance. Requests may be that the caller has misplaced their glasses or is feeling a little unwell and it would be inappropriate to send formal support services. The operator will contact the warden, responder etc. and inform the caller that assistance will soon arrive.

When it is decided that the emergency services are needed the operator will contact the police or ambulance station nearest to the caller and identified by the computer system. If the fire brigade is required then a normal 999 call is used. Again after providing the information to the emergency service, the outcome is reported to the caller.

If medical attention is required then, based on the information provided by the caller, the operator will decide whether a GP or the ambulance service should be contacted. It would be unusual if the operator had any formal medical training and therefore it would seem likely that the ambulance service is contacted when in fact a doctor would be more suitable. If the GP is contacted they will then decide on the appropriate cause of action. In some circumstance the GP will be contacted for information, perhaps because the caller had forgotten their appointment time, or were unsure when to take medication. After agreement has been reached with the GP the information is relayed to the caller.

*Process 5: 'Close call'*

When the operator has dealt with a call the caller will be informed and the call closed. The call centre equipment provided by TeleLarm or Jontek, for example, will not allow a call to be closed until the operator enters what action was taken. This information is then used for accountability purposes and management analysis. With such systems the operator must choose from a list of options such as; pulled in error, GP contacted, responder contacted etc. and additional space is provided for any comments that may be necessary for example, '.... *responder contacted, will call after work* ....'. When the necessary information has been entered it is time and date stamped and stored for future reference.

## 4.6 Government Plans

Since the present government came into office in May 1997 it has sought to '.... *modernise the NHS* ....' and published an information strategy for the period 1998-2005[334]. The purpose of this is to ensure that information is used to help patients receive the best possible care. The strategy seeks to enable NHS professionals to have the information they need both to provide that care and to improve health. It also aims to ensure that patients and carers have access to information to aid them in decisions about their own treatment and care. To achieve these objectives, the strategy commits to[334]:

- Electronic health records (EHR) often refereed to as Electronic Patient Records (EPR).
- On-line clinician access to patient records and information about clinical practice.
- Seamless care for patients through GPs, hospitals and community services sharing information across the NHS information highway.
- Public access to information and care through on-line information services.
- Provide NHS health planners and managers with the information they need.

The government recognises that the information strategy will also impact upon service delivery, for example[334]:

- Opportunities in the field of telemedicine will be seized to remove distance from healthcare. GPs will be able to send readings or images to hospital specialists many miles away and in the same way receive results and advice more quickly. Nurse practitioners in the community will be able to consult with doctors and specialists.
- Telecare technology will be used to provide reliable but unobtrusive supervision of vulnerable people who want to sustain an independent life in their own home. Video links with electronic monitoring will allow community health and social care workers to 'visit' patients at home more easily.

- On-line services will be provided for GPs and their patients to make hospital appointments or obtain diagnostic results. The sight of NHS professionals searching through folders or hand-writing referrals will be consigned to history as soon as possible.

In order to achieve the government's information strategy, one of the keys may be considered the Electronic Patient Record (EPR). This will provide a single resource for patient information on all interactions with health professionals and save time for nurses and doctors who currently spend 25% of their time gathering or using information[335]. The information barriers between health and social services are acknowledged by government who have commented that the '.... *concern and frustration expressed about the need for mutual access to patient/client records by health and social care professionals needs to be determined and agreed urgently* ....[334]'. It is planned that the on-line patient records will be accessible by family doctors, hospitals, NHS Direct, out of hours and ambulance services, mental health trusts and social services[336].

In 1995 a messaging network, called NHSnet, was created[337] and it is envisaged that this network would provide secure, reliable and fast access for the information strategy although it currently does not have the capacity for high speed video connections[338]. The government white paper '*The New NHS*' has suggested that all general practices will be connected to NHSnet, by the year 2002[228]. By March 2001, 95% of practices will have access with the remaining being connected by March 2002[339].

The specific modernisation programme and time scales are reproduced in Appendix A4.1.

In addition, in July 2000 the Government published the NHS National Plan[340] with one of the main considerations being the bringing together of the health service and social services. Incentive payments to local authorities, health authorities and primary care centres are to be made to reward joint working. However, where local health and social care agencies have failed to work together effectively the government will 'take powers to establish integrated arrangements'. Some of the key indicators of performance have been acknowledged as:

- Reductions in bed blocking by older people.
- Reductions in preventable emergency admissions.
- Readmission of older people.
- Readmission of people with mental health problems.

Clearly the government are seeking to bring down the barriers between agencies and stimulate collaboration. However, where voluntary collaboration is not evident it appears that it will be enforced.

## 4.7 Conclusions

The questionnaires in Chapter 3 and recent technology developments by community alarm providers have indicated that the present community alarm system must develop. However, it is important that the developments actually assist rather than hinder the user and, as such, smart home technologies may be inappropriate for many. A plug-and-play or modular system is required that allows equipment from various suppliers to work effectively together to meet any particular individual's needs. However, communication standards are not in place at present to enable this while the sensors required to gather data are also not available or in a suitable format to be used effectively.

Nevertheless, a review of technology in other fields has indicated that much of the basic technology exists, even if it is not in a suitable format at present. Medical monitoring equipment such as ECG recording are available and although at present they require the user to wear the equipment, developments could result in effective home based monitoring. Nanotechnology and implanted sensors could meet the target telecare aim of continuous monitoring without the user having to wear a device externally. Speech recognition technologies continue to develop and are likely to provide a suitable user interface over the coming years.

The major hindrance to the development of future telecare systems may not be in respect to the technology but rather in the combined working of organisations that such systems prescribe. The barriers between health, social services and housing have been recognised but telecare systems will require these organisations to work together. The formal analysis of the present system clearly identified that the present system has little collaboration between providers and that information obtained by one party is not provided for the benefit of others. There is therefore the real possibility that decisions are made on inaccurate information. The governments IT strategy has commented that technology can be used to promote new and more efficient ways of working, delivering services across traditional organisational boundaries[334]. However, breaking down the barriers between organisations and professionals could be difficult.

In June 2000, the then health secretary Alan Milburn commented that '.... *modern health care depends on modern IT systems* ....[339]'. Based on a review of the technology and incorporating the government's IT strategy it is possible to define the new systems and suggest the steps required to meet the target aims of telecare. Chapter 5 therefore suggests these steps both in terms of the information flows and technologies required.

# 5 Defining Telecare Systems

***Chapter structure:*** *In order to achieve the goals of the target system, stepping stone systems are required that bridge the gap. This chapter therefore defines two systems in terms of the technology required and how it should interact, but also the impact that the systems may have on the information flows between various organisations. Finally the target system is fully described and analysed, providing a framework for development for the next 15 years.*

In Chapter 2, the 3 generations of telecare as defined by Doughty *et al*[166] were discussed and it was indicated that only 1st generation systems were currently available. It was suggested that the 2nd generation system would include some form of monitoring and system intelligence and efforts have been made in this direction with the work by Anchor/BT, IST and TiH. However, it is still not possible to purchase a 2nd generation telecare system indeed, little has been done to actually define the components that contribute to such systems. A review of the literature revealed that only one suggestion was evident, with this being relatively vague. It is reproduced in Fig. 5.1[341].

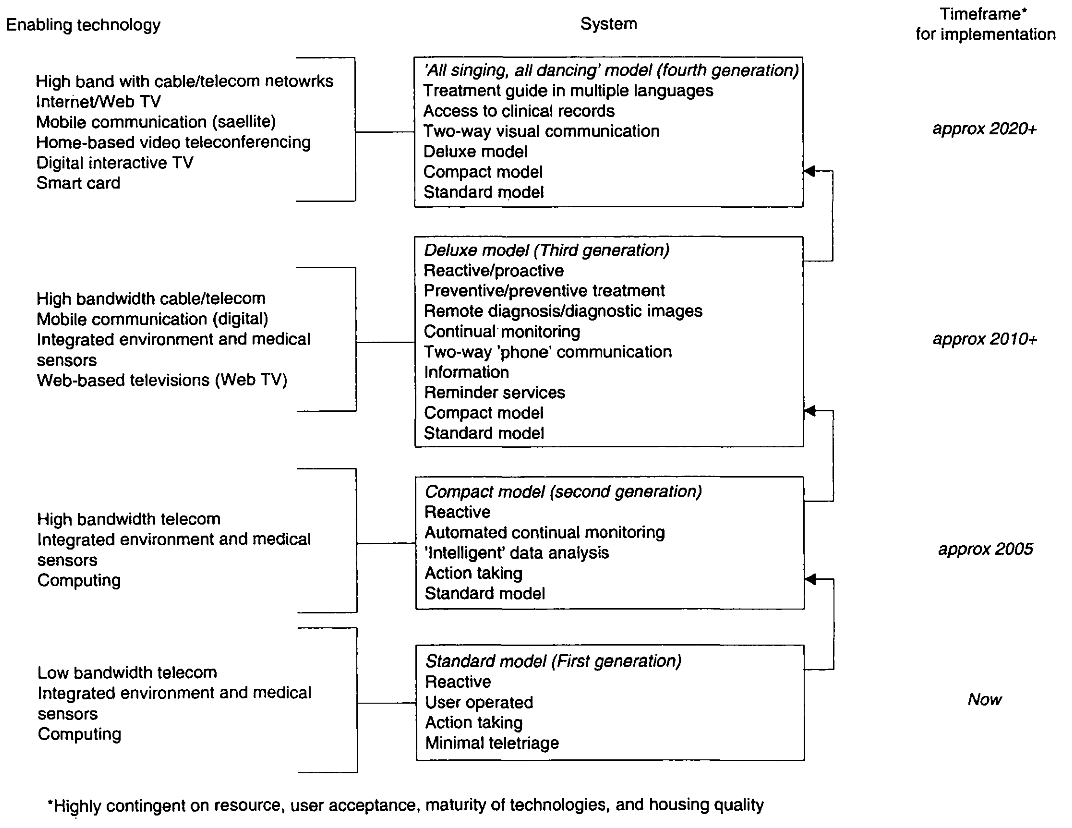



Figure 5.1 *Previous suggestions of advanced telecare systems*

In order to move from the current position to more sophisticated and beneficial systems, a clearer direction and system specification is required. The preceding chapters have laid the foundation for such a specification. Chapter 3 has indicated the requirements of users and providers while Chapters 2 and 4 suggest the technology developments required and indicated possible time scales. Chapter 4 also indicated that the information flows of future systems are as equally important as the technology used. From this base new generations of telecare can be defined, working towards the target telecare system which could be available in 10-15 years.

In order to correctly define the new telecare generations a formal procedure is required:

- **Requirements definition**: this is written in natural language and describes what the system is expected to provide[342].
- **Functional requirements**: these relate to system behaviour, they describe what the systems do, how they do it and how they respond to deviations from anticipated behaviour[343].

In addition to these a context diagram using the Yourdon notation, identified in Chapter 4, will again be used to define the information flows with external organisations.

## 5.1 2nd Generation System

### 5.1.1 Requirements definition for the 2nd generation telecare system

A 2nd generation system builds upon the present 1st generation or community alarm system. It is a system that provides greater support and monitoring and removes the constraint of the user having to initiate a call for assistance. Automatic call generation and monitoring is provided through a number of new technologies, such as drug dispensers, automatic fall detection, or lifestyle monitoring. Each of the technologies included in the 2nd generation system can be provided on an individual basis such that a user may have a fall detection unit without a drug dispenser or lifestyle monitoring. The system is therefore truly plug-and-play or modular. The intended users are the present community alarm users, while modules of the system may also benefit people in institutional care, such as residential or nursing homes.

User information is currently distributed across many service providers. In the 2nd generation system this information is grouped together into an EPR (Electronic Patient Record). The information from health, housing and social services is maintained in one place, however access to the information is on a need to know basis. Therefore, if a carer accesses the EPR, only information relevant to them will be available, whereas a doctor would have access to medical information from the hospital and general practise. Due to the additional monitoring in the users home, the information gathered by the lifestyle monitoring modules etc. is stored for future analysis and is also used to alert healthcare and other professionals of situations that need further investigation. Current users looked upon this option favourably as identified in Chapter 3.

Assistance with medication can be provided, including prompting users to take their medication if they forget. Early detection of general medical problems can be recognised through medical monitoring equipment and any identified problems automatically routed to a medical professional for examination.

The home also becomes a safer environment in terms of the appliances used and the detection of emergency situations, such as a fall, fire or the presence of intruders. The system automatically calls for assistance when pre-defined conditions arise and a clearer, improved communication link between the user and control centre operator should be maintained with full-duplex speech. Access to the Internet or virtual neighbourhoods should be available for people with health or mobility problems if it is thought that such access could be beneficial.

In summary, any advanced system needs to provide access to more information of greater accuracy and relevance and should make this information available in a controlled manner. The home environment needs to provide stimulation, motivation, medical support including some diagnostic capability, independence and security with a greater quality of care. The majority of users should view any equipment in the home as non-intrusive and it is suggested that a suitable time scale for the implementation of this system would be by 2003 to 2005, although particular modules of the system may be available prior to this. This time scale is based on the Governments IT strategy, the current status and the likely developments, in technology and the possible take-up of the system by users and providers.

## 5.1.2 Functional requirements for the 2nd generation telecare system

**Function**

- Support independent living.
- Support next-generation community healthcare systems.
- Support the deployment of enhanced sensors.
- Support the use of machine based intelligence in the provision of community healthcare services.
- Support inter-agency communication and data transfer.
- Integrate automatically generated alarms with the operation of control centres.
- Prioritise calls and provide enhanced decision support for control centre operators.
- Provide enhanced management information features.

| | | |
|---|---|---|
| **Major System Elements** | Fall detection. | Medical monitoring. |
| | Fire detection. | Incontinence monitoring. |
| | Lifestyle monitoring. | Virtual consultations/neighbourhood. |
| | Security. | Intelligent Home Alarm System (IHAS). |
| | Gas detection. | GP surgery. |
| | Water detection. | EPR. |
| | Temperature analysis. | Control centre. |
| | Drug dispenser. | Hospital health services. |

**Module** **Fall detection.**

Process

If a fall occurs anywhere in the home this should be detected. If another person is present then both they and the person who has fallen should be informed that the control centre will be contacted unless a cancellation is received. The cancellation time should be based on the mobility and distance to which the user must travel to cancel the call. If no cancellation is received the control centre should be contacted. Cancellation can also be achieved by activating the users pullcords or pendant, but the cancellation time should be based on the possible distance to travel from the incident to the control box due to the high percentage of users who do not wear their pendants.

If the person who has fallen lives in the home the incident should be recorded in the users EPR if consent has be given. If the call is received at the control centre the operator will then record what actions were taken.

The detection of a fall must only occur for an adult and not a young child who may be visiting their grandparents. Also a user lying on the floor, perhaps because of a back complaint, should not be recognised as a fall.

If a particular individual falls several times within a few days, regardless of the control centre being called, then their GP should be contacted and the reason for this investigated.

Inputs — User falling. User cancellation.

Outputs — Inform the user that a fall has been detected. Inform the control centre if no cancellation is received. Store event and response in the EPR.

Major error — Unable to test the components of the module and validate any potential problems. Unable to detect a fall in all/any part of the home. Unable to communicate with the IHAS.

Exception — The module must be given a period of time to resolve itself. If after this time the fault still exists the user should be informed through the IHAS. The user should only be informed if it is recognised that the user is not asleep in bed, that guests are not present and that at least one able user is in the home (i.e. if the user is severely disabled the system should only be informed when another adult is present). If the fault continues to exist a fault report should be generated, the control centre contacted and the users informed.

Current status — Fall detection units are available from TeleLarm[292], Vivatec[280] and Tunstall[223] in the form of a device that must be worn by the user. Results from field trials have not been published and it is unclear how successful such devices are. They also suffer from the constraint that the user must wear the device and, as identified with pendants, users are often reluctant to wear them.

The use of a video camera and Mpeg graba card would allow individual snap shots in time to be gathered and compared. If this was done, perhaps once a second, then the motion of a fall could be detected. How effective such a solution would be is unknown, while the ability of a single camera to work effectively in large rooms is questionable. It is also unknown how intrusive, and therefore acceptable, current users would view such a development.

Acoustic signature is a further possibility, where the sound of the fall is detected; however it appears that such a technique has yet to be formally trialed.

**Module** — **Fire detection.**

Process — If a fire is detected in the home, anyone present should be informed and time given to cancel a call to the control centre. If the call is cancelled then fire readings from this room should be ignored for a period of time sufficient for any smoke or excessive heat to clear. Readings from other rooms should continue to generate alarms. If the control centre is contacted then they should be informed of the fire and in which room the fire was first detected.

Inputs — Smoke or heat indicative of a fire. User cancellation.

Outputs — Inform users of the fire defaulting to the control centre.

Major error — Unable to test the components of the module and validate any potential problems. Unable to detect a fire in all/any part of the home. Unable to communicate with the IHAS.

Exception — The exception response is the same as that identified for the fall detection module.

Current status — Sensors are commercially available to detect both smoke and heat, although their reliability and the number of false alarms may need to be addressed.

The use of a video camera could enable the detection of smoke and has been used in power plants, however their application in general properties does not appear to have been researched.

**Module** — **Lifestyle monitoring.**

Process — Movements within each room should be recognised so it is known which room a user is in. Where two or more users live in the home the movements and recognition of each should be identified so that activities concerning each user can be recorded accurately.

When an identified user enters a room the time being spent in that room should be compared with agreed and defined times. For example, the bathroom may have a defined maximum time of 2 hours. If a user is in the bathroom in excess of the 2 hours then an alarm should be raised. The user should be informed that a potential problem has been recognised and be asked to clarify the situation. If the user does not respond and cancel the call, the control centre should be contacted. The defined maximum times for each room should be agreed for each user in the home. The module should monitor the living patterns of users and automatically tailor the maximum room times for the user.

The module should also detect and record when the user has gone to bed. This can be calculated from recognising that the user is in the bedroom and if no motion is detected for 15 minutes, it can be assumed that the user is in bed. It is recognised that the user may be reading in bed, but no provision for detecting this is provided in the 2$^{nd}$ generation system. Having identified when a user is in bed the amount of sleep during the night or afternoon can be identified and recorded. The number of times the user may get up during the night can also be identified and a record kept in the EPR. The sleeping patterns of users can be useful to doctors but consent must be obtained before such details are stored. In order to be efficient it may be appropriate to keep a rolling record where perhaps the last 6 weeks of data is kept.

The Lifestyle monitoring module can also be used to generate a 'bed' and 'morning time'. These are the expected times a user would go to bed at night and get up in the morning. Significant deviations can then be investigated, for example if the person is bed 2 hours after they would normally be moving in the morning then this should generate an alert as it may indicate the user is unwell. The module must be flexible to adjust these bed and morning times based on changes in the behaviour patterns of the user. It must also work on a daily basis for example a user may change their normal pattern on specific days. The module must also be easily overridden if the user anticipates that they will not follow their normal pattern on a specific day, for example if they plan to rest in the morning. In addition the module should provide the capability for a 'wake-up' call, where at a specified morning time an alarm can be raised to wake the person if requested.

If the fall detection module is not installed, or as a backup, the lifestyle monitoring module should also be used to detect falls. For example, if it is known that a user spends a maximum of 3 hours in the living room without movement being detected then if the user has fallen and motionless for this period of time the module will generate an alarm.

This module can also be used in conjunction with the majority of the other modules. For example, with fire detection if no one in the home then the control centre can be informed immediately, rather than raising and alarm and waiting for a cancellation response which would never occur. The operator can also inform the fire brigade that the property is empty. Alternatively, if movement is detected the operator can communicate with the occupant(s), informing them that the fire brigade has been contacted and to leave the building, closing doors and windows where possible.

| | |
|---|---|
| Inputs | Any movement in the home. User cancellation. Time of day (system clock) and 'bed/morning time'. |
| Outputs | Inform the user when they have been in one room for an excessive time defaulting to the control centre. Alter 'normal' or expected pattern of behaviour, i.e. the 'bed/morning time' or maximum time allowed without movement in a given room. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to detect the movement anywhere in the home. Unable to recognise which room movement has occurred in. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | The potential of lifestyle monitoring has been highlighted in the Anchor Trust/BT trial[108]. However, this trial did not provide the processing necessary to alter the maximum times in given rooms. It was also not possible to detect situations where two or more individuals lived together. In order to achieve this with the use of PIR's used in the Anchor Trust/BT trial it would be necessary for users to wear an electronic tag to differentiate from one another. A tag would also be required with moving pets, such as a cat or dog, to differentiate between the movements of the user and a pet. |

Acoustic signature may be a possibility but research would be needed to analyse how effective this would be.

| | |
|---|---|
| **Module** | **Security.** |
| Process | A panic button near to points of access should be available for occasions where intruders have forced their way in. Once activated the control centre should be informed and the police contacted if necessary. Once the operator has contacted the police, or if conformation is required from the home, the operator can communicate with the user. If the control centre operator recognises an intruder is present they should activate an alarm in the home informing the occupant that the police are responding. The operator should cancel this alarm once the intruder has left. Once the security alarm is activated no cancellation is provided to ensure that intruders do not cancel the call.<br><br>Access to a users EPR for carers, home helps, nurses and GP's to enable them to record the time they arrived and departed should be provided. They should also enter details of the activates they undertook. In order to gain access to the EPR, verification of the individual requesting access should be sought.<br><br>If both the lifestyle monitoring and security modules are present then if no one is in the home and movement is detected without access through the front or back door the control centre should be immediately contacted as this is likely to be a burglar. |
| Inputs | Intruder alarm activation. Carer, home help, nurse or GP request access to EPR. In combination with the lifestyle monitoring module, the home being empty but activity being recognised at points other than the front or back door. |
| Outputs | Access to EPR. Security alert to control centre. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to communicate with the lifestyle monitoring module (if installed). Unable to validate carer, home help, nurse or GP. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Intruder switches at entry doors are common on current burglar alarms. Recognition of carers, home helps, nurses and GP's could be achieved through a smart card or thumb print recognition. It is now possible to buy a mouse that will use the user's thumb print to recognise the user and therefore only allow specified users access to a computer, current costs are approximately £100[344]. A further option would include the possibility of iris recognition and if video cameras were already present due to the requirements of other modules, this may represent a cost-effective method. |

| | |
|---|---|
| **Module** | **Gas detection.** |
| Process | The level of gas in rooms should be monitored so that when above a critical level the user is alerted and informed. If the level of gas reaches a dangerous level then the gas supply should be terminated. This should be recorded in the EPR and if a pattern is recognised social services can assist.<br><br>When the gas supply is terminated the users should be informed through the IHAS. Re-connection should be performed when the user indicates they are present and information should be provided through the IHAS that gas appliances need to be turned off prior to the supply being re-connected. |
| Inputs | Gas. |
| Outputs | IHAS. Terminating and re-connecting the gas supply. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to detect the presence of gas. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Gas detection equipment is available for example, TiH[345] , the BESTA flats[188] and Bongtra[346]. |

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| **Module** | **Water detection.** |
| Process | Throughout the home if the bath, sink or shower starts to overflow and water is detected on the floor then this should be detected and the water flow terminated. The water flow should only be stopped for the tap left on as terminating the whole supply could cause damage to appliances such as a washing machine.<br>When supply has been stopped the user should be informed through the IHAS. Re-connection should occur after the user has indicated that flooding is no longer taking place. Monitoring for floods should continue immediately after the supply is reconnected. The occurrence of 'flooding' should be recorded in the users EPR. |
| Inputs | Water detected on the floor. |
| Outputs | IHAS and EPR. Termination of the water supply for specific taps/shower. |
| Major error | Unable to detect water or communicate with IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | A valve inside, or sensor attached, to the plumbing would be achievable or acoustic signature may be a possibility. The detection of water on the floor could be detected by a sensor on the floor, however having activated an alert it may be difficult to reconnect the water supply, as contacts on the floor may still be wet. Condensation on tiled floors in particular may also result in action when it is not necessary. |

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| **Module** | **Temperature analysis.** |
| Process | This module should detect the room temperature and generate an alert if there is a risk of hypothermia. In combination with the lifestyle monitoring module, if installed, an alert should only be raised when it is known that a user is in the home and not resting or asleep. If the lifestyle monitoring module is not available then the times when an alert should not be occur should be based on the 'bed' and 'morning time' supplied by the user.<br><br>The room temperature should be analysed at a stated time after a user enters a room, therefore providing sufficient time for the user to heat the room. Originally the room temperature alert should be set at 68°F (20°C)[347] however, the user must have the capability to change this level for each room in their home. If an alert is generated then this should be provided through the IHAS and recorded in the users EPR. |
| Inputs | Room temperature. Lifestyle monitoring module. EPR (to store the individual room temperatures). |
| Outputs | Alert user. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to measure room temperature. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | The use of thermistors is common place and they are cheap and effective. Research into the placement may be required to ensure that sun light does not affect the accuracy of readings. |

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| **Module** | **Drug dispenser.** |
| Process | Tablets and syrups should be automatically dispensed as defined by a GP; i.e. how many times a day and the specified quantity. Both tablets and syrups should be dispensed into individual boxes appropriate for everyday use. The dispensing of syrups should only be performed when the box is placed under the dispenser in order to ensure the syrup is not spilt.<br><br>The EPR records when medication should be taken and in what quantities. If the user has not taken medication a specified time after that defined in the EPR then a reminder should be given and this should continue at various times during the day or until medication is dispensed. If the lifestyle monitoring module is installed, then reminders should only occur when someone is in the home. Morning reminders should take place after it has been recognised that the user has got out of bed, unless the EPR suggests that the timing of medication is critical. The same procedures should occur for medication that is required before going to bed at night. |

The medication for a particular day should be cable of being discharged from the dispenser, therefore allowing the user to be absent from the home with their medication. Medication above one day should not be allowed to reduce the risks of an overdose. To dispense the medication two buttons should have to be pressed or some other recognition pattern, to protect children/pets from obtaining the medication.

The system should be able to operate with several drug dispensers for different users who may be in the home; each dispenser should be identifiable to each user. The drug dispenser should be able to be detached from the IHAS and other equipment so that it can be transportable to other destinations i.e. holiday. When the drug dispenser is detached from the home system i.e. cannot access the EPR, communicate with IHAS and hence user, the dispenser should alert the user both visually and audibly if medication has not been taken at times originally defined in the users EPR. Under these circumstances no provision for changing the drug regime is available. The module should record the discharge of medication and update the EPR when re-connected.

For some users it may be necessary for the GP to be informed if they are not taking their medication. This must be discussed between the GP and user or person acting on their behalf. Therefore, if medication is not taken several times within a short time period (defined by GP) the GP can be automatically informed.

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| Inputs | User taking medication. Time (system clock). EPR. Lifestyle monitoring module if installed. Medication. |
| Outputs | Alert to user. GP. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to dispense medication. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Manual medication dispensers are available for a week at a time. Basic tablet dispensers are also available from TeleLarm[292] and IST[217], although they do not provide the functionality discussed. |

**Module** **Medical monitoring.**

Process The GP will suggest when a user should use the stand-alone medical monitoring equipment (i.e. once a week, daily etc.). This information is stored in the users EPR but the user can use the equipment whenever they wish. If a user fails to use the equipment within the defined time scale they should be reminded through the IHAS. If a user should use the equipment once a week and they use it within the last seven days, seven days should be taken from the last time of use and not on a set weekly time (i.e. 10:00 every Monday).

If the lifestyle monitoring module is installed and a reminder is required then the user should be reminded when they get up in the morning and prior to going to bed at night if this level of monitoring is required. If the user is in bed then they should be reminded when it is recognised that they are doing their normal morning routine, i.e. bathroom, kitchen etc and these activities occur at a similar time to the 'morning time'. If the equipment is not used after the reminder then this should be recorded in the EPR. If the lifestyle monitoring module is not installed then times for reminders should be agreed with the user and based on the 'bed/morning' times.

If two or more users use the same medical monitoring module then the system will need to recognise the difference between users.

Every time the medical monitoring module is used the information gained from its use should be stored in the users EPR. The information is then compared with parameters defined by the GP. If outside of these parameters the user should be informed through the IHAS and the GP contacted irrespective of the time of day. A cancellation option should be available if the user decides they would prefer not to consult with the GP at this stage. If the measurements indicate that immediate medical attention may be required then during surgery hours the GP should be contacted, while at all other times the control centre should be contacted. Cancellation should again be provided ensuring that control is with the user, although they should be informed of the possible consequences of their actions in this instance.

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| Inputs | Use of module by user. EPR for comparison of parameters and when reminding the individual to use the module. |
| Outputs | IHAS for reminding the user to use the equipment. Informing the user of any action needed and contacting the GP/control centre if necessary. Storing results and any action in the users EPR. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to read/write to the EPR. Unable to communicate with the IHAS. Unable of measuring medical parameters. Unable to recognise user. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Equipment supplied by Instromedix[187] and American TeleCare[185] provide ECG and other readings. However, the integration of the system defined above is not currently available. Thermography could also be a possibility but is not currently available. In addition to using standalone medical equipment information for diabetes and other illnesses indicated by a change in urinary sugar levels could be gathered from an 'intelligent toilet'. Such a system is currently being developed in Japan[348]. |

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| **Module** | **Incontinence monitoring.** |
| Process | For users suffering from incontinence this module will detect when the wear needs their incontinence pad to be replaced. Pattern analysis should be performed so that any carer visits can be co-ordinated to fit in with an anticipated replacement of the pads. |
| Inputs | Wetting. |
| Outputs | Inform the IHAS and carer. |
| Major error | The exception response is the same as that identified for the fall detection module. |
| Exception | Unable to detect wetness. Unable to communicate with the IHAS. |
| Current status | The NAIS Care Home in Japan are trialing a sensor to detect incontinence and inform carers when the pad needs changing[348]. |

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| **Module** | **Virtual consultations/neighbourhood.** |
| Process | Due to the limited transmission speed of the current telephone system, videoconferencing cannot effectively take place. Chapter 4 identified several technologies that are becoming available and could be used, but cost is prohibitive on a large scale. It is therefore envisaged that there would be few users of this module in the 2$^{nd}$ generation system. Users are likely to suffer from medical conditions and receive virtual consultations with their GP in order to reduce the number of home visits. |

If the user contacts the surgery using videoconferencing but the GP does not have access to a camera then the system should continue to work with just speech. If visual communication can be secured then the user should be capable of viewing the GP and what their camera is transmitting. The GP should also be able to see both themselves and the user, but in addition also have access to the users EPR. Any medical records or data that are not stored on the EPR should also be available. When performing virtual consultations the GP should have the capability to move the users camera and therefore view the user in a way that best meets their requirements.

Prior to the virtual consultation the EPR stored at the users home should update the central EPR stored at the control centre. This therefore ensures that when performing a virtual consultation the GP has the most up-to-date information available.

When receiving virtual calls no image should be sent from the home until the user specifically activates the camera. Therefore, providing the user with control. If the user decides not to answer the virtual call, communication should be made through the telephone (or through the pendant or

IHAS if appropriate).

In a similar fashion the nurse may also replace some home visits by videoconferencing. Such consultations would typically include courtesy calls and informative sessions. Their system should work in the same fashion as the GP's, and use the same user interface.

When a user contacts others on the virtual neighbourhood a list of contacts or favourites should be available so the user does not have to enter the individual telephone numbers of people they regularly contact.

This module also includes access the Internet. The keyboard and mouse should be wireless to ensure users or visitors do not fall over loose cables. An alternative to the mouse may be a tracker ball or joystick, but whichever device is used it should be wireless.

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| Inputs | Receipt of an incoming virtual call. External control of the camera for GP's and nurses. |
| Outputs | Making a virtual call. Access to the Internet. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to contact someone on the network. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Virtual neighbourhoods on a 1-to-1 basis exist but are relatively 'slow' when using ISDN2 and impractical on standard telephone lines. ISDN6, ADSL or other advanced networks are available and provide the necessary transmission speeds. Currently in order to achieve accurate speech a microphone needs to be positioned near to the speaker's mouth; it would be beneficial to move away from this and for the microphone to be positioned near to the camera but is unlikely in the 2nd generation system. Cameras are available and are appropriately small with suitable resolutions. Stand alone videoconferencing equipment is available from a number of suppliers such as MotionMedia[349] and Vspan[350]. |

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| **Module** | **Intelligent Home Alarm System (IHAS).** |
| Process | The IHAS communicates with all of the modules installed in the home and external systems, such as the control centre or GP surgery. Each module will define what event initiates the need for communication with the IHAS and the IHAS will communicate with the user, reporting the results back to the calling module if necessary. For example, with a cancellation of a fire call the sensor that generated the alert will be put into a 'sleep mode' and not communicate with the IHAS for a stated period of time. |

Communication should be achieved through a series of recorded/generated speech messages. A sufficient number of microphones and speakers must be installed in the home to enable two-way speech throughout the home. An additional component is the use of a speech pendant. This could facilitate communication anywhere in the home for example answering the telephone, whilst also working in the surrounding area such as, the garden.

When communicating to the control centre through one of the microphones distributed throughout the home or the pendant, both options should have the capability to automatically mute the television, reducing the affect of background noise. When the call ends the television's volume should automatically return to its previous (or stated) volume level. Full-duplex speech should also be available. It may also be beneficial to reduce the volume of a stereo system.

The IHAS should contain a cancellation button so that calls to the control centre/GP can be cancelled if necessary. All calls should be capable of being cancelled except calls where it is thought intruders are present. An additional 'information button' will call the control centre and can be used for advice and assistance.

When communicating with people in the home through speech the recorded/generated message should be heard in the appropriate rooms at a volume that the users should be capable of hearing. If the lifestyle monitoring module is installed but cannot detect any movement within a short period of time then the message should be repeated at a volume level capable of wakening the user if they were asleep. If the message being delivered concerns a fire then the message should continue until a user cancels the call.

In the unlikely event of two or more incidents occurring at the same time the IHAS should concentrate on the module with the greatest priority. This includes instances where two events occur at the same time or when an event is in progress but another event occurs. The priority of the modules should be fire, gas, security, falls, lifestyle monitoring, medical monitoring, incontinence monitoring, water detection, drug dispenser, and temperature analysis.

The module referring to the IHAS defines the automatic communication with external organisations. The calling module will define what inform is required to be passed and in combination with the IHAS and the time of the event, the IHAS will decide whom to contact. The EPR contains the telephone numbers of the appropriate external organisations. If a users GP has the capability to access the EPR then calls where the user is outside of medical parameters should go directly to the GP. The EPR should maintain details of surgery hours so that the IHAS can inform the user when the GP is likely to respond. If an individual's GP is not connected and cannot access the EPR then the call should go to the control centre, where the operators can contact the GP or out of hour's centre and provide the information verbally to the doctor if necessary. If the medical monitoring module considers that a user may require immediate medical attention then during surgery hours the GP should be contacted (if connected to the system) and the control centre at all other times.

When the IHAS contacts the control centre as part of the header[351] of the call, the type of call should be recognised by the control centre system. For example, if the call is a fire call then 'F' could be entered in the header so that the control centre system recognises that the call regards fire. CLI (call line identification) can be used to identify the location of the caller and hence this information can be used to prioritise calls at the control centre. If an engaged tone is received then the IHAS should automatically re-dial after a short delay and inform the user of the problem. If the telephone line from the home to the GP surgery is continually engaged then the control centre should be contacted. If communication cannot be made with anyone then the user should be informed that there is a problem with the telephone line.

If the telephone line is in use but the calling module defines an emergency, a recorded message to both the caller and receiver of the telephone conversation should be made and the call terminated to enable the emergency call to be made. When an external call is being made the call must not be interrupted by the user picking up the telephone receiver. Communication should be secure and cryptography algorithms used.

When wishing to call from the home to someone else on the virtual neighbourhood the camera must be turned on before the IHAS will allow communication. Having turned the camera on the user can enter the telephone number to call, or choose from a selection of stored numbers. When receiving virtual calls a distinction should be made between normal telephone calls and a request for a virtual call. The receiver should have the capability to answer a virtual call through the telephone if they do not wish to be seen by the caller.

If the user is not in the home when a call is received an answer machine facility should be provided both for virtual transmissions and traditional speech. When the user returns they should be informed that they have messages and these can be replayed/deleted at leisure. In addition, an option should be available to route all virtual calls to the answer phone system without displaying the callers details on the television screen or an audible noise being observed. This in affect puts up a 'Do not disturb sign', and will not disturb an individual who may be watching an important television program. If it is recognised that the GP surgery is calling then this capability should be overridden.

When a carer or home help accesses the EPR and leaves the users home, the EPR at the control centre is immediately updated. However, if the control centre is not updated within a defined time, perhaps a week, then the IHAS should establish all the details that have changed on the EPR and update the control centre's main records. The EPR physically stored in the home should then be reset so it is known what has been updated. If no fields have been changed since the last update then the call should still be made to verify that the equipment is working correctly. Each home should only have one defined time and all of the users EPR's living in that home should be accessed, and one telephone call made. The same principle should be employed for warden schemes so that at a defined time all the homes in the warden scheme should be accessed on the internal warden scheme network and one call made to the control centre.

When the IHAS receives calls from the control centre, the IHAS module should recognise the telephone number and update the EPR without informing the user (ringing the telephone). Meterlink[352] provides this capability. Appropriate security measures should be in place to ensure that it is the control centre making amendments.

For people with hearing problems the communications system should alert individuals by a flashing a light or a vibrating pager worn by the user. Speech should be used as well for those users with reduced hearing or for a partner who may be able to hear. The reason for the alarm and appropriate information can then be presented to the individual through the television. The appropriate resolution for the users vision should be automatically stored in the EPR and the information presented in an easily understandable way. The user can then be reminded to take their medication or be informed of any other alarm through this medium.

Using the television for access, the user should be able to alter the system performance for example, the user should be capable of modifying the temperature analysis module, change the 'morning/bed time' or turn other modules on/off at will. Clearly some modules rely on others so the user should be informed of the implications through text on the screen and generated speech. The user can then make an informed choice about how the system works in their home. These amendments should be viewed in the EPR so that GP's etc. can see what modules are functional. The television also provides access to the virtual neighbourhood.

A further role of the IHAS is to provide information to users and carers. This can be achieved through the general content of the Internet, but also specialised advice centres. Such advice would include how to detect the onset of medical problems and basic treatment on conditions, or advice on user rights and the responsibilities of service providers.

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| Inputs | Interrupts from all home based modules. Incoming voice/virtual communication. Modifying the home based monitoring modules. Cancellations of a possible emergency call. |
| Outputs | Contact GP or control centre. Recorded or generated speech messages to users, alternatively appropriate communication for a deaf user through a vibrating pager and flashing lights distributed throughout the home. Ultimately communicating through the television. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to cancel an emergency call. Unable to communicate with the user. Unable to communicate with other modules. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | Communication between modules is attainable with present technology, for example Bluetooth[295]. Communication for people with hearing problems is also attainable with current technology. |

**Module** **GP surgery.**

Process The GP surgery receives 3 types of call and the system must recognise which call is being received:

1. Verbal telephone call: The call can be answered and dealt with in the usual manner – book appointment, provide advice over the telephone etc.
2. Videoconferencing call: The receptionist should answer the call using videoconferencing equipment. If this is not available then by speech only. Again the outcomes may be booking appointments or giving advice.
3. User outside of medical parameters: The GP should be informed of the user parameters either immediately during surgery hours or when they are next available.

If a queue of users outside of their medical parameters exists the GP should employ a FIFO, First in First Out strategy. This is because some users may be very ill and have parameters that would indicate a serious problem if readings were just outside of the defined parameters. While for others, being outside of the parameters may not be as significant. It is impossible to determine this ethically. (I.e. to state on a users EPR that they are extremely ill and hence 'jump them up the queue', such a system would also be open to abuse.)

When the GP analyses readings that are outside of the defined parameters a consultation may be required and can be performed by videoconferencing if appropriate. Having decided on the appropriate course of action this should be recorded in the EPR and the user informed. If changes affect the home, for example the medical monitoring equipment or drug dispenser then the home EPR should be updated immediately.

When the GP receives a call regarding measurements that are outside of allowable parameters, an automatic message should inform the patient that the doctor will be contacting them shortly, the doctor may be performing a consultation and therefore cannot respond at that moment in time. If the call was received during surgery hours but the GP did not respond by the time the surgery was closed then these calls should be left on the queue and available for the GP on the next working day. The delay should be relayed to the user. However, calls that were not answered by the GP and may require immediate medical attention should be re-directed to the control centre so they can inform the out-of-hours GP centre. This should occur randomly so as not to overload the control centre and should not coincide with the logging on/off of wardens. (a busy time for the control centre system)

When the GP is performing virtual consultations, the receptionist should contact the user prior to the consultation. The GP may be behind schedule and if users called the surgery numerous telephone lines could become engaged, while some would be uncomfortable paying the telephone charge. If the user is available then a virtual consultation can take place; if however the user is unavailable then the receptionist can leave an appropriate message on the answering system and the next user contacted.

A user can also request a consultation even if the medical monitoring equipment does not indicate they require one. The surgery can receive a call either by voice only or voice and vision and the receptionist should answer the call in the similar fashion if capable. Appointments should be made in the normal manner, but for users who may struggle to physically attend the surgery a virtual consultation appointment should be made if the user and surgery have the technology. Based on a virtual consultation a decision can be made for a physical consultation if necessary.

If a user has the lifestyle monitoring module installed and the GP decides the user is likely to be less mobile for the duration of the illness then the GP should be able to put the module into an 'ill mode'. The time allowed in each room before an alarm is raised should therefore be increased. The doctor needs to define how long this period will last and therefore on the defined day at 0 hours the lifestyle monitoring module must automatically revert to the settings prior to the GP's intervention.

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| | After successfully meeting the security requirements the GP can make the necessary changes to the EPR in the users home when performing a home visit. After the GP has completed the consultation the users EPR can be updated at the control centre. |
| Inputs | User outside of defined parameters. User requesting a consultation or appointment. Organised virtual consultation. |
| Outputs | Consultation (virtual/physical). Change within the EPR for the medical monitoring equipment, drug dispenser etc. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to contact a user. Unable to change parameters in the EPR. Unable to achieve a virtual consultation. |
| Exception | The exception response is the same as that identified for the fall detection module. |
| Current status | The basic technology needed is available. |

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| **Module** | **EPR (Electronic Patient Record).** |
| Process | The EPR stores all of the relevant information concerning a user. Access by each organisation (GP/control centre/carer/hospital etc.) must be controlled through a security system that ensures access to authorised professionals, while only presenting the information relevant to the professionals role. I.e. a carer should not have access to detailed medical information. Updating the EPR can be achieved by the system; for example the IHAS will contact the control centre within defined times to update the EPR stored at the control centre. Alternatively, an authorised professional can update the EPR, for example the control centre operator editing personal details. |

Data from social services should be included on each users EPR so that it is known what care package a user has been given in the past and what the present care package entails. The results of any assessments should also be included with dates for a possible reassessment/follow up. Hospital discharge information should be recorded on the system for those requiring medical data. Social services may use this data when considering hospital discharge from their viewpoint. Ambulance personnel should also have access to the EPR from their ambulance and be able to update the EPR with any action taken.

The EPR should be physically stored at the control centre to meet the requirements of the Data Protection Act 1984 although to reduce telephone communications some of the EPR should be stored physically in the users home. The home will then contain the most up to date information and must be requested when a GP or operator requests a users EPR. Details stored in the home should be:

1. Appropriate contact telephone numbers for communication purposes (surgery, control centre).
2. Tablet/syrup information, i.e. for each drug how much to dispense and when. It should also indicate if the drug is time critical so that a warning can be given immediately after the medication should have been taken.
3. Medical parameters which would result in the need for the GP to be contacted (not immediate medical attention).
4. Medical parameters which would result in the need for immediate medical attention.
5. Record of recent results from the medical monitoring module which were not out of the defined parameters and have not been updated at the control centre.
6. Falls – time, date, and where the fall occurred.
7. Pets – what they are and how many.
8. Personal details – name, address, responders, family.

The EPR physically stored at the control centre should include not only include the above but:

1. GP diagnosis and treatment.
2. Hospital discharge summaries.
3. Social services details and care package details.

4. Full version of EPR information. I.e. last 30 falls, last 100 uses of medical monitoring equipment, carer records for last 2 months etc.
5. A list of when the EPR was recently accessed and by whom.
6. Language requirements, i.e. English non speaker and preferred language to converse in.
7. Current location, whether they are currently in hospital.

Locking procedures must exist to resolve issues of mutual exclusion and potential conflict. These are:

- If the GP or nurse is viewing/amending a particular users EPR and the control centre wish to view that same EPR the control centre should be given priority as they may be dealing with an emergency call and the GP should be locked out from amending the fields until the control centre has finished.
- The EPR is being viewed/amended by an organisation (GP/control centre etc.) and the EPR being viewed is being updated from the EPR physically stored in the home. If this occurs the EPR should be updated and the organisation viewing the file made to wait.
- The EPR is being viewed/amended in the home and the GP surgery/control centre wish to view the user's record. The surgery/control centre should be given the information stored at the control centre and informed that the EPR is currently being updated. The EPR should be updated at the control centre when editing in the home has been completed. The surgery or control centre can then be updated with the latest information.

Inputs — Amendments from the temperature, lifestyle monitoring and fall modules. Professional amendments from the GP, social services, hospital, carers/home helps and ambulance personnel.

Outputs — Secure accurate information for the IHAS, social services, GP and hospital.

Major error — Unable to update/view any field. Unable to protect what each organisation is allowed to update/view.

Exception — A period of time must be given for the problem to resolve itself, if after this time the fault still exists then a fault report should be generated and the control centre contacted.

Current status — In theory such databases are available but non exist which specifically cater for the needs described above.

**Module** — **Control centre.**

Process — When a call is received at the control centre the system must distinguish the type of call. If the call is electronic then the first part of the call will contain a header with the reason for the call i.e. fall, fire etc. For non-electronic calls this information will not be available but by their very nature they will be non-emergency calls that require the operator. The control centre system should prioritise calls so that the most important calls are answered first. This priority should be:

1. Fire.
2. Gas.
3. Security.
4. Falls.
5. Medical monitoring outside of surgery hours requiring immediate medical attention.
6. Lifestyle monitoring.
7. Medical monitoring*.
8. User activated emergency call.
9. Carer/home help failed to log on at the expected time.
10. Incontinence.
11. User telephone call.
12. User information enquiry.
13. Non compliance to drug regime from the drug dispenser*.
14. GP enquiry for EPR.
15. Hospital access to EPR.
16. Warden log.

*only received if the users GP surgery does not have access to the EPR.

The queue should be re-organised each time a new call is received, however allowance should be made to ensure that a low priority call is not continually left on the queue.
When a carer or home help updates a users EPR this is automatically sent to the control centre and their daily schedule can be updated with the time they arrived and left the users home. This allows the control centre system to monitor the progress and safety of carers and home helps and if they fail to arrive at the anticipated time for the next appointment the reason for this can be investigated. It also gives the capability for the control centre system to estimate the arrival time of a carer or home help if they are running behind schedule. Therefore, if a user contacts the control centre enquiring when they will receive their visit a realistic estimation can be made.

When producing a carer or home help schedule the control centre system should recognise if users are in hospital and therefore do not require a home visit (this information being supplied on admission to hospital).

Non emergency calls concerning a warden/carer logging on/off duty, access or updating of the EPR should all occur without the control centre operator being involved. The control centre system must ensure there are sufficient telephone lines for user emergency calls to be received. Therefore, non emergency calls should be postponed if there is a danger of emergency calls receiving an engaged tone.

When a warden logs on/off duty this information should be recorded and if any calls are received from a wardens site while the warden is off duty they should be informed when they return to duty. This technique should also be used when generating the carer and home helps schedule, therefore allowing the reason for the call to the control centre to be further investigated.

If an emergency call is being answered by a control centre operator this call should be completed before taking the next call but the operator should be able to see the 'queue' of calls waiting for their response and the nature of those calls. The control centre operator should only be allowed to answer the next call, i.e. the one with the greatest priority. When a call is answered the control centre operator should automatically be provided with details such as, the callers name, address, users natural language and ability to speak English, key holders, family, pets, nearest police and fire station, care package, GP and position of anyone in the home if the lifestyle monitoring module is installed.

When a control centre operator receives a call, full-duplex speech should be available through the IHAS. If language barriers exist or communication cannot be secured then the information provided by the IHAS will generally be sufficient. The greatest deficiency is that comfort and reassurance cannot be given to the caller. Stored messages in the caller's language should be available to control centre operators informing the caller of the action the control centre operator is taking.

Three-way speech should also be provided to the control centre operator so that communication between the caller, control centre operator and one other can be secured. The other would typically be a key holder, GP or family member who may interpret between the control centre operator and non-English speaking family member.

When the call has ended the EPR should be updated showing who answered the call, how long the call was, when the call was made, how long the caller had to wait to be answered and what action was taken. This information can then be used for management and accounting purposes.

If the control centre is unable to accept telephone calls then the telephone exchange should re-route the calls to a back up control centre; no calls should be lost in this process. The need for a

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|---|---|
| | contingency arrangement is required for accreditation by BS5979[240]. |
| Inputs | Manual enquiries. Emergency calls from the IHAS. Warden/carer log in. Access to EPR by the GP and hospital. |
| Outputs | EPR displayed for the operator. Communication with caller through IHAS in emergencies. Inform warden of calls received while they were off duty. Contact carer/home help, family, key holder, emergency services, GP. Fault report for engineers. |
| Major error | Unable to test the components of the module and validate any potential problems. Unable to access user EPR's. Unable to receive/make telephone calls. |
| Exception | The module must be given a period of time to resolve itself, if after this time the fault still exists then inform the operators and automatically run a parallel (backup) system, defaulting to a separate control centre if the problem is significant and persists. |
| Current status | Call handling systems are available but need to be amended to provide the facilities above and integrate in the manner suggested. |

| | |
|---|---|
| **Module** | **Hospital Health Services.** |
| Process | When a user is admitted to hospital their EPR should be accessible and details of their medical history available. Such information is the GP's records and any historical data secured from the medical monitoring equipment. Details of responders etc. can be viewed through the EPR and relatives informed. The EPR should be edited so that it is known when a user is admitted and discharged from hospital. Therefore, allowing the control centre to produce efficient carer schedules.<br><br>Prior to discharge the control centre should be informed with the anticipated discharge date, therefore enabling the user to be included in the carer schedules. On discharge the discharge summary should be entered into the EPR and be readily available for the GP.<br><br>GP's should also be able to arrange appointments with hospital consultants during a GP consultation and have access to hospital test results. |
| Inputs | User presented at hospital. EPR. |
| Outputs | Contact family/friends. Halt and resume care package through updating the users EPR. |
| Major error | Unable to access the EPR. Unable to provide medical assistance. |
| Exception | A period of time must be given for the problem to resolve itself, if after this time the fault still exists then a fault report should be generated and the control centre contacted. |
| Current status | By the end of 2002[228] the government has indicated that GP's will be able to access the hospital's records through the NHSNet. Access to a users care package is technically possible but not currently performed. |

Each module installed in the users home should continually test itself. If there is a malfunction then the IHAS should be informed and communicate this to the user, and ultimately the control centre if the problem cannot be resolved.

The current 1st generation or community alarm system as described in Chapter 4, did not contain the hospital as it operated in isolation. The hospital received patients, treated them and discharged them with little or no interaction with the control centre, or indeed GP's. Due to the greater access to information in the 2nd generation system, the hospital can easily gather information on users and also provide input into the system, such as the discharge summary, thereby breaking down some of the operational barriers that currently exist.

Based on the views of current users, Chapter 3 indicated that a modular system was required that could be enhanced as user need increased. Three possible levels are suggested in Table 5.1 along with the 2nd generation modules that would be included at each of these levels.

Table 5.1: *Possible modular community alarm system – based on current user questionnaire*

| Level | Description | Modules |
|---|---|---|
| One | Current community alarm system with speech synthesis for false alarms and a security system. | Fire detection<br>Security<br>IHAS<br>EPR<br>Control centre<br>GP surgery<br>Hospital health services |
| Two | In addition to the above system automatic fall detection and lifestyle monitoring. | Fall detection<br>Lifestyle monitoring<br>Temperature analysis |
| Three | In addition to system two, telemedicine and video conferencing. | Medical monitoring<br>Virtual consultations/neighbourhood |

In addition, Table 5.2 suggests further modules that can be added at any of the levels identified in Table 5.1.

Table 5.2: *Additional modules based on specific need*

| Module | Possible reason for installation |
|---|---|
| Gas detection | Signs of forgetfulness |
| Water detection | Signs of forgetfulness |
| Drug dispenser | History or possibility of poor compliance to drug regime |
| Incontinence monitoring | Any user with incontinence |

The decision on the level of system and installation of any additional modules must become part of the community care assessment currently performed by social services. A technical understanding would not be necessary but the benefits of each module must be known in order for users to obtain systems which best meet their needs. The installation and maintenance of the equipment will also require additional training for the installers and engineers.

Despite the increased monitoring and communication that each level of the 2nd generation telecare system provides, the impact on the home is likely to be insignificant in terms of intrusion for the user. It is likely that a small unit would be required in each room with a microphone and speaker for the improved communication of the IHAS, while a PIR or similar device would be required for the lifestyle monitoring module. The virtual consultations/neighbourhood would require a camera unit to be placed on the television while the medical monitoring module would require a stand alone medical device. Communication between the modules and control box could be achieved with wireless communication, such as Bluetooth. The overall impact of a level 1 system is shown in Fig. 5.2, where the small unit in each room is highlighted in red and the control box can be seen in the hall way. A virtual tour of such a home is provided on the accompanying CD.

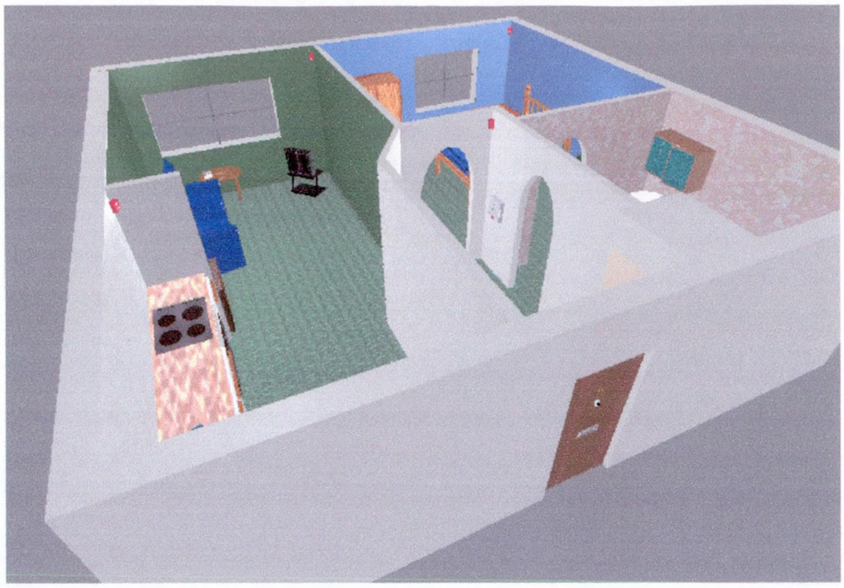

Figure 5.2: *The implication for users with a 2nd generation telecare system*

### 5.1.3 2nd generation context diagram

There are a greater number of organisations working together in the 2nd generation system as highlighted in Fig. 5.3. Perhaps the most significant change is that the user is at the centre of the system as opposed to the control centre, as identified to be the case with the present system (Fig. 4.1).

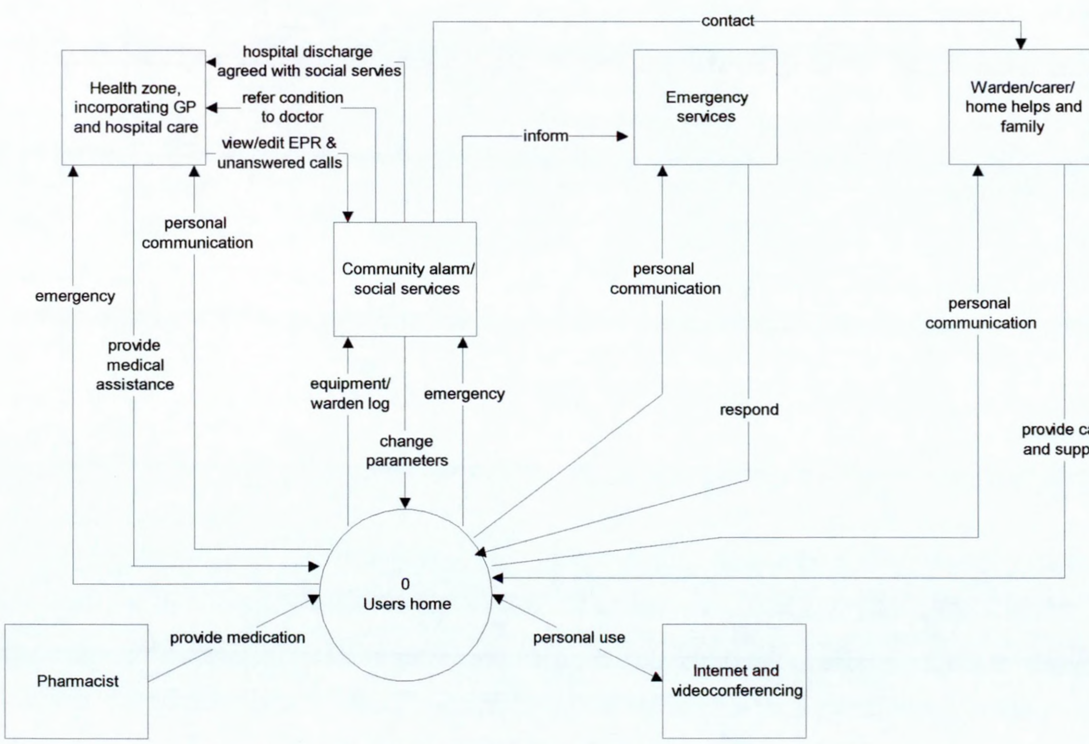


Figure 5.3: *Context diagram for a 2nd generation system*

In the 1st generation system once a user instigated a call for help the control centre facilitated this request and provided assistance as necessary. The 2nd generation system can automatically call for help and assistance is provided from the GP surgery or control centre as appropriate. Fig. 5.3 indicates that with the exception of medical monitoring, all of the alarms, whether generated by the system or user, are routed to the control centre. It would be possible to send alarms directly to organisations that could respond, but due to legal requirements it is unlikely that this will occur. For example, it would seem appropriate for a fire alarm to be sent directly to the fire brigade, but under the current legal framework, the electronic detection of a fire cannot be sent to the fire brigade without being validated by the control centre operator[240].

When the control centre is contacted, Fig. 5.3 indicates that social services and the control centre are grouped together. It is not suggested that the control centre, which is commonly situated in housing departments, and social services are merged, but rather the information on care packages etc. is fully accessible to the control centre operator and information held by the control centre is accessible to social services. Once the control centre is contacted the calls can be queued based on need and the same organisations as identified in the 1st generation system are again available to respond namely, the emergency services, responders or medical expertise.

The final additional feature of the 2nd generation system is the ability for users to videoconference one with another. This could be used to provide motivation and a feeling of community or togetherness for users. However, due to the need for ADSL or other appropriate transmission speed it is probable that there will be few users of this function at this stage.

Data flow diagrams for this 2nd generation telecare system are provided in Appendix A5.1.

## 5.2 3rd Generation System

### 5.2.1 Requirements definition for the 3rd generation telecare system

Having introduced a 2nd generation system capable of detecting some emergency situations and monitoring some medical parameters, the 3rd generation system introduces additional monitoring to detect further emergency situations. The performance is also improved to enable conditions requiring attention to be detected earlier. Improvements in medical monitoring will enable further parameters to be measured while for some users continuous 24-hour monitoring will be possible. The introduction of expert systems[14] enables further analysis and trend recognition to enable prevention to play an increasing role.

Any GP surgeries that had not previously obtained access to the EPR or videoconferencing should now obtain access and become a component of the overall system.

Overall, the 3rd generation system is enhanced and made more flexible and responsive. Tasks that were previously carried out by staff but did not require contact with users are taken over by the system. This therefore enables staff to spend more time with users and provide a more caring environment. It is suggested developments of the 3rd generation system will result in an operational system by 2005-2010.

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[14] Expert systems are defined as software applications that allow users to benefit from the knowledge of an expert human consultant[353].

The main features of the 3rd generation system are described in Table 5.3, while the functional requirements are provided in Appendix A5.2.

Table 5.3: *Main features of the 3rd generation telecare system*

| Main features |
|---|
| **Components of 2nd generation system**: the previous modules are available in the 3rd generation system. |
| **Lifestyle monitoring**: identify the movements of users without having to use tagging, also measure the users gait and how often they climb stairs (if present). |
| **Security**: more developed burglar alarm and automatic recognition of user. Access to EPR for all professionals. |
| **Weight detection**: measures the users weight. |
| **Drug dispenser**: enable repeat prescription reminders and analysis of the medication held within the dispenser. |
| **Medical band**: provide 24-hour continuous medical monitoring for users wearing a medical bracelet or vest. |
| **Distance support**: communicate with the medical band and allow the user to call for assistance when away from the home. |
| **Intelligent Home Alarm System (IHAS)**: the ability to track the user if they fail to return home at a specified time. |
| **User control**: provide verbal communication with the home based system. |
| **Virtual GP/neighbourhood**: provide remote physiotherapy and exercise schemes. |
| **GP surgery**: expert system to suggest to the GP what medication they should prescribe. |
| **Pharmacist**: enable paperless prescription. |
| **EPR**: store the users data. |
| **Control centre**: support for foreign languages and analysis of users EPR's to ensure that correct medication is being used. |
| **Hospital Health Services**: no change when compared to the role undertaken in the 2nd generation system. |

In order that the 3rd generation system provides the necessary assistance and support at the correct levels, it is again suggested that the modules are provided on a plug and play basis. During the assessment process it can then be agreed which modules of the 2nd and 3rd generation system are required to meet each individuals specific need.

### 5.2.2 3rd generation context diagram

In a similar fashion to the 2nd generation system, in the 3rd generation system described in Fig. 5.4 the users home is the beginning of the process and therefore holds a central position. This 3rd generation system continues to improve the communication and information held and new organisations, although present in the 1st and 2nd generation systems, now interact with the telecare system:

1. Pharmacist: The pharmacist has always provided medication to users but now provides information into the system. When the GP prescribes medication the prescription is entered into a pharmacist database, enabling a paperless system. When users are provided with their medication this can be entered into their EPR and checks made to ensure medication has been collected and used.
2. Warden/carer/home helps & family: The users home can contact family members or responders directly. This is an important development as it allows the system to support the user while reducing the work load on the control centre. For instance, if the home based system recognises that the user is suffering from a minor illness, or there is a reduction in the number of visitors or in the use of the

telephone or videoconferencing, then contact can be made with responders and family who can check on the users well being and provide care and support if necessary.

3. Remote exercise schemes/physiotherapy: In addition to being enjoyable[354], exercise helps to reduce the probability of a fall and prolongs the length of time older people are able to perform basic tasks for everyday living[355]. Although exercise schemes were previously available to users, the 3rd generation system enables these to be performed remotely and details stored in the EPR. Remote physiotherapy also enables users access to assistance when previously their treatment may have ended. The economies of scale with group videoconferencing makes this possible.

The remainder of the data flows between organisations are similar to those defined for the 2nd generation system. The main EPR is again stored at the control centre and is updated with the latest information, either on a request from the health zone and control centre operator, or at pre-determined times, perhaps once a week.

Data flow diagrams for this 3rd generation telecare system are provided in Appendix A5.3.

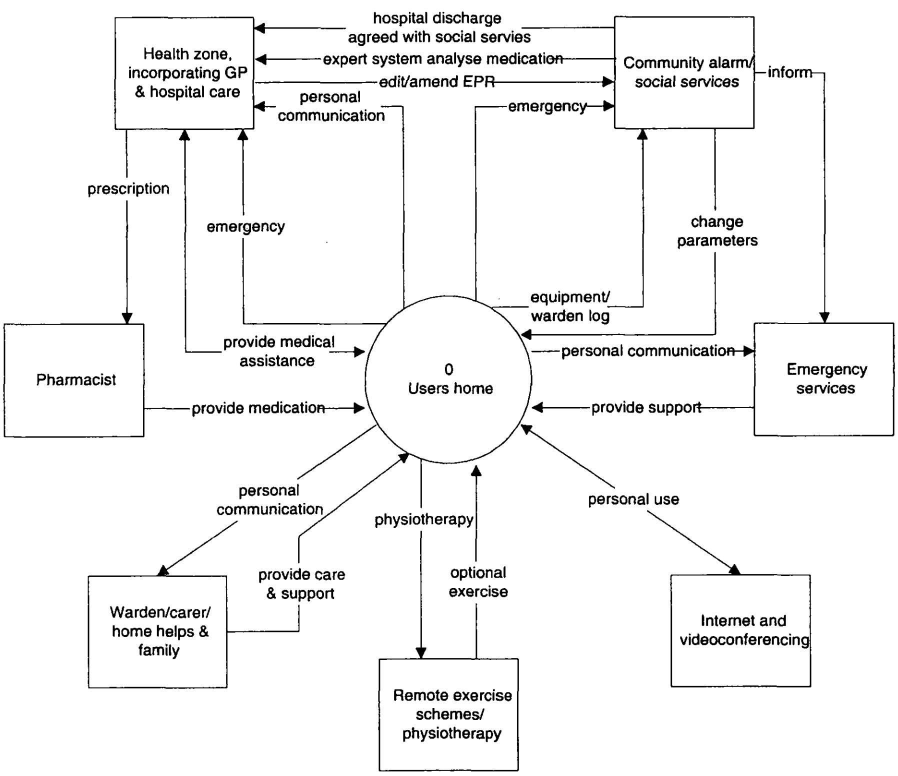


Figure 5.4: *Context diagram for a 3rd generation system*

## 5.3 4th Generation System

### 5.3.1 Requirements definition for the 4th generation telecare system

The focus of the previous generations was to monitor users and detect emergency situations. Attention was also given to prevention in respect to medical parameters, while the introduction of expert systems enabled the system to ensure that medication was prescribed correctly. The 4th generation system builds upon these previous generations by developing the system for both the user and provider.

For the user, intrusion is reduced with implanted sensors so the user no longer has to wear a pendant or similar device when in the home. When outside of this environment, the implanted sensors work in the same manor as the medical band module, communicating with the distance support module. Assistance with tasks of daily living enable users to stay independent in their own homes for longer, automatic robots provide tasks such as cleaning.

Medical professionals received support from expert systems in the 3rd generation system and developments in artificial intelligence will enable remote assessment. The Activities of Daily Living (ADL) has conventionally been used by social services in assessing older peoples need for long-term care[100], however this annual 'snap shot in time', assessment has often failed to assess the user as their needs change, especially relevant after hospital discharge[145]. The 4th generation system addressees this deficiency by monitoring the user on a daily basis and automating the assessment. Users can then be formally assessed after the system has indicated that intervention would be beneficial.

Any pharmacist that had not previously obtained access to the pharmacist database should now obtain access and become a component of the overall system. It is suggested developments of the 4th generation system will result in an operational system by 2010-2015.

The main features of the 3rd generation system are described in Table 5.4, while the functional requirements are provided in Appendix A5.4.

Table 5.4: *Main features of the 4th generation telecare system*

| Main features |
|---|
| **Components of 2nd and 3rd generation system**: the previous modules are available in the 4th generation system. |
| **Water detection**: monitor the washing habits of the user. |
| **Incontinence detection**: detect the onset of incontinence. |
| **Robotic assistance**: provide mechanical assistance with vacuum cleaning, retrieving items from the floor and dressing. |
| **Virtual GP/neighbourhood**: the scanning of letters and forms that cause distress. Assistance being provided from friends or relatives, and ultimately the control centre or social services. |
| **Implanted medical monitoring**: implanted sensors measuring vital signs 24-hours a day. |
| **Intelligent Home Alarm System (IHAS)**: route emergency fire calls directly to the fire brigade. |
| **User control**: the use of the mind to control electronic devices around the home. |
| **Control centre**: through an expert system, each users EPR is analysed under the automatic ADL assessment. |

For each module installed in the users home it should continually test itself. If there is a malfunction then the IHAS should be informed to communicate this to the user and ultimately the control centre if the problem cannot be resolved.

In order that the needs of each user are meet it is suggested that modules from the 2nd, 3rd and 4th generations are combined. Modules can then be added or withdrawn depending on the annual assessment or system generated assessment for users with the 4th generation system.

### 5.3.2 4th generation context diagram

The communication in Fig. 5.5 between the 4th generation telecare system and external organisations is not dissimilar to the 3rd generation system. The only difference being the automatic routing of fire calls from the home to the fire brigade as indicated in red on Fig. 5.5. As part of this process the fire brigade contact the control centre to inform them of the action taken. Such information could be useful in an ADL assessment. When the IHAS wishes to contact the police and ambulance service this is achieved through the control centre. However, the action taken by all of the emergency services is recorded in the users EPR.

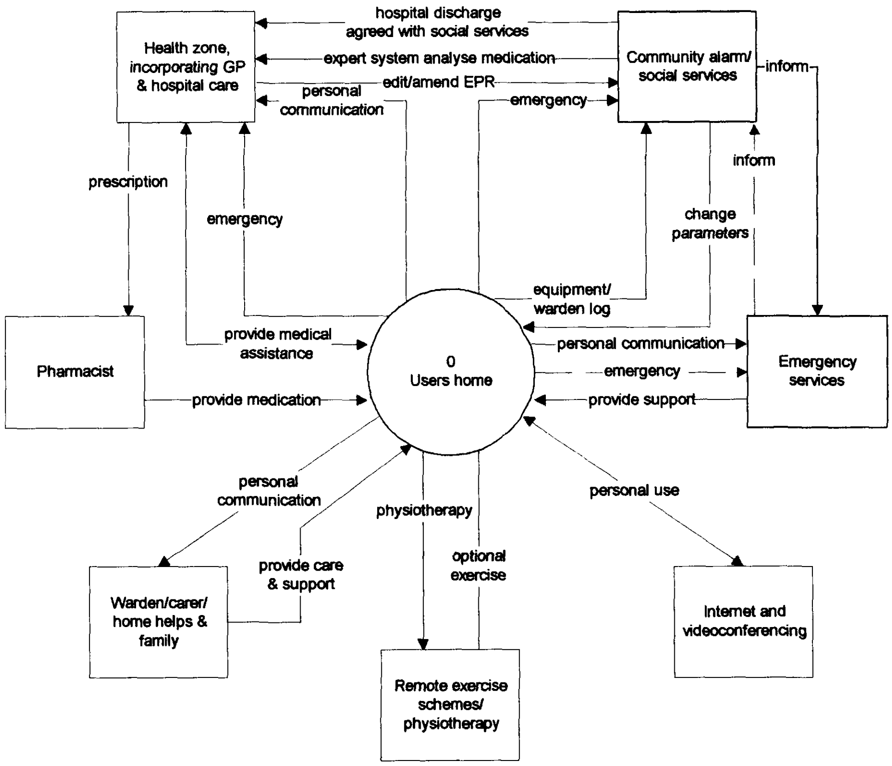


Figure 5.5: *Context diagram for a 3rd generation system*

Data flow diagrams for this 4th generation telecare system are provided in Appendix A5.5.

## 5.4 Conclusions

It could be said that the aim of any telecare system is to prevent morbidity, increase user choice and provide a safe environment for the user. The American study by Roush *et al*[171] suggested a 25% reduction in hospital admissions and a reduction from 9.2 days to 5.7 hospital inpatient days due to the intervention of the 1st generation system. However, it is suggested that it is not until the 4th generation system that a truly effective system is available. This 4th generation provides:

- Emergency detection of situations both inside and outside of the home environment.
- 24-hour continuous medical monitoring and deviations from allowable parameters resulting in almost immediate medical attention. This allows prevention and also provides medical professionals with a history of reliable medical data.
- Prevention due to medical expert systems ensuring the correct medication is provided to users.

- Improved efficiency and provision of aids and adaptations due to the automatic ADL assessment.

In order to move to this 4th generation system from the current and technically simple 1st generation system, two stepping stone systems have been introduced. These are required to enable the technology to develop and improve the communication between organisations. In defining each telecare generation attention has been given to modules which the majority of the current 1st generation users could benefit from. As such there are various developments which are not included but are likely to be available to the benefit of some users. Developments would include, automatic environmental heating control, height adjustable work surfaces and cupboards, a bar code reader on the bin to automatically replace food. Developments may even analyse user's responses to ensure that they are telling the truth, it is claimed that such a development has an accuracy of 95%[356] and could be used in the assessment procedure.

Accurately estimating when each of the telecare generations will be available is a difficult task due to the technical innovation and organisational change that is required. Indeed, it should be appreciated that the current 1st generation system has not significantly changed since the late 1980's[115]. The time estimates given are therefore based on the availability of technology that could be applied from other disciplines, the likelihood of organisational change, and the governments desire to move to a preventative system along with its published IT strategy.

# 6 Developing A Cost Analysis Tool

***Chapter structure:*** *The first stepping stone system or 2nd generation telecare system is used to develop a cost analysis model and discover the costs and potential savings involved. This chapter reviews the current literature, indicating the formal constraints imposed in the development of an effective cost analysis tool, and explains how the cost analysis model was developed.*

The qualitative benefits of telecare and telemedicine have been widely published[58, 72, 135, 357] and it could be argued that they are generally accepted. However, the greatest stumbling block to the development of telecare systems is the apparent lack of evidence for the sustainability and cost-effectiveness of such systems and it has been suggested that this has mitigated against the further development of such services in the UK[61].

Whitten *et al* comment that one of the most commonly posed questions about telecare and telemedicine is whether the use of information and communications technologies is a cost-effective method of providing health services[358]. As indicated in Chapter 2, cost-effectiveness studies are crucial to the introduction of telemedicine into national health services as no government will introduce telemedicine [and telecare] on a significant scale without firm evidence of cost-effectiveness[233]. However, there is little evidence[58, 61, 164, 235, 237, 238] and in 1999, no such evidence had been published in the UK[234]. Where consideration had been given to costs, they have tended to be quite simplistic as in the paper by Tang and Venebles referred to in Chapter 2[168].

Elsewhere, Håkansson *et al*[359] suggest that there is a consensus amongst health economists that the introduction of new technology often leads to an increase in cost. Stode *et al* suggest that in many instances telecare merely shifts, rather than saves costs[360]. Without cost-effectiveness information it is not possible to decide if the benefits of telecare and telemedicine are worth their associated costs, or if indeed services can be delivered with a financial saving. In order to move from the array of relatively small-scale projects to deployment on a national and international scale an understanding of the financial implications will be beneficial.

As indicated in chapter 2, the use of telecare to assist older people and other users is a relatively new area of research. Mair *et al* in 2000 suggested that much of the research has been aimed at answering the question 'can we do this?' and the question 'should we do this?' remains unanswered[238]. Consequently, a considerable proportion of the work to date has been concerned with developing the technology and systems, rather than implementation issues. It may also be suggested that one of the reasons why evidence is lacking, is that assessing the costs and benefits of any proposal is a complex exercise[361]. This is particularly true where information on current and likely future costs is difficult to assess or predict while operating in a complex and ever changing technological, medical and political environment[135]. By way of illustration, computer memory costs approximately £2 per megabyte today, in the 1960's this would have cost £2 million[362].

## 6.1 Economic Evaluations

In order for the results of a cost analysis tool to be accepted by academics and professionals it must adhere to accepted procedures. In this respect information is provided by the NHS Research and Development Health Technology Assessment programme that aims to '*ensure that high-quality research information on the costs, effectiveness and broader impact of health technologies is produced in the most efficient way*'[363]. It suggests that fundamental to this aim is the requirement that an economic evaluation is performed. Drummond *et al* consider the economic evaluation of healthcare interventions as the systematic evaluation of alternative courses of action, both in terms of the costs and the consequent health outcomes from the action[364].

The basic tasks of any economic evaluation are to identify, measure, value and compare the costs and consequences of alternatives under consideration[359]. Mair *et al* have suggested how an economic evaluation of telecare should be performed and she commented that the fundamental concept was 'opportunity cost', specialists can either be travelling or treating patients. The true cost of travel is the missed opportunity to treat patients. All of the resources used in the provision of a service must be identified, measured and valued and she suggests that only by using such a comprehensive approach to cost measurement can it be ensured that all of the consequences arising from telecare are incorporated into the evaluation[238].

Mair *et al* also comments that economic evaluations must incorporate a sensitivity analysis as recognition of the uncertainty related to point estimates of costs and benefits[238]. In this context a point estimate is where, the cost of an intervention is calculated at perhaps £1,000 with the number of users for example at 20, the total costs are £1,000 * 20 = £20,000. The £20,000 is considered as the point estimate but in calculating the £1,000 assumptions may have been made and the intervention may for example, vary from £600 to £1,400 making the total intervention cost range from £12,000 to £28,000. Presenting the results with consideration to the range of possible intervention costs is referred to as the sensitivity analysis.

The most common form of sensitivity analysis is where one or more components of an evaluation are varied across a plausible range of values in order to examine the effect on the results as demonstrated above. In a one-way sensitivity analysis each value which has a level of uncertainty associated with it is varied individually[363]. It has been argued that a set of one-way analyses may be sufficient if each of the uncertain variables is independent of the others[365]. However, this has been questioned, since even if variables are independent, they do not vary one at a time and the effect of joint uncertainty will often be wider than suggested by one-way sensitivity analysis[366].

A multiway sensitivity analysis involves varying two or more inputs at the same time, and studying the combined effect on the results of the evaluation. Inevitably, it becomes progressively more difficult to present the results of multiway analyses the greater the number of inputs that are varied, and evaluations frequently exhibit uncertainty on more inputs than can be feasibly handled. A solution commonly used is to present multiway analyses in the form of what has been termed 'scenario analyses'. This can be used to explore the implications of different 'states of the world', each of which affects a number of different parameters in the evaluation[363].

Other forms of presenting the cost analysis results are by using a threshold analysis. This is concerned with identifying the critical value of parameters above or below which the conclusions of a study will change[367], for example what values do the parameters need for the intervention to be cheaper than the present system. Another form of sensitivity analysis, closely related to multiway/scenario sensitivity analysis, is the extreme scenario analysis. In this form, analysis is given to a best and worst case scenario by systematically combining all the most optimistic and pessimistic values[363].

## 6.2 The Cost Analysis Model

In order to demonstrate the cost-effectiveness of telecare systems, the cost analysis tool needs to compare the present community alarm system with a proposed future system using the rules described by the NHS Research and Development Health Technology Assessment programme. As such, there are five key areas where the costs and benefits need to be considered:

- Home environment.
- Community alarm control centre.
- GP surgery and primary care system.
- Hospital environment.
- Residential care.

The model needs to have the capability to include the functions of the 2nd generation system discussed in Chapter 5 and highlighted in Fig. 6.1.

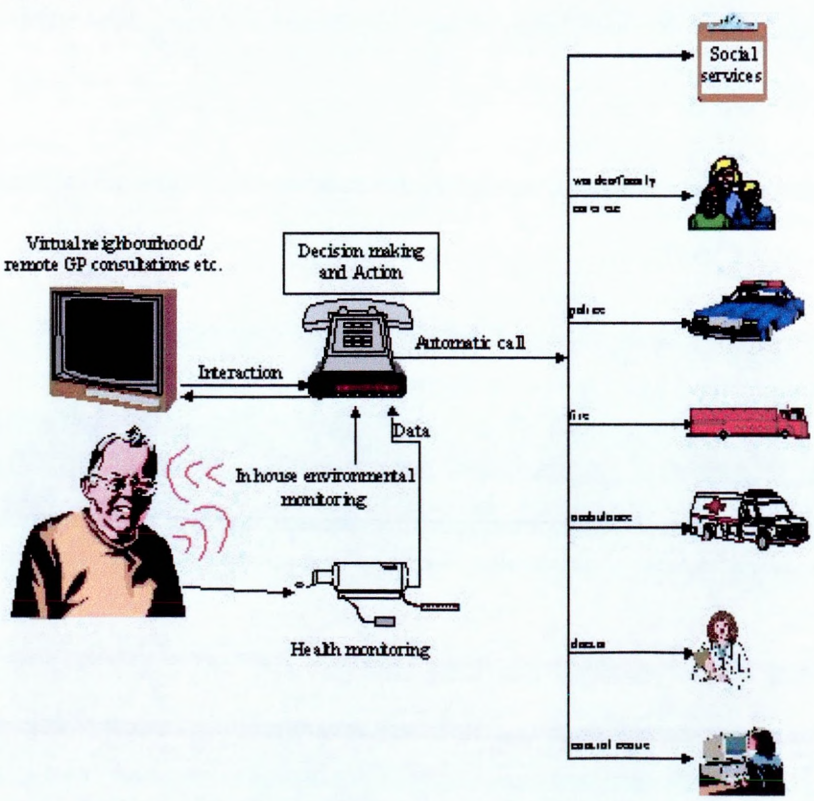


Figure 6.1: *The components of the proposed telecare system*

To provide the necessary performance, it is argued that a new generation of equipment is required. Elements of the proposed telecare system are summarised in Table 6.1:

Table 6.1: *Elements of the proposed system*

| Element | Description |
|---|---|
| Lifestyle monitoring | Automatic detection of situations where assistance is required and the user is unable to raise the alarm themselves. The in-house equipment first verifies assistance is needed before contacting an external source. Room temperature should also be measured in an effort to reduce the risk of hypothermia. |
| Security | Linked to the lifestyle monitoring component, the in-house equipment automatically activates/deactivates a home security system, it also indicates if occupant(s) are in the home. |
| Automatic fall detection | This could be part of the lifestyle monitoring system or a stand-alone device, where necessary a control centre will autonomously inform a control centre. |
| Emergency monitoring | This should automatically detect if a cooker has been left on by mistake and turn the cooker off if necessary, this element should also automatically detect fire and gas appliances left on by mistake, responding as necessary to maintain safety. |
| Medical monitoring | A basic set of medical parameters are measured and if outside of GP defined boundaries the GP can be contacted. |
| Virtual GP consultations | Some GP consultations are performed remotely through video conferencing and the medical monitoring equipment in the home, rather than physically in the home or surgery. |
| Virtual nurse visits | Nurse visits that do not require 'hands on' care can be performed remotely through video conferencing and the medical monitoring element. |
| Improved communication | Data gathered from the home is stored locally and at defined times sent to the control centre for predictive analysis and accurate information for hospitals, social services etc. (EPR – Electronic Patient Record) |
| Automatic drug dispenser | Dispensing the correct medication when required, as defined by the EPR and updated by the GP when necessary. |

## 6.3 Methodology

Because the elements of a 2nd generation telecare system are not yet commercially available it is not possible to quantify any resulting health outcome benefits. It should also be noted that one of the assumptions currently made when performing a health economics cost analysis is that costs falling outside the specific budget of the health service are excluded as costs attributable to other parties are not pertinent to the problem of maximising outcomes from a specific budget[368]. However, telecare systems are likely to impact on several budget holders (Health, Social Services, Housing) and therefore performing a health economics cost analysis on a telecare system would not, under these assumptions, provide the true system costs. Therefore, although the rules of an economic evaluation have been adhered to, a systems approach has been undertaken in an attempt to establish all of the costs and benefits independently of where those costs/benefits may be evident.

The approach adopted for the cost analysis model is that of a quantitative analysis based on quantifiable and attributable costs where only those costs required for the purposes of decision making have been included as described by Drury[369]. Throughout the analysis, assessment of the potential of equipment and possible costs has been based on available information. Where possible, Government or other authoritative published figures have been used. Thus when calculating the number of people aged 65 and over admitted to hospital per annum, a figure of 32.4% has been used. This is derived from information provided by the UK Department of Health[251] and has greater authority even though for the city of Birmingham, which is used as an example of current practice in the model, a figure of 46.8% may be more appropriate[252].

Where Government or published figures are not available, input from professionals has been used. Where conclusive agreement between professionals is not available, any possible savings have been disregarded. Thus, while it is generally agreed that early detection of fires will result in a saving for the fire service as well as in reduced building damage, quantifying this prospective saving has proved difficult and it is not therefore included in the analysis.

*Inflation*

The problem of measuring returns on investment when prices are affected by inflation is a subject that accountants have not fully solved[370]. Indeed, there is no satisfactory definition of inflation, but it can be regarded as either an upward movement in prices, or a downward movement in the purchasing power of the monetary unit[371]. Over the past 20 years many attempts have been made to establish a means of accounting for inflation, but all have been unsuccessful[372].

The basis of accounting prescribed by the Companies Act[373] is the historical cost accounting (HCA) system that assumes all values are based on the historical costs incurred. In other words no consideration is taken for the impact of inflation. This means that 19X9 pounds can be added to 200X pounds and a meaningful result obtained[373]. The convention holds that assets should be shown in accounts at their outlay cost to the business. This approach has the advantage that what a business actually paid to acquire the asset is a matter of demonstrable fact and any other value placed on an asset is likely to call for some expression of opinion[374]. Use of the HCA convention gives the confidence that figures have not been manipulated to give one impression rather than another, and with a conservative outlook sought this provides the model with the greatest confidence. It has been said that the use of a basis other than HCA raises questions about the choice of the alternative[374]. The advantage of HCA is that when prices are static HCA accurately and fairly shows the profits made by the business and the value of the assets less liabilities to the business[373]. However, when prices are changing there are difficulties[371]:

1. *Gross profit is overstated.* The closing stock tends to have a higher value than goods purchased in earlier periods (this is because the closing stock is deducted from the opening stock plus any purchases made). However, when the stock is eventually sold it will probably cost more to replace than it did when it was purchased.
2. *Depreciation is under stated.* This is because it is usually based on the historic cost of the fixed assets. The fixed assets will eventually have to be replaced at a greater cost than was originally paid, so not enough cash may have been set aside to replace them if the depreciation charge is based on the historic cost.
3. *There is a loss on loans.* If the entity has put some of its funds into short or long term loans, such loans will lose value in a period of inflation.
4. *Gains on borrowings.* If an entity borrows money on a short or long term basis it will benefit. Goods purchased on credit terms, for example, will be settled in money terms, but the monetary payment will not be worth as much as it was when the goods were purchased.

With the deficiencies evident with HCA accounting alternatives have been sought, but all of the attempts fall within one of two categories[373].

*Current Purchasing Power*

The Current Purchasing Power (CPP) was published in May 1974[375] and involves adjusting the HCA using a general price index (the Retail Price Index) so that all items are expressed in £'s of year-end purchasing power[373]. However, many accountants thought it misleading to adjust specific assets such as stock and fixed assets by means of a general price index which was far more relevant to the spending power of a family than that of a trader[373].

*Current Cost Accounting*

The current cost accounting system is a based on value accounting and requires fixed assets and stocks to be included in their accounts at their current value, rather than their historic cost[371]. Therefore the value of an asset is the cost to which an identical asset could be purchased. However, the accurate determination of the replacement cost of an asset can be problematic.

In 1974 the Sandilands Committee was formed to consider whether, and if so how, company accounts should allow for changes (including relative changes) in costs and prices[376]. The committee considered CPP, value accounting systems and cash flow accounting; recommending the development of CCA where an asset was valued at its replacement cost[376]. SSAP 16[377] was issued in March 1980 and was mandatory, making companies present historical accounts and current cost accounts[376]. SSAP 16 was considered as a complicated statement but did try to reduce the level of historic cost profit so some allowance could be made for the effects of inflation. However, SSAP 16 was very unpopular and was subsequently abandoned in 1985[371]. The additional cost of collecting data to make adjustments for inflation tend to outweigh the benefits[370].

As a result of the abandonment of SSAP 16, most companies no longer make any sort of adjustment to their historic cost accounts in order to allow for inflation[371]. Indeed most organisations seem content to prepare HCA accounts, presumably considering that they are aware of the inherent limitations therein[373]. Despite the limitations of HCA there is no accurate method of accounting for inflation and as such the HCA accounting system is employed throughout this model with inflation being considered as zero. If inflation were included it would tend to overstate the returns[371] and an example of this is considered in Chapter 7.

## 6.4 Model Assumptions

Throughout the development of the model assumptions have been made regarding the benefits and costs involved. Full details are provided in the spreadsheet on the attached CD. A summary of applied assumptions is provided in Table 6.2.

Table 6.2: *Applied assumptions*

1. The transmission speed of the present telephone system is not generally sufficient for videoconferencing, in reality ISDN, some form of DSL (Digital Subscriber Line)[303] or a communications system using mains cables[299] may be required. The necessary cost for such systems has not been included due to the uncertainty of possible charges. The history of telecommunications suggests that these costs are likely to fall with time. Comparison is therefore made with the present running costs, namely 4.2p minimum charge for short calls and an average of 1.5p a minute for calls in excess of the imposed minimum charge.
2. Throughout the analysis it is assumed that each user has a telephone, (93% of older households had a telephone in 1994[84]).
3. For the purpose of costing, all present and proposed users have a pendant system.
4. For the present system the life expectancy of home based equipment is 5 years[240] while for the proposed system this is expected to increase to 10 years. Life expectancy of warden scheme and control centre equipment is identical.
5. There are 11,618 community alarm users, living in sheltered housing and/or the general community.
6. 5% of units and 18% of pendants need replacing annually with the present system[240]; it is estimated that this will reduce to 3.5% of units and 16% of pendants with the proposed system. A 'faulty' home unit in the present system is replaced with a new unit, whilst the proposed system with self testing, will indicate which module needs replacing at a cost of £30 per hardware module, not including fitting. The cost of a replacement pendant is £50, plus fitting for both systems[240].
7. The proposed system requires a small sensor unit in each room, in certain rooms and dwellings mains power will not be available; it is thought that this may account for 90% of users each requiring an average of 5 batteries. The remaining 10% having fully hard-wired systems with mains power. Battery life is expected to have a mean of 5 years and require replacement by a trained installer, not a warden, friend or family member.
8. Hospitals have access to the pool of data held at the community alarm control centre (EPR) without incurring additional costs. It is presumed that the data collection costs upon admittance with the present system will be the same with the proposed system. However, a saving in time is highly probable with the proposed system and therefore a further potential saving.
9. Human resources are available and transferable, therefore additional community carers are available where necessary.
10. No borrowing is needed in year 1 for the present system. Only expenditure in addition to this is subjected to borrowing at the base rate of 6% as of April 2000[378].
11. No borrowing is required in year 5 for the present system to replace existing equipment.
12. The residual value of assets (the value of an asset at the end of it's 'useful economic life')[379] is said to be zero.
13. Where specific figures for community alarm users are not evident, it is assumed that figures for older people can be used. This is based on 87% of the community alarm users in sheltered housing in Birmingham aged 65 and over[240] while the average age of new tenants entering Hanover Housing Associations sheltered housing schemes is 78[78].

## 6.5 Model Costs And Benefits

For each of the five identified key areas, home environment, community alarm control centre, GP surgery and primary care system, hospital environment, and residential care, the costs and benefits are presented on the spreadsheet provided on the accompanying CD. However, for demonstration purposes the GP surgery and primary care system has been reproduced in Table 6.3. The current system describes the costs and benefits for the present community alarm system while the proposed telecare system indicates the impact of the alternative, intervention system.

Table 6.3: *Costs and benefits for the GP surgery and primary care system*

| **Variables** | **Current System** | **Proposed System** |
|---|---|---|
| Average time for a surgery consultation (mins) **[1]** | 8.4 | 8.4 |
| Average time for a home visit (mins) **[2]** | 13.2 | 13.2 |
| Average travel time for a home visit (mins) **[3]** | 12 | 12 |
| Number of times medical measurements are outside of agreed parameters [229] | | 1 |
| Additional phone time required prior to virtual consultation (mins) **[5]** | | 2 |
| Additional calls for patients not taking medication **[6]** | | 0.03% |
| Average time needed for patients not taking medicine (mins) **[7]** | | 8 |
| Time required to set up clients medical monitoring parameters (mins) **[8]** | | 10 |

| | | |
|---|---|---|
| Average number of surgery consultations **[9]** | 5.07 | 5.07 |
| Average number of home consultations **[10]** | 1.43 | 1.43 |
| Average additional time required for a virtual consultation **[11]** | | 2.4 |
| Percentage of unsuccessful virtual consultations (surgery based) **[12]** | | 0.5% |
| Percentage of unsuccessful virtual consultations (home based) **[13]** | | 1.0% |
| Phone line time required for a virtual consultation (prev surgery) (mins) **[14]** | | 12.8 |
| Phone line time required for a virtual consultation (prev home visit) (mins) **[15]** | | 17.6 |
| GP travel cost for a home visit [377] | £12.03 | £12.03 |
| GP's charge per minute **[17]** | £0.84 | £0.84 |
| Percentage of consultations requiring parameters in the home to be edited **[18]** | | 15% |
| Number of GP's **[19]** | | 574 |
| Cost for each GP/nurse being able to videoconference **[20]** | | £560.00 |
| Number of nurse visits (week) **[21]** | 232 | 232 |
| Average nurse travel time to client (mins) **[22]** | 15 | 15 |
| Average duration of nurse visit (mins) **[23]** | 12.5 | 12.5 |
| Number of nurse visits per day per nurse **[24]** | 7.96 | 8.30 |
| Nurse charge per day including overheads **[25]** | £161.54 | £161.54 |
| Saving due to early detection and cheaper prescriptions **[26]** | | £11.16 |

**Description points**

1. This is the average duration of a GP consultation performed in the surgery. Obtained from the General Medical Practitioners' Workload Survey 1992-93[380].

2. The average duration of a GP consultation performed in a patient's home. Obtained from the General Medical Practitioners' Workload Survey 1992-93[380].

3. The average GP travel time required when performing a home visit (includes return travel time). Obtained from the General Medical Practitioners' Workload Survey 1992-93[380].

4. Due to the medical monitoring equipment in the home, physiological data will be gathered and compared with allowable parameters, defined by the GP. This value indicates that during the first year of operation each user, in addition to the normal number of consultations, will require an additional consultation because they are outside of the initial parameters defined by the GP. In subsequent years when users are outside of their allowable parameters, consultations are incorporated as one of the average consultations performed throughout the year and indicated in description points **9** and **10** below.

5. When performing a virtual consultation in order to ensure efficiency a patient is contacted 2 minutes prior to the consultation to ensure that they are present and ready. Whitten *et al* suggest 2 minutes based on a videoconferencing trial with nurses[381].

6. Through the use of an automatic drug dispenser in the proposed system, the home equipment can indicate if medication is not being taken. The figure shown is an estimate of the percentage of people who this may account for. The detection of non-compliance must be agreed between the doctor and patient or representative of the patient before such monitoring takes place. The difficulty of prescription non-compliance together with other adverse drug reactions is a major problem with older people in many developed countries[382], although obtaining a figure for this has not been possible.

The detection of non-compliance may result in the GP inheriting costs which previously they may not have observed, previously prescription non-compliance may have by passed the GP and resulted in hospital admission instead. The preventative measure of detecting non-compliance early on should result in the overall health zone saving money because the patient's health should not deteriorate by as much. When the GP is informed of non-compliance it is presumed that a virtual consultation takes place and the time needed for this described in **7**. In addition to the virtual consultation there are 3 telephone calls in this process. One from the home to the GP raising the alarm, the GP updating the control centre home record (EPR) and it is presumed that the control centre will contact the home and amend the parameters when the home based system is to alert the GP of non-compliance. This is based on the assumption that the GP will want to increase the monitoring of the drug regime and be informed of non-compliance earlier than at present.

**7.** Indicates the average virtual consultation time required for patients who have not complied with their drug regime. It is presumed that only 1 consultation is necessary.

**8.** When the proposed system is first installed in a users home, the doctor needs to define the initial medical parameters for the medical monitoring equipment. It is assumed that this is achieved through a remote consultation. However, it could be achieved by a nurse or become part of a normal GP consultation. It could also be included in the compulsory annual screening for people 75 and over[10].

**9.** This indicates the average number of consultations that older people, and by implication community alarm users receive, per annum, at the surgery. A 1994 Office of Population Censuses and Survey suggests that those aged 65 to 74 have 6 consultations and those aged 75 and over have 7[45]. In Birmingham of those people aged 65 and over, 52% are 65 to 74, and 48% aged 75 and over[383]. Therefore a split of 50:50 has been used to indicate the number of consultations per user per annum, resulting in a figure of 6.5 consultations per annum.

In 1994[84] the average number of surgery consultations was 69% for people aged 75 and over and 87% for those aged 65 to 74. Taking the 50:50 split again indicates that 78% of consultations are performed in the surgery and 22% in the home. For each user this represents a figure of 5.07 consultations per annum for surgery-based consultations and 1.43 for home visits.

It is evident that in the proposed system the number of consultations remains the same however, this can be altered from the 'Cost analysis' worksheet, (see cells A:25 and A:26 in Appendix A6.1 or the accompanying CD).

**10.** Explanation is provided in **9**.

**11.** As indicated in **1** present surgery based consultations are approximately 8.4 minutes in length while home consultations take an average of 13.2 minutes **2**. Telephone consultations with a GP currently requires 10.8 minutes[380], which is 2.4 minutes longer than a present surgery based consultation, this additional 2.4 minutes has been added to the virtual consultation times. Therefore, a virtual consultation that was previously a surgery visit is set at 10.8 minutes, while a virtual consultation that was previously conducted as a home visit is calculated as 15.6 minutes.

It would be anticipated that a virtual consultation would require less time than a telephone consultation due to the ability to see images, however a conservative outlook has been sought throughout the model and the full additional time included. Currently telephone consultations represent 12.3% of all GP consultations[380], however details of what proportion of older people use this method has proved unobtainable and hence telephone consultations have not been given specific attention. Rather they are assumed to be part of the normal number of consultations defined in **9** and **10**. It could be suggested to distribute telephone consultations according to the proportion of the population who are aged 65 and over, however it was considered that such a breakdown would be speculative and that telephone consultations for older people were more likely to result in a physical consultation. This is because patients who describe vague symptoms associated with chronic conditions over the telephone are considered as difficult to assess by doctors because of uncertainty whether symptoms indicate something new or are part of a 'long-standing illness'. The result is that such difficult cases often result in a physical consultation[384]. According to the Department of Health[244], 41% of those aged 65 and over suffer from such 'long-standing illnesses'.

The percentage of consultations to be performed virtually is indicated on the 'Cost analysis' worksheet (see cells A:27, A:28 in Appendix A6.1).

**12.** It is recognised within the model that some virtual consultations may not provide the necessary information and that an additional consultation is required. This parameter indicates the percentage of unsuccessful virtual consultations that then require a consultation in the surgery.

**13.** This parameter indicates the percentage of unsuccessful virtual consultations that would require a further home visit.

**14.** This indicates the telephone time required for a virtual consultation that was previously based in the surgery. It includes the telephone line time before a consultation as indicated in **5**, the duration of the consultation **1**, and the additional consultation time **11**.

**15.** Indicates the required amount of telephone time required for a virtual consultation that would previously be a home visit.

**16.** An estimate is made for the monetary cost of travelling for a home visit. This is calculated from the average travel time for a home visit **3** being 12 minutes, which assuming an average speed of 30 mph would indicate an average journey of 6 miles. Using a cost of 33p a mile would equate to approximately £2 per home visit, while 12 minutes travel time is included based on the cost per minute described in **17**.

**17.** The monetary cost of each minute of a doctor's time is suggested. This is calculated from estimating the average annual doctor's wage at £45,000 and charges for office space and human resources as a multiplier of 2.25. The resulting figure of £101,250 is then represented as a charge per minute. In calculating the charge per minute no account is taken for annual leave, therefore the time denominator is calculated as indicated in Equation 6.1.

$$\text{number of weeks in a year} * \text{average number of hours worked}^{15} * \text{number of minutes in an hour}$$
$$= 52 * 38.84 * 60 \qquad 6.1$$

**18.** This indicates the percentage of GP consultations that require the parameters in the home record to be altered, i.e. changing the home record to reflect changes in drug regime, for an automatic drug dispenser or altering the parameters for generating alerts from the lifestyle monitoring sub-system.

**19.** In Birmingham there are 242 GP practices and 574 GP's[385]. In order that all of the GP's can perform videoconferencing each of them is provided with the necessary equipment on a 1-to-1 basis.

**20.** Based on the home equipment cost for a user, 80% of this cost represents the cost of the GP and nurse equipment. This allows the GP and nurse to effectively communicate with patients for videoconferencing and also have access to the community alarm control centre and home record (EPR). The cost also includes additional telephone exchange technology.

**21.** This figure shows the number of nurse visits to community alarm users in a week. This figure is estimated from the survey results in Chapter 3. Access to the exact information for Birmingham City Council has not been possible.

**22.** The average travel time in-between nurse visits. This is based on some local authorities averaging the travel time of carer visits at 15 minutes[386].

**23.** The average duration of nurse visits in the UK has been suggested at between 10 and 15 minutes, an average has been taken for the model[381].

**24.** Shows the average number of nurse visits achieved by a single nurse in any given day, based on the information provided above. For demonstration purposes the figure of 8.30 for the proposed telecare system includes 7.5% of nurse visits being performed virtually, clearly the more consultations performed via videoconferencing, the greater the number of consultations performed as videoconferencing reduces the travel time.

**25.** This figure is an estimate of the daily cost of a nurse. It is calculated on the basis of £14,000 as a wage and a multiplier of 3 as an overhead. This figure is then divided into a charge attributable to a day. The overhead of 3 includes car and transport costs, as well as office space. The overhead is

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[15] The average number of hours worked by GP's is 38.84[380].

considered the same in the proposed system, although efficiency will improve through the use of virtual nurse visits.

**26.** Due to the prevention element of the remote medical monitoring, it is believed that less expensive 'strong' medication will be needed, as treatment can begin earlier than at present. There are also savings in terms of a reduced treatment period and, hence fewer drugs in certain circumstances. The figure presented is derived from the basic cost of prescription items dispensed in 1995 as £3,681 million[387], with older people accounting for 25-30% of this expenditure[388]. For the purpose of the analysis the average is assumed at 27.5%, giving a total cost on prescription drugs for older people as £1,012m.

Taking an average of the number of people aged 65 and over in the UK from Age Concern[16][389], the Institute on Ageing[17][29] and the Joseph Rowntree Foundation[18][32] gives a mean of 9,071,226. Therefore, the prescription costs per older person is £1,012/9,071,226 = £111.59. For the reasons stated it is assumed that this can be reduced by 10% per person per annum, giving a saving of £11.16 per user

## 6.6 Model Variables

The above indicates what the baseline figures are for the GP surgery and primary care system, each of the five identified sections of the model are structured in the same way. The opening worksheet titled 'Cost analysis' (see Appendix A6.1 or the accompanying CD) presents the results and allows the investigation of what may be considered as the main components. This allows the easy investigation of different scenarios to be investigated. These are highlighted on the 'Cost analysis' worksheet from cells A:24 to A:38 in Appendix A6.1; with each variable having the capability to be modified for any of the 10 years in the system cycle; therefore allowing the impact to be investigated as the system becomes more widely implemented. The particular variables and generation of critical values for investigation are:

*Duration of hospital stay*

A 1998 figure for people aged 65 and over from Hospital Episode Statistics indicates a mean stay of 10.03 days in Birmingham and a mean stay of 9.5 days on a national scale[251]. The national figure has been used as the baseline in the calculations as the population base to derive this is greater than that of Birmingham.

According to Government Expenditure Plans[390], the average unit cost for acute care is £990 per case, the duration of which was 6.7 days. The duration is less than that used as the baseline because this accounts for people of all ages with younger people traditionally being discharged earlier than older people. This figure is however used to calculate the average cost of an acute hospital bed per day as:

---

16 Suggest 9,186,000 people aged 65 and over
17 Suggest 9,036,000 people aged 65 and over
18 Suggest 8,991680 people aged 65 and over

$$£\frac{900}{6.7} = £147.76 \qquad 6.2$$

Similarly the cost of a geriatric bed per day is calculated at £135.35. The model uses an average of these figures (£141.56) to account for the fact that older people will be present in both sections of the hospital.

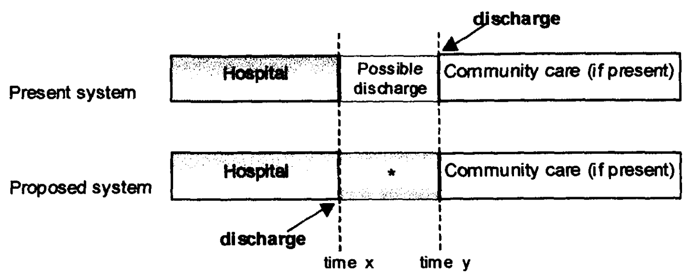
In addition to conventional community alarm users, it may be beneficial to provide some hospital patients with a community alarm for a short period after discharge. Further diagnostic enhancements, targeted at specific medical conditions, could in future be added to the telecare system if required[147]. Such options have not been included in the model due to the uncertainty of estimating the percentage of people for whom this may be possible and the uncertainty of operating costs.

Published literature indicates that one of the benefits of telecare and telemedicine is early release from hospital[58, 135, 298, 357]. However, an indication of exactly how much earlier discharge could be are lacking. In order for the model to represent changes that may occur it is necessary to accurately predict the impact of the proposed system and obtaining such figures can be difficult. A review of the UK literature could not uncover any suggested figures for the impact of telecare on the duration of a hospital stay. However, an American study by Roush *et al*[171] analysed 106 people with an average age of 79, one year before they were provided with a community alarm and subsequently one year after its installation. In terms of the duration of hospital stay the results indicated that there was a reduction from 9.2 to 5.7 hospital days per user. Other evidence to support these results is not forthcoming, and the shortcomings of the Roush study may be suggested as:

- The study is based in America, and comparing the results to the UK may not be representative.
- Community alarm users may be not be in the same health state as their UK counterparts.
- The intervention was a community alarm and this cost analysis uses the community alarm user as its base and seeks to investigate the intervention as a telecare system.
- Inadequate sample size (106) to be conclusive.

The actual figures used throughout the model were derived from a review of the literature and discussion with the project review group (Prof. D Bradley, Pentyre, HET, TeleLarm, Birmingham City Careline service). The model therefore reduces the duration of a hospital stay from 9.5 to 8.5 days, although investigation of the various sensitivity analyses allows this reduction to be altered.

In reducing the duration of a hospital stay it is recognised that early discharge from hospital and technological home monitoring cannot provide the hands on care that some people may require. In order to address this the model incorporates additional nursing and home care in the community immediately after discharge and in addition to any care plan that may be in place. This is graphically represented in Fig. 6.2.




* Advanced community alarm and additional community care.

Figure 6.2: *Achieving early hospital discharge*

The number of additional home care visits is calculated as:

Additional Home care visits =
(Average hospital duration in present system – Average hospital duration in proposed system) * 1.5     6.3

Therefore, if in year 5 of the 10-year system life cycle the average duration of hospital stays is suggested at 8.5 days, and the present system maintains the current duration of 9.5 days, then the average number of additional home carer visits per discharge is estimated at (9.5-8.5) * 1.5 = 1.5. A cost of £10[71] for each visit is used.

The average number of additional nurse visits is calculated by Equation 6.4 with the cost estimated by Equation 6.5.

Additional nurse visits =
0.85 * (Average hospital duration in present system – Average hospital duration in proposed system) 6.4

$$\frac{\text{Daily nurse cost[25]}}{\text{Number of nurse visits per day [24]}} = \frac{161.54}{7.96} \approx £20 \qquad 6.5$$

*Percentage of admissions to hospital*

As previously indicated, 32.4% of people aged 65 and over can be anticipated to receive hospital treatment each year. The model presumes this figure as the present system figure and provides the capability to increase or decrease this figure over the 10 years of the proposed telecare system.

Although there is published literature to suggest telecare could achieve early discharge from hospital there does not appear to be any evidence that telecare could reduce the number of people admitted to hospital. It would appear there is agreement that telecare can be used in prevention, drawing attention to medical situations at the earliest possible juncture, but no evidence exists to suggest this will reduce the number of people entering hospital. Referring to the American study by Roush *et al*[171] indicates that a 25% reduction in hospital admissions was observed, specifically hospital admissions fell from 1.18 to 0.88 per person. The model incorporates a reduction from 32.4% to 32% in order to maintain a conservative outlook, although this decrease is altered in the sensitivity analyses.

*Bed Blocking*

Of those in hospital at any one time, 20% of people aged 75 and over are ready for discharge but the appropriate arrangements or provision has not been made[320]. Similarly people 65-74 may also be 'bed blockers' but an authoritative figure has proven difficult to obtain and as such any reduction that may be obtained for people of this cohort has not been included. Due to the improved access and greater amounts of information stored at the community control centre and indicated in Chapter 5, the proportion of people termed as 'bed blockers' should decline. It could also be easier to find accommodation in residential homes as discussed below. In order to maintain a conservative outlook it is assumed that the people who 'block' beds, do so for only 1 day.

*Residential Care*

Residential care is provided for those individuals who, even with domiciliary support, cannot manage to live in their own homes, but who still do not need intensive nursing care[3]. Tinker suggests that 5% of older people live in some form of institutional care; mainly old people's homes or hospitals[3]. Figures for Birmingham suggest that some 3.5% of older people live in residential care[252] and this lower figure is used in the model as it is believed this has a greater accuracy. Assistive technologies and telecare have the potential to provide an infrastructure to support people in the community instead of residential care. For instance, in West Lothian, Scotland, there is a plan to replace 3 residential homes with 105 smart houses linked by telecare services[142].

Within the cost analysis model it is possible to reduce the percentage of the population in residential care to zero or alternatively increase it. Many older people view residential care as a last resort[10, 391] and because of this for each new person entering residential care the model provides the capability to delay entry. In a similar fashion to the earlier discharge from hospital, additional community support is provided during this 'delay' period. This consists of extra carer visit every day and 3 additional nurse home visits (physically in the home) per week, however these figures can also be altered to investigate the impact of changes. The period of 'delay' is estimated at 8 weeks, but provision for modifying this 'delay' period is provided.

*Change in the number of consultations*

One of the consequences of the introduction of the proposed telecare system is that with the medical monitoring in the home, greater efforts will be made in prevention, identified as a key goal of western governments. As medical problems are diagnosed earlier than at present it may result in a single GP consultation being sufficient as opposed to two or more consultations if the users health deteriorates to the point when they seek medical intervention. Conversely, medical monitoring in the home may result in the detection of medical problems that currently go by without notice; as a result the GP may encounter more consultations than at present. Evidently, the key is to accurately define the parameters for the home medical monitoring equipment in order to ensure that inappropriate alerts are not generated.

The model includes the possibility to both increase and decrease the number of surgery consultations and home visits. It should be noted that an analysis of the literature reveals that no attempt has been made to estimate the impact of telecare systems on the GP. It would appear there is recognition of a general move from secondary to primary care, with increasing numbers of patients being discharged earlier from hospital to community services[392] but this trend is likely to be accelerated with the implementation of telecare systems. The model also allows for changes in the number of nurse visits.

*Virtual consultations*
The use of videoconferencing could, at a relatively low cost, be incorporated into the primary care system. Small scale initiatives have proved to be a success[393] and it has been suggested that approximately 15% of nurse visits could be performed through this method, although this is likely to be an underestimation of the potential rather than vice versa[216]. A review of published literature does not reveal the proportion of GP consultations that could be performed virtually, however there is evidence to suggest the majority of a medical consultation is centred around speech and not necessarily sight[177].

The model provides the possibility to introduce virtual consultations as a replacement for GP consultations previously provided in the surgery and by home visits. Allowance is also given to nurse consultations being provided by this method. As indicated by description points **12** and **13** above, it is recognised that some consultations performed virtually will not provide the necessary information and that an additional physical consultation will be required.

*Emergency Services*
Published literature indicates that one of the benefits of telecare and telemedicine is a reduction in ambulance calls[72]. This may be achieved through a reduction in the number of people being transported to hospital, while early diagnosis ensures that for some people an emergency admission to hospital can be avoided. Agreeing a saving has not proved possible and hence savings, although likely to be evident by the ambulance service, are not included in the model. Details of possible savings are highlighted on the 'Emergency services' worksheet in Appendix A6.5. Despite the uncertainty and ultimately the removal of financial savings for the ambulance service from the model, it is accepted that there will be a change in the number of telephone calls observed at the control centre. This change has been included as the associated costs are known. (See 'Control centre C:12, Appendix A6.3)

Savings for the police service could also be observed in the proposed telecare system. It is estimated that an advanced security system will reduce the amount of crime encountered by telecare users in their homes by 20%[394]. Alongside the direct financial benefit to the police of reduced crime and burglary there could also be a reduction in the stress experienced by users with one publication suggesting 25% of older people feel unsafe in their own homes during the day, increasing to 40% at night[41]. Again, quantifying an appropriate financial saving for reduced crime has proved difficult and therefore is not included, although a reduction in the number of telephone calls to the control centre is included.

In total, an estimate of the overall savings achieved by the emergency services and directly related to the proposed telecare system could be in the region of £8-£14 per user per annum. Such a figure is not universally agreed, and is not therefore included in the analysis.

## 6.7 Conclusions

There is no question that there is a need and desire from academics and professionals for a greater understanding of the financial implications of telecare and telemedicine. However, as demonstrated developing a tool to investigate the potential is not a straightforward task while access to the appropriate information is a time consuming exercise.

The model created is based upon standard health economic evaluations as suggested by the NHS Research and Development Health Technology Assessment programme. Accounting procedures have been adhered too and the Historical Cost Accounting (HCA) protocol used. As such no account of inflation is included as the profits are exaggerated and therefore the use of HCA provides confidence that figures have not been manipulated to give one impression rather than another.

A conservative outlook has been sought concentrating on tangible benefits. Intangible benefits, such as a reduction in travel time and cost for patients, an increase in social contact for those who seek it, a reduction in stress and anxiety for patients and their relatives, all of which are likely to add to the overall savings have not been included. By concentrating on the attributable and quantifiable cost variables, and hence a conservative outlook, a greater degree of confidence in the outcome can be secured.

The model compares the current community alarm system and compares a proposed telecare system over a 10-year system life cycle. The model enables many of the proposed telecare system parameters to be modified, enabling particular themes to be investigated. Therefore, enabling the highlighted sensitivity analyses to be performed.

The model developed has various Microsoft Excel worksheets which contain the 5 key areas, for example home environment, community alarm control centre, etc. The costs and benefits for each of these areas are identified and presented as indicated by Table 6.3. Each value can be altered, however the figures used for the key areas are the most accurate ones available. The opening worksheet 'Cost analysis' (see Appendix A.6.1) allows various scenarios to be run and values altered as this worksheet considers the impact and 'take-up' of the intervention system and not specific costs. Chapter 7 discusses and presents the results obtained from the model.

# 7 Cost Analysis Results

***Chapter structure:** Having created a cost analysis tool the model is investigated and the results reported using various economical assessment procedures.*

The formulation of a cost analysis spreadsheet provides the capability of generating a very large number of results and consequently there can be difficulty in presenting them. This chapter therefore presents an expected model, where the parameters and changes in service delivery are anticipated, before using the various forms of sensitivity analysis identified in Chapter 6:

- *Single point analysis*: varying a single point within an allowable range.
- *Threshold analysis*: defining the system performance in order that the proposed system is profitable.
- *Multiway analysis*: varying key parameters within a possible range of values.
- *Extreme scenario analysis*: examining the system with a pessimistic and optimistic outlook.

## 7.1 The Expected Model

In order for the proposed telecare system to be used more in a preventative way, advanced and hence more expensive technologies will be required. Table 7.1 indicates the initial expenditure for the present community alarm system and the proposed telecare system. The figures are based on a city such as Birmingham assuming a total of 11,618 users.

Table 7.1: *Comparison of initial system expenditure*

| | Cost (£) | |
|---|---|---|
| **Technology costs** | Present system | Proposed telecare system |
| Technology cost of home based equipment | £175[19] | £700[20] |
| Home based equipment cost | 1,909,000 | 7,487,000 |
| Warden schemes | | 141,000 |
| Control centre | | 50,000 |
| GP and nurse equipment | | 337,000 |
| **Sub total** | **1,909,000** | **8,015,000** |
| **Installation and training** | | |
| Creation of each users computerised medical home record for telemedicine | | 97,000 |
| Installation of home based equipment inc. training of end users | 208,000 | 262,000 |
| Installation of GP/nurse equipment | | 15,000 |
| Staff training at 10-20% of capital costs[21] 20% is used as a conservative measure | 71,000 | 176,000 |
| **Sub total** | **279,000** | **550,000** |
| **Total Initial expenditure** | **2,188,000** | **8,565,000** |
| ***Additional expenditure for proposed systems*** | | **6,377,000** |

In order to compare the two system costs of the present and proposed system over a 10-year system lifecycle it is necessary to include all of the present system costs. For example, the cost of staff training are included in the present system, although in reality this cost would not be evident as the system is

[19] Personal Communication, Ms Pauline Poole, Birmingham City Council, Careline manager.
[20] Personal Communication with suppliers (TeleLarm, Technology in Healthcare) and the project review group.
[21] Between 10-20% of capital costs is needed for re-engineering in order to achieve maximum potential[395].

already operating. However, in order to directly compare one system with another, these costs must be included, as they are relevant to the purpose of decision making as described by Drury[369].

It is evident that the capital and related costs of the proposed telecare system are approximately 4 times that of the present system. These costs do not however show the complete cost, only relevant costs; therefore the real figure for both systems will be higher. For example, the cost of the control centre and warden equipment is evident in both, but in terms of making a decision, only the additional equipment costs for the proposed telecare system are included. The home based equipment in the community alarm system has a life expectancy of 5 years, while in the proposed telecare system this is set at 10 years. In order to compare both systems over a 10 year lifecycle it is therefore necessary to replace all of the community alarm home based equipment in the fifth year of operation. This costs approximately £2m. Even with this cost included, equipment costs for the proposed telecare system would still be approximately 50% more, comparing £4.1m to £8.6m.

*Possible savings*

If the cost of installing a system based on advanced, and hence more expensive, technologies is to be financially justified there must be compensating savings. Maintenance savings of £64,000 per annum are indicated in Table 7.2, saving £0.64m over the 10-year system life cycle, an almost insignificant amount.

Table 7.2: *Maintenance expenditure*

| ***Description*** | ***Cost (£)*** | |
|---|---|---|
| **Maintenance expenditure** | **Present system** | **Proposed telecare system** |
| Home based equipment | £99,000 | £17,000 |
| GP and nurse equipment | | £1,000 |
| Pendant and battery replacement | £127,000 | £144,000 |
| **Total maintenance expenditure** | **£226,000** | **£162,000** |

If the proposed telecare system is to be cost-effective then there must be significant operating savings to finance the initial expenditure. The 2nd and 3rd generation telecare systems enable more advanced communication possibilities and consequently the present health, care and support system will need to adapt to these changing circumstances, Table 7.3 indicates the change in specific areas. It should be noted that the proposed telecare system does not radically change service delivery in the first year of operation, instead the change is gradual as the use of telecare services become more widespread. The operating figures for the present system are the same throughout the system lifecycle and this is a reasonable assumption based on the community alarm system not altering in the last 10 years[115].

Table 7.3: *Service implications for the proposed telecare system*

| *Affect on service providers of proposed system - Community alarm users only* | **Present system** | *Operational year of the proposed telecare system* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Yr 1** | **Yr 2** | **Yr 3** | **Yr 4** | **Yr 5** | **Yr 6** | **Yr 7** | **Yr 8** | **Yr 9** | **Yr 10** | |
| Reduction in GP surgery consultations (physical and virtual) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | % |
| Reduction in GP home visit consultations (physical and virtual) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | % |
| Percentage of GP surgery consultations to become virtual | | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | % |
| Percentage of GP home visit consultations to become virtual | | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | 35 | 37.5 | % |
| Percentage of nurse visits to become virtual | | 7.5 | 10 | 12.5 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | % |
| Probability of a community alarm user being admitted to hospital (percent). | 32.4 | 32.2 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | % |
| Average duration of a hospital stay for client base. | 9.5 | 9 | 8.75 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | Days |
| Average additional care visits due to early hospital release (per discharge) | | 0.8 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | Days |
| Average additional nurse visits due to early hospital release (per discharge) | | 0.4 | 0.6 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | Days |
| Percentage of people in hospital delayed in discharge – Bed blockers | 20 | 18 | 16 | 14 | 12 | 10 | 10 | 10 | 10 | 10 | 10 | % |
| Percentage of people in residential care | 3.5 | 3.38 | 3.25 | 3.13 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | % |

Using these service delivery changes within the cost analysis model reveals that there is the potential for significant savings, as identified in Table 7.4. It should be noted that the population size is based upon 11,618 and not the total number of older people in Birmingham. For example, the number of people presently admitted to hospital can be calculated as:

$$0.324 \times 11{,}618 = 3{,}764\,persons \qquad 7.1$$

with a hospital stay of 9.5 days at a daily cost of £141.56. Therefore, the total cost for hospital admissions in the present system is:

$$3{,}764 \times 9.5 \times 141.56 \approx \pounds 5\ million \qquad 7.2$$

including the cost of bed blocking indicates the total cost, as is shown in Table 7.4.

Table 7.4: *Operating expenditure in the present and proposed systems*

| Operating costs (£ x 000) | Present system | Proposed telecare system Year 1 | Year 3 | Year 5 | Year 7 | Year 10 |
|---|---|---|---|---|---|---|
| Forced entry to properties | 23 | 18 | 18 | 18 | 18 | 18 |
| Unsuccessful carer visits | 3 | ≈ 0 | ≈ 0 | ≈ 0 | ≈ 0 | ≈ 0 |
| Telephone (inc. control centre, GP/nurse) | 14 | 36 | 33 | 34 | 35 | 37 |
| GP surgery consultation | 413 | 526 | 330 | 336 | 342 | 351 |
| GP home visit consultations | 383 | 330 | 322 | 314 | 306 | 294 |
| Nurse visit (change to virtual consultations) | 245 | 147 | 143 | 142 | 142 | 142 |
| Hospital bed costs | 5,098 | 4,858 | 4,618 | 4,611 | 4,611 | 4,611 |
| Residential care | 5,603 | 5,392 | 4,993 | 4,793 | 4,793 | 4,793 |
| **Total** | **11,782** | **11,307** | **10,457** | **10,248** | **10,247** | **10,246** |

At present if a community alarm is activated and the control centre operator cannot obtain a response from the user, this can lead to a forced entry to the property as the operator is unsure if the caller needs assistance. It may have been a cat activating a pull cord or the caller may have collapsed after activating their community alarm. Forced entry to a property can also be sought if the warden on a sheltered housing scheme is concerned for a residents well being, as they believe they are in their home but conformation of the users well being cannot be obtained. The lifestyle monitoring element of the proposed system in combination with the security system can provide data concerning whether anyone is in the dwelling and hence only when forced entry is necessary will it actually occur. This can potentially save £5,000 per annum. Likewise, the lifestyle monitoring system can, in combination with individual carer's timetables and hospital admittance data, ensure that where users have been admitted to hospital, the appropriate carer's timetables can automatically be updated and unnecessary visits avoided.

The proposed telecare system relies on a telecommunications infrastructure to provide secure and accurate data transfer between relevant parties and the telephone variable in Table 7.4 gathers together all telephone operating costs for the proposed telecare system. Approximately 60% of the telephone costs originate from additional telephone calls between each users home and the control centre for data transfer, ensuring that data is 'backed up' and also testing the status of the telephone line on a regular basis.

The other large constituent (22%) of the telephone costs is due to videoconferencing for GP's and nurses. For the proposed telecare system it is anticipated that in the first year of operation there will be an additional virtual GP consultation for each user because they fall outside of parameters defined by the GP. In addition, there will also be a telephone cost in originally defining the medical parameters on the users home system and storing the data at the community alarm control centre in the EPR. These 'set up' costs explain why year 1 observes a greater expenditure than in year 3. After the initial 'set up' costs telephone operating costs increase due to the expected growth in virtual consultations expressed in Table 7.3. Overall telephone costs increase by in excess of 250% in the proposed telecare system.

Similar to telephone operating costs, the cost of surgery based consultations also increases in the first year. This is due to the costs involved in defining the medical parameters for each individual and for the anticipated additional consultation when they fall outside of these parameters. The gradual increase from the first year onwards arises from an increase in virtual consultations that replace some consultations previously carried out in the surgery. This type of consultation saves the patient time, without the need to travel to the surgery, but increases the time needed by the GP to perform their duties, assuming that a virtual consultation takes 2.4 minutes longer than a physical consultation in the surgery. It may be that patients would welcome such a possibility but it remains to be seen if GP's would be prepared to offer such functionality. However, GP home visit consultations produce savings from year 1 due to a reduction in the need to travel to a patient's home and the associated expenses. Any time saved for GP's has been included as a financial saving but the time saved has not been apportioned to any other activity.

Virtual nurse visits also result in reduced costs in the proposed system by reducing the need to travel to users homes. Thus, for each home visit performed through videoconferencing it is estimated that there will be a saving of 12.5 minutes travel time together with the associated costs. The increased telephone costs for videoconferencing are provided in the telephone section of Table 7.4. Table 7.3 shows that from year 4 onwards, the percentage of nurse visits that could be achieved through videoconferencing does not alter and hence the potential savings do not increase from this point.

Figures suggest that the NHS costs around £115m a day to run[396]. Table 7.4 indicates that the adoption of the proposed system in a city such as Birmingham, could save in the region of £250,000 in operating costs during the first year of operation, increasing to £500,000 in the fifth and subsequent years. It should be noted that such sums only take into account relevant costs such as 'bed blocking' and occupancy, and not the totality of possible savings. It is believed that further savings could be evident if more specialised equipment was provided for general patients on a short-term basis after discharge, as suggested in Chapter 6.

Table 7.4 indicates that one of the most significant savings is in the area of residential care. This is due to a reduction in the number of people in care declared in Table 7.3 and the 'delay' in entering care, the duration of the delay is estimated at 8 weeks in the expected model. Further reductions after year 4 are not evident because the variables defined in Table 7.3 do not alter from this point.

In total, on a conservative estimation Table 7.4 suggests that the proposed telecare system can save in the region of £475,000 in the first year of operation, while in the fifth year operating savings, in the order of £1.5 million are suggested. These calculations assume the present operating costs remain consistent throughout the 10-year life cycle. It may be that the operating costs decline but such savings would also be available to the proposed telecare system and under relevant costing accountancy procedures are not calculated.

*Financing*

Despite the significant potential savings in Table 7.4, if the proposed system is to be introduced it is clear from Table 7.1 that substantial initial borrowing would be required and this must be included as a cost of the proposed system. Assuming that the loan is paid for out of the proceeds of the project as profits occur, with an interest rate of 6% at the start of the first year there would be £6.4m outstanding. It is not until the fifth year that breakeven is achieved and thereafter a positive cash flow is secured. Continuing a conservative outlook it is assumed that no interest is gained on finance after the loan has been repaid. As such, by the end of the system life cycle, in year 10, there is an accumulated return in the order of £8.3m compared to the present system, as shown in Fig. 7.1.

If this sum were not absorbed elsewhere, this would effectively finance a new replacement system without the need to borrow in the future. The savings with future systems, 10 years hence, would then be even greater as the initial borrowing requirement would be removed and the relatively slow 'take up' of telecare suggested in Table 7.3 would be replaced with operating levels suggested in year 10 (of Table 7.3). At the end of year 10 it is probable that the proposed telecare system could be purchased again at a lower price than it would be today. Technology and systems develop and new enhanced systems would be available and sought after, offering improved functionality and further potential operating savings. Such systems would again be at the cutting edge of technology with an appropriately higher purchase cost.

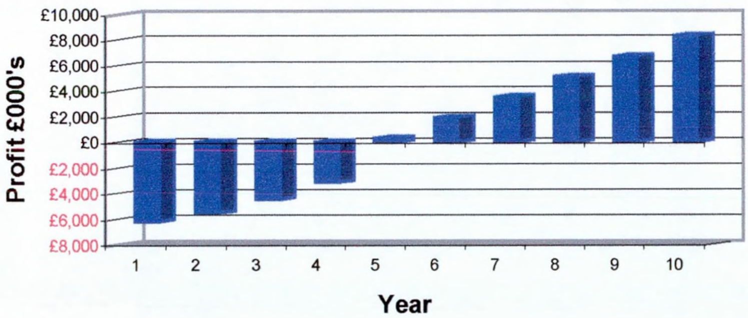



Figure 7.1: *Projected cash flow while paying the loan out of the proceeds of the project*

Fig. 7.1 indicates there is a significant increase in cash flow during year 5. This is due to the community alarm system needing to replace the home based equipment as it's life expectancy is only 5 years while the proposed telecare system has an expectancy of 10 years. The cost of replacing the community alarm equipment is approximately £2m and because it is not evident in the proposed telecare system, is a saving.

Fig. 7.1 uses an interest rate of 6% but Fig. 7.2 suggests that even if a higher interest rate is used there is still financial evidence for the development of telecare systems alongside the generally accepted qualitative benefits. Indeed, if the interest rate were raised to 14%, there is still a return of almost £5m at the end of the 10-year system life. Therefore, even at this rate the proposed system pays for itself and provides finance towards its own replacement.

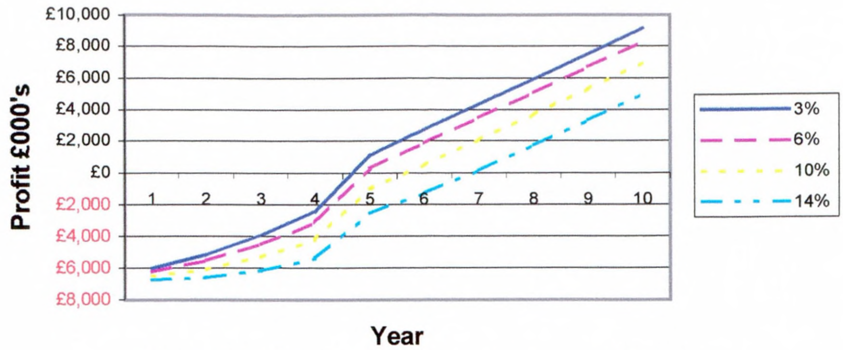



Figure 7.2: *The effect of interest rates on profitability*

An alternative funding regime to paying the loan off through the proceeds of the project as profits occur, i.e. as quickly as possible, is by paying the loan off over a fixed time period, typically at 5 and 10-year intervals. In each case the annual repayment is calculated on the basis of Equation 3 such that the loan is paid off at the end of the period.

$$\text{Balance\_Carried\_Forward} = \text{Starting\_Balance} + \text{Annual\_Interest} - \text{Annual\_Repayment} \qquad 7.3$$

Assuming the same interest rate, namely 6%, the annual repayment for the 5-year repayment model is £1,513,835 for the duration of the loan therefore requiring £7,569,175 to be repaid in total. This is slightly less than the previous repayment method (£7,917,599) but does not take account of the additional borrowing that would be required to cover the operating losses over the initial 4 years as depicted in Fig. 7.3. At the end of the 10-year system life cycle, based on this repayment method, the proposed system approaches a saving of £8.7m

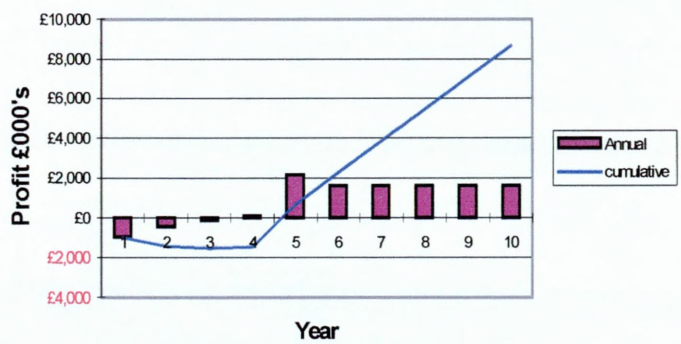



Figure 7.3: *5-year repayment model*

The 10-year repayment method represented by Fig. 7.4, requires an annual repayment of £866,406 and a total loan repayment amount of £8,664,060. Consequently, compared to the previous repayment methods the total system saving is reduced to £7.6m. However, this method ensures that a positive cash flow is observed earlier than either of the previous methods. Indeed, a positive cash flow is evident in the second year of operation.

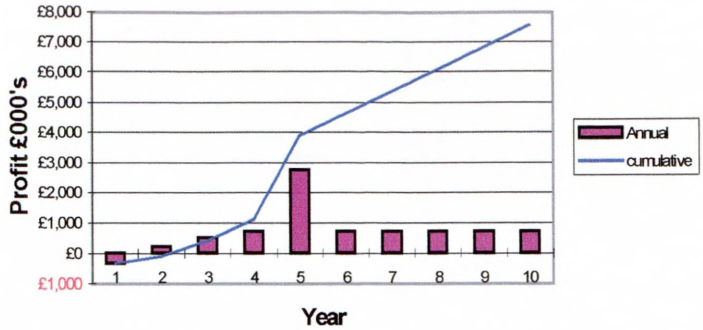



Figure 7.4: *10-year repayment model*

The repayment method employed should be determined by available finance when installation commences. If finances are available, then the model indicating the greatest long-term financial rewards are to pay off the loan as quickly as possible, for example using the first method. However, providers observe no financial rewards until the loan is repaid in year 5. If financial rewards are required at an early stage than prolonging the loan ensures an earlier return on investment but consequently less total return than may other wise be possible.

## 7.2 Single Point Analysis

The expected model indicates substantial financial savings using £700 as the cost of equipment in the home. This figure was based on the technical developments highlighted in Chapter 4 and discussions with manufacturers. However, as the technology is not commercially available there is an uncertainty with the accuracy of this figure. The use of the single point sensitivity analysis therefore allows investigation of the expected model but changes the home based equipment cost to £500 and £1,000. Table 7.5 describes the changes this makes to the initial system expenditure.

Table 7.5: *Comparison of initial system expenditure when the home based equipment cost is varied*

| **Technology costs** | Cost (£) Present system | Proposed telecare system | | |
|---|---|---|---|---|
| Technology cost of home based equipment | £175 | £500 | £700 | £1,000 |
| Home based equipment cost | 1,909,000 | 5,362,000 | 7,487,000 | 10,675,000 |
| Warden schemes | | 141,000 | 141,000 | 141,000 |
| Control centre | | 50,000 | 50,000 | 50,000 |
| GP and nurse equipment | | 241,000 | 337,000 | 482,000 |
| **Sub total** | **1,909,000** | **5,794,000** | **8,015,000** | **11,348,000** |
| **Installation and training** | | | | |
| Creation of each users computerised medical home record for telemedicine | | 97,000 | 97,000 | 97,000 |
| Installation of home based equipment inc. training of end users | 208,000 | 262,000 | 262,000 | 262,000 |
| Installation of GP/nurse equipment | | 15,000 | 15,000 | 15,000 |
| Staff training at 10-20% of capital costs[22] 20% is used as a conservative measure | 71,000 | 157,000 | 176,000 | 205,000 |
| **Sub total** | **279,000** | **531,000** | **550,000** | **579,000** |
| **Total Initial expenditure** | **4,097,000** | **6,325,000** | **8,565,000** | **11,927,000** |
| ***Additional expenditure for proposed systems*** | | **2,228,000** | **4,468,000** | **7,830,000** |

Evidently if the home based equipment cost is £500 the proposed telecare system is 50% more expensive, while if the home equipment cost £1,000 additional funding in the region of 275% or £7.8m would be required. Clearly the cost of this equipment has a substantial impact on the initial expenditure and therefore on the likely profitability of the proposed telecare system. Paying the loan off through the proceeds of the project as profits occur, i.e. as quickly as possible, reveals that at the end of the system life cycle, at £500 a return of £11.3m is possible. However, when using £1,000 as the home based equipment cost this is reduced to an overall return of only £3.3m as indicated by Fig. 7.5. Nevertheless, it should be noted that the system is profitable and in combination with the qualitative benefits for telecare would suggest that the proposed telecare system is more desirable than the community alarm system for all parties.

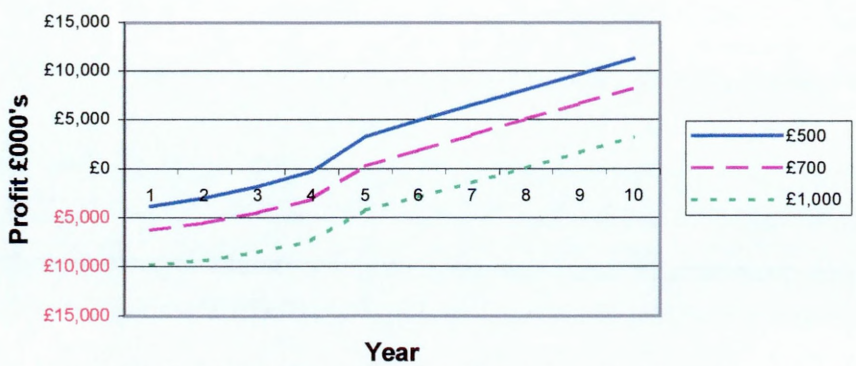



Figure 7.5: *The effect of varying the home based equipment cost*

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22 Between 10-20% of capital costs is needed for re-engineering in order to achieve maximum potential[395].

Using the expected model reveals that if the home based equipment cost was £1,170 then the community alarm and proposed telecare systems would cost the same to implement as the return from the proposed system approaches zero. The decision of which system to implement would then based on the qualitative merits of each system.

## 7.3 Threshold Analysis

With such an analysis the cost analysis model is investigated in order to identify the point at which the conclusions of the model alter. For example, as discussed above the point at which the proposed telecare system no longer results in financial savings. In order to perform this sensitivity analysis each of the home equipment costs of £500, £700 and £1,000 are investigated in order to discover the service delivery requirements for the system to break-even.

Based on the home equipment costing £500, Table 7.6 (a) indicates the sort of service delivery changes necessary for the proposed telecare system to reduce its savings from £11.3m in the expected model to zero when the interest rate is 14%. It should be appreciated that the service delivery changes suggested in Table 7.6 (a) are just one of a number of possible combinations. Fig. 7.6 (a) indicates the resulting system profitability at varying interest rates.

Table 7 (a): *Assumed saving requirements when the home equipment costs £500*

| Variables | Present system | Proposed telecare system (Year) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Percentage of GP surgery consultations to become virtual | | 2% | 4% | 6% | 8% | 10% | 12% | 14% | 14% | 14% | 14% |
| Percentage of GP home visit consultations to become virtual | | 7.5% | 10% | 12% | 14% | 16% | 18% | 18% | 18% | 18% | 18% |
| Percentage of nurse visits to become virtual | | 7.5% | 10% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% |
| Probability of a community alarm user being admitted to hospital (percent) | 32.4% | 32.3% | 32.1% | 32.1% | 32.1% | 32.1% | 32.1% | 32.1% | 32.1% | 32.1% | 32.1% |
| Average duration of a hospital stay for client base. | 9.5 | 9.35 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 | 9.2 |
| Average additional care visits due to early hospital release (per discharge) | | 0.2 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 |
| Average additional nurse visits due to early hospital release (per discharge) | | 0.1 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Percentage of people in hospital delayed in discharge – Bed blockers | 20% | 19% | 18% | 18% | 18% | 18% | 18% | 18% | 18% | 18% | 18% |
| Percentage of people in residential care | 3.5% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% | 3.4% |

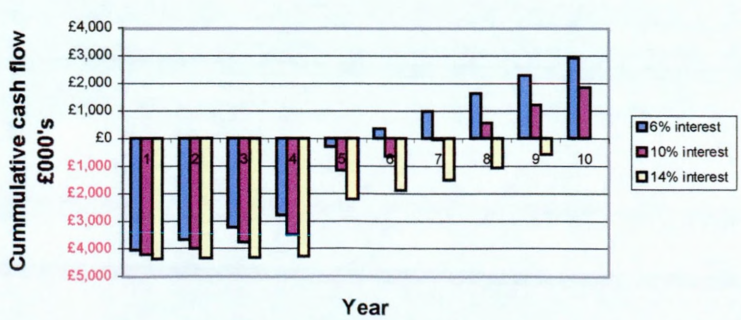



Figure 7.6 (a): Cash flows for a £500 home equipment cost

Table 7.6 (a) indicates that there is a relatively small change in service delivery, yet the proposed telecare system saves almost £3m when the interest rate is 6%. Of this saving 10% is saved in what may be considered as the housing budget, 61% in the health service and 29% in residential care. Tables 7.6 (b), 7.6 (c) and Figs. 7.6 (b) and 7.6 (c) indicate the required changes and associated cash flows when the initial home based equipment costs are set at £700 and £1,000 respectively.

Table 7 (b): *Assumed saving requirements when the home equipment costs £700*

| Variables | Present system | Proposed telecare system (Year) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Percentage of GP surgery consultations to become virtual | | 10% | 12.5% | 15% | 17.5% | 20% | 22.5% | 25% | 25% | 25% | 25% |
| Percentage of GP home visit consultations to become virtual | | 10% | 12.5% | 15% | 17.5% | 20% | 22.5% | 25% | 25% | 25% | 25% |
| Percentage of nurse visits to become virtual | | 2.5% | 5% | 7.5% | 10% | 12% | 12% | 12% | 12% | 12% | 12% |
| Probability of a community alarm user being admitted to hospital (percent) | 32.4% | 32.3% | 32.2% | 32.2% | 32.2% | 32.2% | 32.2% | 32.2% | 32.2% | 32.2% | 32.2% |
| Average duration of a hospital stay for client base. | 9.5 | 9 | 8.75 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| Average additional care visits due to early hospital release (per discharge) | | 0.8 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.6 | 1.5 | 1.5 |
| Average additional nurse visits due to early hospital release (per discharge) | | 0.4 | 0.6 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Percentage of people in hospital delayed in discharge – Bed blockers | 20% | 18% | 16% | 14% | 12% | 10% | 10% | 10% | 10% | 10% | 10% |
| Percentage of people in residential care | 3.5% | 3.45% | 3.40% | 3.35% | 3.3% | 3.25% | 3.20% | 3.15% | 3.1% | 3.05% | 3% |

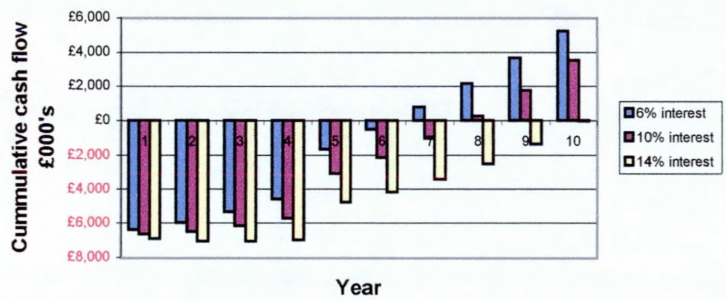



Figure 7.6 (b): *Cash flows for £700 home equipment cost*

Table 7 (c): *Assumed saving requirements when the home equipment costs £1,000*

| Variables | Present system | Proposed telecare system (Year) 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Percentage of GP surgery consultations to become virtual | | 10% | 12.5% | 15% | 17.5% | 20% | 22.5% | 25% | 25% | 25% | 25% |
| Percentage of GP home visit consultations to become virtual | | 20% | 22.5% | 25% | 27.5% | 30% | 32.5% | 35% | 37.5% | 40% | 40% |
| Percentage of nurse visits to become virtual | | 10% | 12.5% | 15% | 15% | 15% | 15% | 15% | 15% | 15% | 15% |
| Probability of a community alarm user being admitted to hospital (percent) | 32.4% | 32.2% | 32.1% | 32% | 32% | 32% | 32% | 32% | 32% | 32% | 32% |
| Average duration of a hospital stay for client base. | 9.5 | 9 | 8.75 | 8.5 | 8.25 | 8 | 7.75 | 7.75 | 7.75 | 7.75 | 7.75 |
| Average additional care visits due to early hospital release (per discharge) | | 0.8 | 1.1 | 1.5 | 1.9 | 2.3 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| Average additional nurse visits due to early hospital release (per discharge) | | 0.4 | 0.6 | 0.9 | 1.1 | 1.3 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Percentage of people in hospital delayed in discharge – Bed blockers | 20% | 15% | 10% | 7.5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| Percentage of people in residential care | 3.5% | 3.3% | 3.1% | 2.9% | 2.9% | 2.9% | 2.9% | 2.9% | 2.9% | 2.9% | 2.9% |

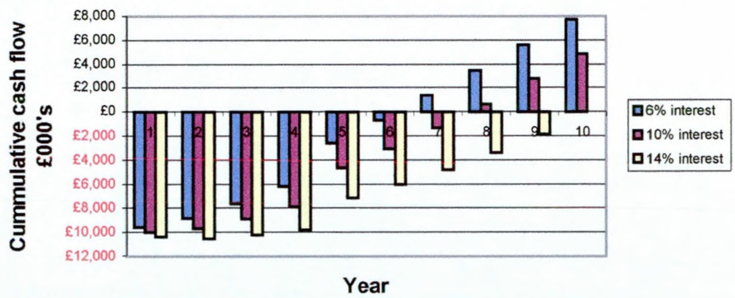



Figure 7.6 (c): *Cash flows for a £1,000 home equipment cost*

The savings suggested in Table 7.6 (b) are achieved through a 6% saving in the housing budget, 55% in health and 39% in residential care. The service delivery changes required in Table 7.6 (c) reveal that housing observe a 3% saving, health 48% and residential care 49%. The single point analysis revealed that the cost of the home based equipment made a substantial difference to overall system profitability. The threshold analysis is based upon this key variable and it is evident from comparing Tables 7.6 (a) with 7.6 (c) that in order for the proposed telecare system to be profitable service delivery does not need to alter significantly when the equipment cost is £500. However, when the cost is £1,000 there is a significant change in service delivery requirements to ensure that the proposed telecare system is cost-effective.

From an analysis of Tables 7.4 and 7.6 the greatest savings are observed from the introduction of virtual consultations for GP's together with reductions in hospital bed costs and residential care. Table 7.7 highlights these particular savings in relation to the service changes prescribed in Table 7.6 (a) and (c). Evidently, the necessary service delivery changes expressed in Table 7.6 (c) to achieve breakeven, result in significant financial savings as opposed to the savings resulting from Table 7.6 (a).

Table 7.7: *Savings due to service delivery changes*

| Saving area | Equipment cost | Proposed telecare system savings £000's Year 1 | Year 3 | Year 5 | Year 7 | Year 10 |
|---|---|---|---|---|---|---|
| Surgery | £500 | (103) | 94 | 89 | 84 | 84 |
| | £1,000 | (112) | 83 | 77 | 71 | 71 |
| Hospital | £500 | 79 | 173 | 173 | 173 | 173 |
| | £1,000 | 245 | 491 | 699 | 800 | 800 |
| Residential care | £500 | 171 | 171 | 171 | 171 | 171 |
| | £1,000 | 333 | 972 | 972 | 972 | 972 |

## 7.4 Multiway Analysis

A multiway sensitivity analysis involves varying two or more inputs at the same time, and allows greater attention to be drawn to specific areas. The impact of the home equipment cost has a substantial impact in terms of defining the costs of the proposed system, while the two components with the greatest impact on savings are hospital bed and residential care costs. The multiway analysis allows the investigation of these critical savings to be altered at the same time, and in this context, the expected model is used with the changes indicated in Table 7.8.

Table 7.8: *Multiway sensitivity analysis variables*

| Affect on service providers of proposed system - Community alarm users only | | Present system | Operational year of the proposed system Yr 1 | Yr 2 | Yr 3 | Yr 4 | Yr 5 to Yr 10 | |
|---|---|---|---|---|---|---|---|---|
| Average duration of a hospital stay for client base | Expected model | 9.5 | 9 | 8.75 | 8.5 | 8.5 | 8.5 | Days |
| | 10% less effective | 9.5 | 9.05 | 8.825 | 8.6 | 8.6 | 8.6 | Days |
| | 30% less effective | 9.5 | 9.1 | 8.975 | 8.8 | 8.8 | 8.8 | Days |
| | 50% less effective | 9.5 | 9.25 | 9.125 | 9 | 9 | 9 | Days |
| Percentage of people in residential care | Expected model | 3.5 | 3.375 | 3.25 | 3.125 | 3 | 3 | % |
| | 10% less effective | 3.5 | 3.3875 | 3.275 | 3.1625 | 3.05 | 3.05 | % |
| | 30% less effective | 3.5 | 3.4125 | 3.325 | 3.2375 | 3.15 | 3.15 | % |
| | 50% less effective | 3.5 | 3.4375 | 3.375 | 3.3125 | 3.25 | 3.25 | % |

The implications of these service delivery changes are shown in Fig. 7.7. The repayment method employed was to pay the loan off through the proceeds of the project as profits occur, i.e. as quickly as possible. Evidently if the 2 key variables suggested in Table 7.8 are only 50% as effective, as suggested in the expected model, then a surplus of only £2.6m is available at the end of the system life cycle. This is £5.7m less than that anticipated in the previous model.

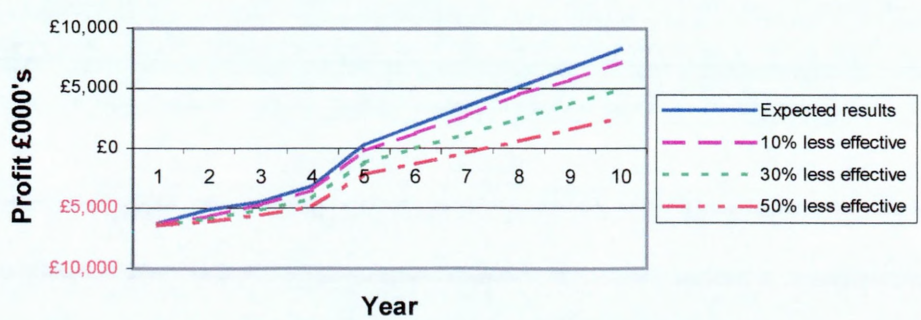



Figure 7.7: *Results of multiway sensitivity analysis*

Changing only these 2 key variables indicates the sensitivity of the telecare system to these parameters. Indeed if other service delivery changes were also not as successful as prescribed by the expected model, then the overall financial viability of the proposed telecare system can be put in doubt. The extreme scenario analysis allows this investigation.

## 7.5 Extreme Scenario Analysis

This analysis alters the service delivery changes in the expected model to extreme levels incorporating a pessimistic and optimistic view of the proposed telecare system. Because there is no verifiable evidence for the effectiveness of the proposed telecare system it is difficult to estimate the impact on service delivery, and hence cost benefit, for the expected model. The extreme scenario analysis suggests that the figures used in the expected model should be varied to incorporate the greatest possible variation. In the results presented below this is achieved by altering all of the service delivery changes in the expected model by 50%.

*Pessimistic view*

Reducing the service delivery changes in Table 7.3 by 50% reveals that at the end of the system lifecycle there is a return of £2.0m, only £600,000 less than that suggested by the multiway sensitivity analysis. Clearly the service delivery changes excluding hospital and residential cares costs make only a slight impact upon the system profitability.

In addition to reducing the service delivery changes by 50% the model allows the flexibility to increase certain parameters. The expected model already includes an additional consultation in the first year of operation due to medical parameters being above GP defined levels. However, it has been suggested that as much as 50% of potential users have medical problems that are currently undiagnosed and could be detected by telecare monitoring[58]. In a worst case scenario the proposed telecare system may increase the number of GP and nurse consultations. The pessimistic view therefore includes an increase of 50% of consultations in the first 2 years of operation.

The 50% increase in GP consultations is an increase from 6.5 to 9.75 consultations per user per annum while the corresponding number of nurse consultations extends from 232 a week to 348. Financially this has an impact of lowering the system profitability from £2.0m to £541,000. A concern over the ability of GP's and nurses to deliver such a dramatic increase in human resources are also worthy of note. It is also worth considering that even with lowering the 'success' of the expected model by 50% and increasing the number of GP and nurse consultations the proposed telecare system is still financially favourable to the present community alarm system.

*Optimistic view*

It would assume appropriate that as the pessimistic view decreased the service delivery changes by 50% that the optimistic model increases them by 50%. The expected model results in a total saving of £8.3m, while the optimistic view results in a total saving of £14.3m. It may also be suggested that because the proposed telecare system is a preventative system, detecting medical difficulties earlier than at present that the number of GP consultations will reduce in the future. It is not thought there would be a reduction in number of nurse consultations as approximately 85% of consultations require 'hands on' treatment, for dressing of wounds etc[216]. Introducing a reduction in GP consultations by 10% for each year in the 10-year system lifecycle increases the return still further to £15.2m.

## 7.6 Discussion

Relatively few economic evaluations are performed along side clinical trials[363] and because no clinical results are available for the proposed telecare system there is a level of uncertainty surrounding the findings. If confidence in the results is to be achieved it is necessary to analyse the expected model using a variety of sensitivity analysis tools in an attempt to understand the uncertainty and identify critical values.

The results from this variety of sensitivity analyses reveals that under all of the conditions exposed to the proposed telecare system, it is more profitable than the current community alarm system. The exact financial savings are difficult to accurately determine, but would fall within the range indicated by Fig. 7.8. Here the most pessimistic and optimistic views are included around the expected model and this therefore indicates a possible range of potential return. In reality the range is not as significant as suggested by Fig. 7.8 as it is unlikely that all of the pessimistic or optimistic factors will occur simultaneously[363].

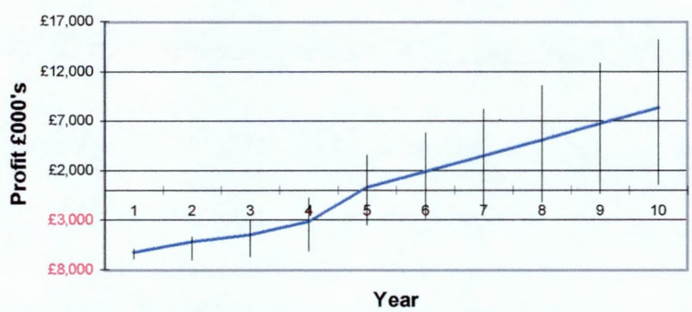



Figure 7.8: *The potential financial savings in the proposed telecare system*

*Choosing between systems*

Having created the model and analysed the results a decision can be made as to which system should be implemented. An aid to this process is the cost-effectiveness plane and this has been widely advocated for the analysis of health outcome results[397]. It is reproduced in Fig. 7.9.

When the results fall in quadrant I a decision must be made if the increased cost of the proposed system is justified by the additional effectiveness of the proposed system. In a similar fashion if the results fall in quadrant III then the reduced cost of the proposed system must be compared with the reduced effectiveness and a decision made. However, when the results are in quadrants II or IV the system under consideration clearly dominates. The qualitative benefits of telecare and telemedicine suggest that the proposed system is more effective, placing the system in quadrants I or II. This financial analysis reveals that in all of the scenarios investigated the proposed telecare system represented a better return on investment and therefore would be situated in quadrant II. The proposed telecare system dominates and should be the system implemented.

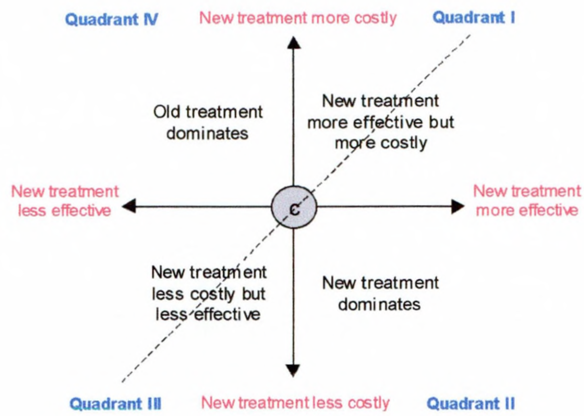



Figure 7.9: *The cost-effectiveness plane*

*Telecare funding issues*

The financial implications of telecare systems are not straightforward, with many parties contributing to funding and benefiting from their use. The results from the model suggest that the main savings are to be derived from reduction in time spent in hospital and residential care. Consequently, to realise the full financial rewards, a holistic approach involving collaboration across all imposed service boundaries is an essential pre-requisite. It has been said that the general cost-effectiveness of preventing an illness rather than treating it is usually favourable, but the specific cost of the prevention traditionally has to be paid by a party that has not yet incurred the obligation to pay for the illness. Nowhere is this problem more obvious than in the boundaries between hospital, extended care facility and in home care for frail but generally healthy patients[291]. The analysis of the proposed telecare system would support this observation. Currently community alarms are funded either privately, through housing benefit and in a few cases by social services or health, however the proposed telecare system suggests that other parties should also contribute to funding as they derive savings from its implementation. In the expected model housing budgets, which provide funding in the vast majority of cases, should only contribute 4% while health budget holders should contribute 47% and residential care 49%.

The funding of telecare trials may be considered as one of the main stumbling blocks to the further development of telecare systems. The responsibility to develop community alarms and introduce telecare systems would appear to rest with those currently delivering the community alarm system, housing providers. However, this analysis would suggest that a telecare system would dramatically increase their spending without observing appropriate financial savings in their budgets. Overall the proposed telecare system requires less finance but until budget holders can join finance innovations there remains little motivation for housing providers to seek developments. This position is also true for community alarm manufacturers, historically the purchasers of their equipment have been housing providers and they are unlikely to develop equipment unless there is a clear purchaser.

Housing providers recognise that the introduction of telecare systems would result in substantial initial expenditure[240] and this may also have militated against developments. A review of the literature revealed that there was little attempt to quantify the initial expenditure or suggest the savings that may result. The cost analysis model developed assists in the evidence base and supports the assumption that telecare systems do require a considerable initial investment. Indeed, in the expected model at the start of the first year £6.4m would be outstanding for a city the size of Birmingham. Putting a figure on the initial investment assists in the knowledge base, but may also hinder developments, since the initial investment is so significant.

Prior to this study no evidence was available to suggest the kind of savings that might be achieved through telecare systems. The analysis has sought to address this issue and revealed where, and the amount, of saving that could be achieved. However, the savings are not backed by a clinical or long term trials and therefore as discussed there is a some uncertainty surrounding the results. The various sensitivity analyses have sought to investigate this uncertainty but without data from field trials this uncertainty cannot be removed.

Another area of concern is the ability of the suggested savings to be realisable; will the £8.3m saving of the expected model be available in cash terms? In the expected model there is a saving of approximately £250,000 in hospital bed costs in the first year of operation. This is achieved by users spending less time in hospital, but a reduction in the number of bed days of telecare users is only a fraction of the total number of bed days in any given hospital. In order to realise the suggested savings there must be a reduction in staff, equipment or beds. Telecare users leaving hospital, for example, two days earlier is unlikely to mean that less staff are required or a hospital ward can be closed down. Therefore, although a two day saving would be costed in the model the ability to actually realise this saving could prove to be difficult. The ward may have greater capacity and hence be better able to meet the winter crisis for example, but an empty bed does not necessarily result in a real cash saving.

*Implementation issues for telecare*

The NHS and Community Care Act 1990 aims to:

*"Provide the development of domiciliary care to support people in their own homes and to prevent unnecessary admission to residential care*[10]*"*.

The introduction of the proposed telecare system could be considered to be one way of moving towards meeting these requirements. A consequence of such a shift is that hospitals will benefit from a reduced workload as people are maintained more successfully in the community. Conversely, there will be greater demands on staff in the community.

Between 1961 and 1993, the number of patients per doctor has dropped from 2,300 to 1,900 but there has been an increase in demand for out-of-hours visits[398]. The change in ethos towards monitoring patients at home rather than in hospitals may also contribute to an increased consulting workload for GPs who will however be compensated by the removal of the need for a significant number of home visits through the use of videoconferencing.

The introduction of the expected telecare system suggests that for each user an additional 18.4 minutes of the GP's time will be required in the first year of operation. This is made up 10.8 minutes for each user falling outside of the medical parameters defined by the GP together with the 8.4 minutes required to initially define those parameters. The introduction of virtual consultations saves a total of 0.8 minutes. However, the 8.4 minutes to initially define user parameters may be included as part of a normal consultation or the annual check up for those aged 75 and over[10].

In subsequent years the proposed system requires slightly less GP's time than the present system (approx. 1 minute). As indicated in Table 7.3 there will be a growth in the number of consultations that are performed with the GP in the surgery and the patient in their home. This results in a time saving for patients, who do not need the inconvenience of travelling to the GP surgery, but requires slightly more of the GP's time, an additional 2.4 minutes to perform the consultation through videoconferencing. If these virtual surgery based GP consultations were not permitted, then compared to the present community alarm system by the 5$^{th}$ year, 3.3 minutes per patient per annum could be saved. This being achieved through an increase in the percentage of virtual home based consultations suggested in Table 7.3; by the 10$^{th}$ year the potential is for savings in the order of 5 minutes.

*The affect of inflation*

As indicated in Chapter 6, inflation tends to overestimate profit and is a problem that accounts have not solved. The expected model results in a saving of £8.3m, and if an inflation rate of 1.9%[23] is subjected on this model the saving increases to £10m. In order to maintain a conservative outlook inflation is not included in the results but others have used inflation to aid their position. For example, Duerinckx *et al*[400] assumed *'a 5% inflation rate to counteract a 5% yearly increase for reoccurring hardware and labour costs.'* To include inflation in such a way is an assumption that introduces uncertainty and as demonstrated by the increase return on the expected model, inflation can have a significant impact.

*National savings*

If the expected model is used as the base model then £8.3m is saved for 11,618 users. Extrapolating these results to represent the whole country reveals that if all of the 1,160,000[119] community alarm users in the UK were provided with the proposed telecare system, savings in the region of £832m would be accepted. As identified in Chapter 1, with the increase in the number of older people and therefore potential number of community alarm users, these savings could be even greater in further years. While a telecare system introduced 10 years after the proposed telecare system would reveal even greater savings, as this system would operate without the need to initially introduce telecare services. For example, the percentage of virtual consultations would not need to start at 15% in year 1 and increase to 37.5%, it could start at a high figure from the beginning of the system lifecycle.

[23] The underlying rate of inflation as of 27 May 2000 was 1.9%[399].

The validity of extrapolated results should be appreciated as extrapolation introduces another form of uncertainty[363]. Throughout the model, where possible authoritative figures have been sought however, at times it has been necessary to use figures relating to Birmingham. For example, it is not believed that national figures are kept on calls observed at community alarm control centres, therefore the model uses Birmingham City Councils Careline data in the 'Control centre' worksheet. However, Birmingham's control centre may receive a different ratio of calls to users than other control centres throughout the country. Another implication is that because the call data is based on Birmingham the number of GP's must be based on Birmingham and being a large city there may be more GP's than the national average. Therefore, the extrapolated results must be used with some caution; they provide an indication of potential savings but cannot have the same authority as for the city of Birmingham.

## 7.7 Model Enhancements

Although the model successfully provides information on the cost-effectiveness of telecare systems there are areas where improvements could be made:

- *Improved data.* As discussed in Chapter 6 it is difficult to define the parameters in the expected model due to a limited amount of data. Access to organisations such as the DoH Research and Development department may be able to provide figures with greater authority. A review of published material does not reveal all of the necessary figures.

- *National authority.* The model is based on Birmingham City which may provide different results to the nation as a whole. In order to influence others and particular government or funding bodies a review on a national scale could be beneficial, if it is not possible to obtain the relevant information a review on a rural area could provide contrasting results. It is likely that a rural area will result in greater savings due to the additional saving on GP travel time for home visits and perhaps fewer GP's/nurses to initially provide equipment and training for. The other parameters in the model are not affected by distance.

- *Improved scenario analysis.* Running different scenario's and sensitivity analyses are possible in the current model but it may be advantageous to be able to use a menu and automatically change from pessimistic/optimistic etc. settings. A restore capability could be equally useful so that particular parameters could be altered and then restored to their original settings.

- *Theme investigation.* It could be useful if particular elements of the proposed telecare system could be investigated. For example, turning off medical home monitoring, video conferencing, or EPR etc. Again a restore function would be beneficial.

- *Linked tables.* The table from D:121 to H:132 on the 'Cost analysis' worksheet (see Appendix A6.1) needs to be altered manually to reflect the system return without interest being paid on any savings. This is manual as the year the proposed system turns into profit alters depending on the parameters in the model. It would be advantageous if this was automatic so others could easily use the spreadsheet.

- *Linked repayment models*. The repayment figures in W:121 and W:122 on the 'Cost analysis' worksheet (see Appendix A6.1) are calculated manually. If these were automatically generated it would enable others to use the spreadsheet without needing the understanding of the repayment scheme. Additionally the multiway sensitivity tables P:165 to S:174, P:177 to S:186, and P:192 to S:201 (see Appendix A6.1) are manually calculated and, in order for others to easily use the spreadsheet, it may be better if these were automatically calculated.

## 7.8 Conclusions

It has been said that the evidence for the cost-effectiveness of telecare is 'meagre'[135]. In order to develop telecare a greater appreciation of the financial implications is required and the model developed has sought to address this deficiency.

The results from the model indicate that compared to the present community alarm system the proposed telecare system is a more profitable system. Overall there is a return of £8.3m at then end of the 10 year system lifecycle. Performing various sensitivity analyses on these results reveals that in every circumstance the proposed system was financially the most desirable. These quantitative results aided by the qualitative benefits of telecare make a strong case for the introduction of such systems.

The multiway analysis revealed that the areas with the greatest impact on system profitability are hospital bed costs and residential care. A 50% reduction in the changes in service delivery suggested for the expected model alters the return from £8.3m to £2.6m. As previously indicated there is little evidence to suggest what impact telecare systems may have on these parameters and therefore the sensitivity analyses performed are necessary to estimate a range of possible outcomes. However, until field trials have taken place the actual impact is not quantifiable. What is important for future developments is that a cost analysis model has been developed and as data becomes available the model can be updated to represent the findings. The model can then be analysed again and the financial impacts investigated.

Despite the results of this analysis indicating that the proposed telecare system is profitable, three 'stumbling blocks' were identified:

- *Holistic funding*: Currently housing budgets provide the vast majority of funding for the community alarm system. In the proposed telecare system it has been suggested that, Housing Department's should provide 4%, the NHS 47% and residential care 49% of the total system costs, as the financial benefits for the proposed telecare system are apportioned in this way.

- *Significant initial investment*: In order to provide the advanced, and therefore more expensive, home based technology at the start of the first year the proposed telecare system has a deficit of £6.4m. This requirement for substantial investment may discourage potential organisations seeking to develop telecare systems.

- *Uncertainty of realising savings*: The model suggests that at the end of the system lifecycle the proposed telecare system is profitable, but there may be some difficulties realising the savings. A reduction in the required number of bed days is considered as a financial saving. However, the hospital may have difficulty realising the benefit, unless staff, equipment or hospital wards are reduced.

The model developed is believed to be the only cost analysis tool for telecare systems and has addressed an area of research which, to date, may be considered to have been overlooked.

# 8 A Service Delivery Model

***Chapter structure:*** *Having defined what a 2nd generation telecare system should consist of and analysed the financial implications the ability to deliver the service is analysed. This chapter therefore describes how a simulation tool should operate and what assumptions are included in the service delivery model. Particular attention is given to how the model simulates call activity to the community alarm control centre.*

The preceding chapters have considered new generations of telecare, indicating a desire from users to embrace such initiatives, and highlighted that there is the potential for substantial financial savings. The data flow diagrams of Chapter 5 indicated that with these new generation systems, more information was available and accessible, consequently there may be concerns as to whether the implied service delivery changes can be achieved. The creation of a model of service delivery allows the impact to be investigated. The Oxford reference dictionary of computing[327] defines a simulation as imitating the behaviour of an existing or intended system. In the context of this study, the purpose of the simulation is to model the previously defined 2nd generation telecare system and discover what impact its introduction has on service delivery.

The 2nd generation telecare system covers several entities; GP surgery, hospital, users home, control centre etc. However, in terms of service delivery, the control centre is the focal point, as with the exception of medical monitoring calls, every communication goes through the control centre. It is also envisaged that prior to the full 2nd generation system being implemented, various individual modules will become available and require the control centre to respond. In order to move towards the 2nd generation, and ultimately the 3rd and 4th generations, if the impact on the control centre can be modelled, it will provide a significant insight into the delivery of telecare.

## 8.1 Required Outputs From The Simulation

Prior to deciding how to create the model and simulate events, the outputs required must first be defined. These were agreed with the project review group as follows:

1. The main aim of the simulation is to analyse historical data for any control centre and investigate the impact of changes on behaviour. Therefore, the model must be able to gather the historical data, analyse it and hence simulate the present system. Such an approach also enables the model to be validated as based on the known historical call data, the simulation should generate a similar call profile.
2. The ability to add hypothetical calls to the present system. In addition to the current categories, the model should provide the ability to easily add new hypothetical categories such as, a fall detector.
3. For each unique category, the number and duration of calls included in the model should be capable of being changed. For example, the use of the 2nd generation system is likely to reduce the number of 'Pulled in Error' (PIE) calls, where the user activates the alarm by mistake. The model should therefore provide the capability to reduce such calls by a given percentage. Conversely, other call types may increase and this should be facilitated. Although the call profile changes should be included in the simulation run, these changes should not impact on the stored user entered call profile's, which may have been obtained from a present community alarm control centre.

4. Provide the capability for incoming and outgoing calls. The community alarm control centre receives calls from users and based on the type of call received an outgoing call can result. For example, a user requesting medical assistance will often result in the doctor or ambulance being contacted. In addition, providing the model with the capability to generate more general outgoing calls based on an independent profile, for example once every 10 minutes during office hours, would provide the possibility of modelling other control centres in addition to a community alarm control centre.
5. Define both system and operator calls. The present community alarm system receives calls that do not require operator assistance and can be dealt with by the system. Typically such calls are wardens logging on/off duty and equipment checks. These system calls are likely to increase in the 2nd generation system while operator calls where the operator must physically respond are included in both the present and proposed telecare systems. The model must provide the ability to investigate both category types.
6. Provide a distinction between call origins. The majority of community alarm control centres receive calls from dispersed users living in the community and users in sheltered housing. The model must enable the effects of an increase or decrease from either source to be investigated. For example, what impact would there be if one control centre took over another and the number of sheltered housing users increased. With respect to users in sheltered housing, the model must enable investigation either based on the number of users or the number of sheltered housing schemes.
7. Distinction between times of the year. In the present community alarm system call volumes alter depending on the time of the year. For example, there are more calls for the doctor during the summer and winter than at other times of the year and daily variations are also apparent[240], for example, there will be a high occurrence of wardens logging on/off duty on weekdays, while only a few such calls will be evident at weekends. The model must include the appropriate trend for every category of call. The example of the wardens also highlights that the model must include the capability for analysis over a short period of time. Many wardens will log on at or around 09:00 as they begin work and again when they break for lunch and at the end of the day. The model must enable the profile of calls to indicate this trend.
8. When generating simulated calls provision must be provided to generate calls only during defined hours. Therefore, if analysis is only required between 08:00 to 10.30 then only the calls during this period should be reported.
9. When the model is used it should be possible to generate simulated calls based on a specific time period. Therefore, if analysis of a particular day, week, month or year is required this can be modelled.
10. Shift pattern analysis should be provided so that the current or 2nd generation system with added categories, can be modelled with different shift patterns. Therefore, investigation can take place as to what affect an additional operator would have for certain periods of the day. Based on the calls generated in the model, an estimate of the optimum shift pattern should be provided for comparison with that entered by the simulation user.
11. The results generated from a simulation run should be saved together with the characteristics used. For example, which categories were included, any changes to categories for example, 50% reduction in Pulled in Error calls. Therefore, different scenarios can be created and viewed at leisure.

In terms of the results the model should provide:

1. An indication of the number of calls generated throughout the chosen time scale, i.e. for each category how many calls were received.
2. Based on the user entered shift pattern reveal how the simulated calls would be answered, when and how many were delayed, and the how long users had to wait to be answered. Where necessary the model should suggest a suitable shift pattern and report the impact this has on the simulation.
3. The results should be capable of being viewed as a total of all of the weekdays or weekends in the simulation run. The majority of control centres have different shift patterns at the weekend and the results should be presented to show this difference.
4. For every call that is delayed, information should be available indicating when the call was received and the extent of the delay.
5. For each hour indicate the utilisation of the operator(s), i.e. what percentage of the operator's time was spent answering calls.
6. Costing information. Indicate the costs and incomes involved at the control centre.
7. Allow user defined queries based on the simulation calls, i.e. enable the interrogation of the data.

## 8.2 The Type Of Simulation

In order to create the simulation there is a choice between using simulation packages or programming. The benefits of these approaches are provided in Table 8.1[401].

Table 8.1: *The benefits associated with using simulation packages and programming languages*

| Simulation package | Programming language |
|---|---|
| Automatically provide most of the features needed to create a model. Therefore reducing the time required | Allows greater flexibility |
| Easier to modify and maintain | Can be more efficient and therefore require less execution time |
| Improved error detection as potential errors are automatically checked for | Software cost is generally lower, but the total project costs may be higher |

There are various simulation packages available such as Arena[402], Extend[403] or Simu8[404] that could all be used to model the system. However, despite the speed advantages of such packages there is reduced flexibility and control. One of the purposes of the simulation is to enable any community control centre's data to be included in the model and investigated. Using a simulation package would quickly provide a general answer based on the average time taken to answer calls but would not model the real world accurately.

Commercial software by IMAJ captures a control centres call volume by analysing the automatic call distribution system. Forecasts are then made based on these calls and/or any user entered categories added[405]. The IMAJ calculator[406] then uses the number of operators, average call duration and number of agents over a defined time to estimate the number of calls received each hour, the probability of a call being queued, and the average delay time.

While such tools are useful in providing an overview, because community alarm control centres receive potentially life-threatening calls, it is important to know the time every user had to wait, rather than just an average figure. It is only possible to achieve this level of detail on a call by call analysis and this suggests that the level of detail suggested in section 8.1 could not be met by using an 'off the shelf' simulation package. An additional consideration for using a programming language was that the research sponsors market a control centre and that a simulation, forecasting and modelling calls, could become an additional feature of their software.

Due to the potentially large amounts of data, linking the simulation to real-world control centre data, the choice of programming language centred on the ability of the programming language to easily manipulate data. Microsoft claim that Visual Basic (VB) is the most widely used development environment in the world, with excellent database manipulation[407]. As such VB was chosen.

## 8.3 Simulation Design

The overall structure of the model is described in Fig 8.1. The possible categories, and their associated call profiles, are stored in the core database and the particular categories to include in a simulation run can be chosen from these. In addition, other parameters relating to the number of users, shift patterns etc. must also be entered.

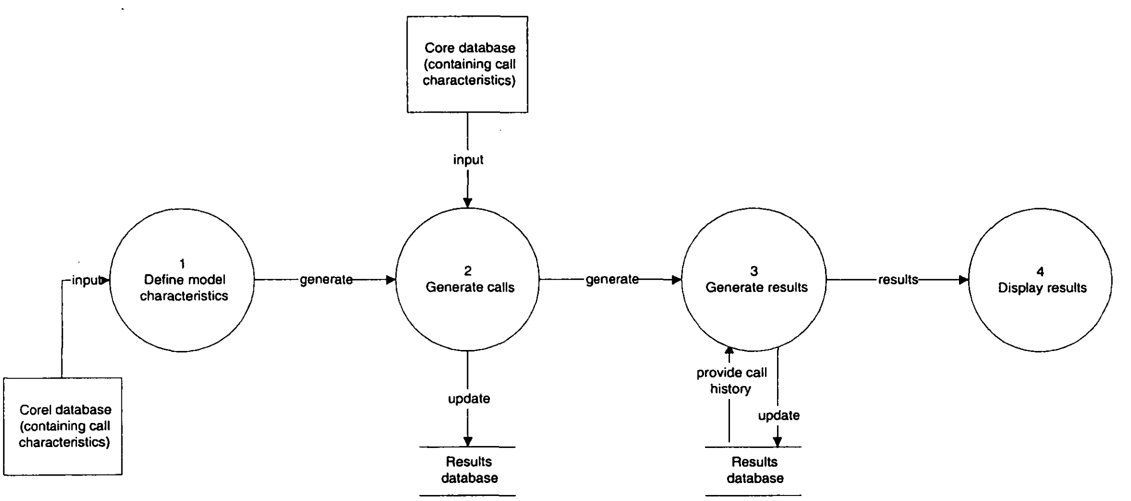



Figure 8.1: *The overall structure for the simulation*

Having entered the required model characteristics, the simulated calls can be generated. The core database contains details of the call profile for each category, when calls are expected to arrive and their duration, and is used to generate the calls in the simulation run, saving them in a results database. Having simulated the calls, in combination with the user entered shift pattern, process 3 will establish when calls were answered and identify any delayed calls. Process 4 then generates the results for specific fields, i.e. how many calls were delayed, utilisation of operators etc. and presents the results for inspection.

## 8.4 Core Database

The core database is external to the workings of the model but provides it with the unique call categories and their corresponding call profiles. In order to meet the objectives defined in section 8.1 it is necessary to establish the following:

- Category name: The unique name of the category, for example 'Pulled in Error'.
- Location: Whether the category refers to sheltered housing or dispersed users in the community.
- Month: Month of the year the category relates to.
- Call direction: Whether the category relates to an incoming or outgoing call. Incoming calls are received at the control centre and include an outgoing call to a responder, doctor, or the emergency services. Outgoing calls refer to calls that the control centre makes without first receiving an incoming call. Currently community alarm control centres do not make such outgoing calls but provision must be provided in case their role changes.
- Operator involvement: Indicates if the call required the operator to answer the call or whether the control centre system could respond without the assistance of the operator. Such calls are refereed to as operator and system calls respectively.
- Data type: This indicates whether the data is historical or predicted. If the call profile for the category relates to historical data derived from the control centre then this can be entered as historical. Where the call profile for the category is hypothetical or based on limited trials then it can be entered as predicted. This distinction enables the same category name to be used in the present or 2$^{nd}$ generation system. For example, the model may simulate calls based on half of the users with the present or historical 'Pulled in Error' call profile, and half of the users with a predicted 'Pulled in Error' call profile.

The combination of these 6 characteristics defines a unique category to which the associated call profile can be entered. In order to meet the requirements of section 8.1 the call profile must also be separated into which day type the call was received, i.e. a weekday or weekend.

In order to validate the model, section 8.1 suggested that a current control centre must be accurately reproduced. Therefore, for each category evident at the control centre, a call profile must be generated that accurately reflects when calls were received, how long they lasted and the probability of contacting a responder, doctor, or the emergency services. Analysis of the call data evident at Birmingham City Council's control centre reveals that calls for certain categories, such as wardens logging on and off duty, often occur within small time frames. In order to reflect this level of detail it would seem appropriate that 5 minute time slots be used.

When obtaining the average duration of a call it depends on the particular category of call (Pulled in Error, request for doctor etc.) but also on whether or not calls are waiting to be answered. Discussions with operators[240] revealed that the duration of a call reduces if another call is waiting. The duration also depends on the caller with some callers requiring additional explanation and assistance. Due to the greater variation of the duration of calls, the 5-minute time slots were not considered necessary, and could be misleading if a 5-minute time slot contained only a small sample that was not representative.

Therefore, it would seem more appropriate to use the average duration of a call based on an hour's data. Discussions with the review group also revealed that in practice most users of the simulation would only require a distinction to be made between during the day and at night.

For certain types of call an outgoing call will often result, for example a request for a doctor, fire detected etc. The Birmingham City Council control centre system records whether an outgoing call to a responder, doctor, or the emergency services is made, but the duration is not stored in the control centre's database. Discussions with the operators revealed that the duration of such outgoing calls was consistent and therefore a single duration could be used throughout all 24 hours of the day[240]. Operators also felt that the probability of an outgoing call for a specific category did not alter depending on the time of day, the reason being a request for a doctor would result in the doctor being contacted irrespective of when the call was received.

Having defined the requirements for the call categories, in order to meet the objectives of section 8.1 two methods are required to obtain the call profile data:

1. Manual data input. Each category and the associated call profile must be entered manually by the user. The main purpose of this function would be to add new categories that were hypothetical or predicted.
2. Automatic database analysis. Under this option the present systems control centre database would be analysed and the categories and associated call profiles would be automatically generated.

## 8.4.1 Core database: Manual data input

Fig 8.2 indicates the overall process for the manual input of call profiles into the core database.

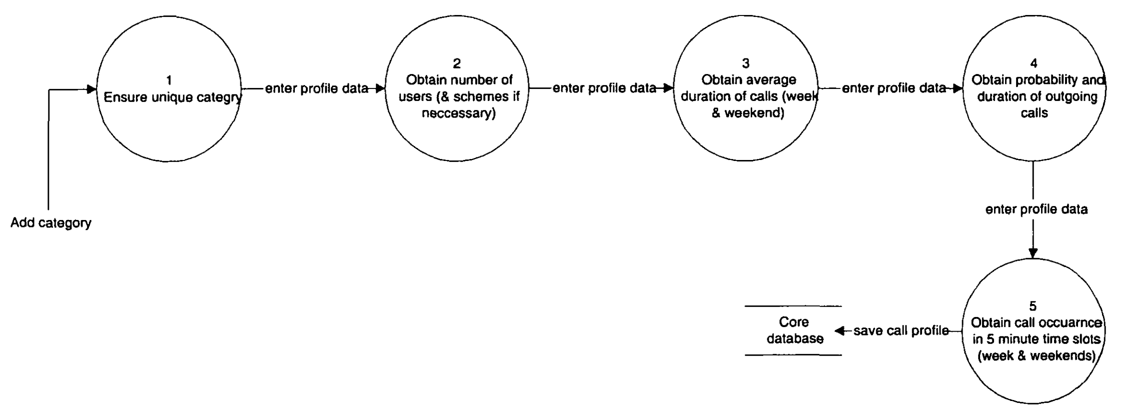



Figure 8.2: *The overall structure for the manual data input of call profiles*

*Process 1: Ensure Unique category*

When adding a new category to the core database it must be unique. A unique category is based on the 6 characteristics identified previously namely, category name, location, month, call direction, operator involvement, and data type. If the category is not unique it should not be allowed.

*Process 2: Obtain number of users (& schemes if necessary)*

The purpose of the core database is to contain the call profiles for each unique category. The control centre systems provided by the three main providers in the UK, TeleLarm, Jontek and Tunstall all provide the ability to calculate the number of calls received over a given duration. Therefore, when entering the call characteristics of the present system into the core database the user is likely to enter the number of calls received for a category during a particular month. In order to generate a call profile it is necessary to know how many users generated the call volume. Then, knowing the number and occurrence of calls, together with the number of users, the call profile for a single user can be derived. This call distribution can then be multiplied to represent the number of users in any particular simulation run.

Where a category relates to sheltered housing users, the number of actual users and schemes should be entered so that the call profile can be manipulated based on a change in the number of users or number of schemes.

*Process 3: Obtain average duration of calls (week & weekend)*

This process requires the user to enter the average duration of calls for each unique category on an hourly basis. However, because the model is only concerned with service delivery and the duties of the operator, calls not requiring the operator do not require their duration to be entered.

For calls where the operator is involved the average duration should be entered for each hour and the type of day, providing a distinction between weekdays and weekends.

*Process 4: Obtain probability and duration of outgoing calls*

For each unique category the probability of an outgoing call to a responder, doctor, or the emergency services should be entered. Although, the operators indicated that the probability of an outgoing call does not depend on the time of day, provision for the probability of an outgoing call based on office and non-office hours may be necessary. This is based on the possibility that if medical expertise was required, depending on the time of day the doctor or ambulance would be contacted. Discussions with operators indicated that the duration of an outgoing call did not alter throughout the day and therefore only requires the user to enter a single duration for each outgoing call.

*Process 5: Obtain call occurrence in 5-minute time slots (week & weekends)*

In order to accurately model the present system, the calls received or expected to be received, need to be divided into week and weekend days. Having divided the calls in this way they need to be broken down into when they occur in 5-minute time slots. In addition, so that the call profile for a single day is known the number of days over which the calls were received is also required.

There are a total of 288, 5 minute time slots in a single day therefore, for just one call category occurring from sheltered housing and dispersed users there would be 1,152 entries (number of 5 minute time slots * [sheltered and dispersed] * number of day types = 288* 2 * 2). Although, this level of detail would provide a realistic model it would be time consuming to enter this amount of data for the 10 to 15 categories that a control centre may receive. In order to reduce the data input burden it would seem appropriate to provide general tools that indicate the trend without having to enter data for every 5-minute time slot.

Table 8.2 indicates 6 tools to automatically generate the 5-minute time slots. Therefore, if every hour of the day used the same distribution, i.e. flat, then instead of the 288, 5 minute data entries the process could be reduced to 1 input specifying the number of calls, and a couple of mouse clicks.
Having entered all of the necessary data the category and profile can be saved in the core database and the process repeated for other unique months for this category, or a new category.

Table 8.2: *Automatic generation of time slots*

| Auto generate | Description | Example using 100 calls as the total for the hour |
|---|---|---|
| Left | The data is secured to the left, i.e. more calls are received at the beginning and decline throughout the time period | 15,14,13,12,10,9,8,6,5,4,3,1 |
| Right | The data is secured to the right, i.e. few calls are received at the beginning and gradually increase throughout the time period | 1,3,4,5,6,8,9,10,12,13,14,15 |
| Flat | An equal number of calls are distributed throughout | 8,8,8,8,8,8,8,8,8,8,8,8, |
| Centred | Follows a normal distribution. More calls are received in the middle than the beginning and end | 2,5,7,10,12,14,14,12,10,7,5,2 |
| Bottom | Follows an inverse normal distribution. More calls are received at the beginning and end than the middle | 14,12,10,7,5,2,2,5,7,10,12,14 |
| Random | The calls are randomly distributed. | 10,6,5,13,11,5,9,9,7,9,7,9 |

## 8.4.2 Core database: Automatic database analysis

This method can only be used to acquire a current control centres data. It is an automatic process but does require some input from the user, as indicted in Fig 8.3.

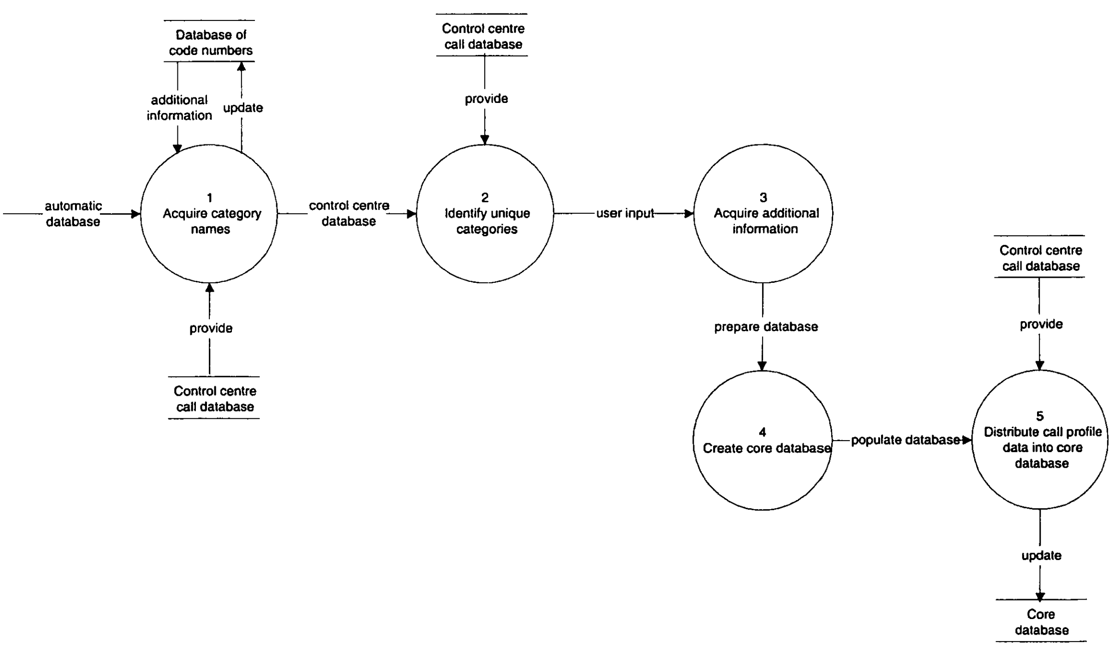



Figure 8.3: *The automatic generation of the core database*

*Process 1: Acquire category names*

The control centre database contains details of every call received at the control centre and the actions taken by the operators. However, the details are stored as number codes; for example, a field exists indicating the origin of the call but the number 1 is used to represent a sheltered housing scheme and 2 for a dispersed user. The closing down comment of the operator, which indicates the reason for the call, is also stored as a number. An additional field 'call type' indicates the type of call where 'M' represents a mains call (i.e. a check, typically every 25 hours, from sheltered housing schemes informing the control centre that the equipment is working correctly).

Process 1 will gather every unique call evident in the control centre database and acquire the category names as opposed to the number format used in the control centre database. For example, a call with a unit category of '1', a call type of 'C', and a data code of '9', indicates that the call is from sheltered housing, the operator answered the call and it regarded a user who had fallen. Using descriptive language rather than the code numbers ensure that the model is easier to use.

The database table of user codes contains a list of the commonly used code numbers and their corresponding descriptive notation. This table can be compared to the calls evident in the control centre table and the descriptive notation suggested. Where the table of codes does not contain a specific code number, the user must enter the descriptive notation. The simulation user must also ensure that the suggested descriptions match the code numbers, as different control centres may use a different call numbering system.

Having entered the call descriptions the database table of code numbers can be updated with the corresponding code numbers and descriptions used. In the majority of cases each code number and description should be unique, however it may be possible for 2 code numbers to represent the same type of call. For example, a specific code number may exist for a warden log from old equipment, while new equipment may have a new code but mean the same activity. In the majority of cases each category description should be unique and should be validated by process 1. However, for the above reason, it may be necessary to override descriptions.

*Process 2: Identify unique categories*

Process 1 created a list of the different categories of call evident in the entire control centre database. The purpose of this 2$^{nd}$ process is to identify each unique category present on a monthly basis. As discussed in section 8.4 every call received at the control centre should have a:

- Category name: For example, Pulled in Error.
- Location: Whether from sheltered housing or a dispersed alarm.
- Month: Calendar month the call was received in.
- Call direction: Whether the call was incoming to the control centre or outgoing.
- Operator involvement: Whether the call is an operator or system call.
- Data type: Historical or predicted.

Process 1 obtained the category names, the month of every call is known as every call received at the control centre is time and date stamped automatically, while because all of the data is from the control centre database the data type will be historical. Process 2 will therefore analyse the control centre database to obtain a list of the categories on a month by month basis. Therefore, if process 1 identifies a Pulled in Error category, then for the month in question the control centre database can be analysed to discover if there were Pulled in Error calls from sheltered housing and dispersed alarm users. It can also be analysed to see if calls require operator involvement or not. This process is developed in the pseudo-code below.

```
BEGIN
Obtain category names (identified in process 1)
Pointer at first category name
WHILE more months in the control centre database
    WHILE more category names
        If category is a system call THEN
            IF at least 1 call for the present month is from sheltered housing THEN
                Accept as unique category - system from sheltered housing
            END
            IF at least 1 call for the present month is from a dispersed user THEN
                Accept as unique category - system from dispersed user
            END
        ELSE
            IF at least 1 call for the present month is from sheltered housing THEN
                Accept as unique category - operator from sheltered housing
            END
            IF at least 1 call for the present month is from a dispersed user THEN
                Accept as unique category - operator from dispersed user
            END
        END
        Increment pointer for the next category name
    LOOP
    Increment to next month in control centre database
    Category names pointer set to first
LOOP
END
```

Having completed this process the 6 characteristics that identify a unique category will have been analysed and every unique category in the control centre database will have been identified.

*Process 3: Acquire additional information*

The control centre database contains details of every call received at the control centre, however additional information is required which is not contained on this database:

- The number of users: The core database can be created containing every category of call and when calls were received, however without knowing how many users there were to generate the call volume, the call profile for a single user cannot be created and therefore the number of users in the model could not be altered. Therefore, the simulation user must enter the number of alarm users (and schemes if the category in question originates from sheltered housing) responsible for generating the call volume.
- The number of days over which data was gathered: Again this is required to generate the call profile for a single day. For example, if 100 calls were received for a particular category over 10 days, then it can be assumed that on average there are 10 calls a day. If there were 5 users over the 10 days then it can be assumed that on average each user called the control centre twice a day. The number of days of data contained in the control centre database can be estimated from knowing when the

first and last call was received for any particular month. However, the control centre database may not contain every day of data and therefore provision for altering the suggestion must be possible.

- Duration of outgoing calls: For every call received at the control centre the occurrence of an outgoing call to a responder, doctor, or the emergency services is recorded on the control centre database. However, the duration of the call is not held within the database, therefore requiring the user to estimate this for each unique category of call.

Processes 2 and 3 are repeated on a month-by-month basis. This is because for each of these 3 elements of additional information they can change over time. For example, if the control centre database contained 6 months of call data, then over this period the number of users is likely to change and provision for the change must be provided to realistically model the current system.

*Process 4: Create core database*

The simulation user should be prompted for a file name and directory location where the core database is to be created. If the information provided results in the possibility of a file being overridden, then the simulation user should be informed and change the file name or location if necessary. Having successfully entered the appropriate file data, no further input from the simulation user is required. The necessary tables for the core database can then be created with fields that include:

- The 6 characteristics that defines a unique category.
- Total number of calls: For each category how many calls were received.
- When calls were received: The number of calls received in each 5-minute time slot and the total for each hour during week and weekend days.
- Number of days: The number of week and weekend days over which the calls were generated for a given category.
- Number of users: The number of users and sheltered housing schemes if appropriate.
- Duration: The average duration of a call on an hourly basis.
- Probability of an outgoing: For each category the probability that a responder, doctor or emergency services will be contacted during office and non office hours.
- Duration of outgoing calls: The average duration of an outgoing call.

*Process 5: Distribute call profile data into core database*

The final process interprets the information obtained in the previous processes, and in combination with the control centre database containing the call data, inputs the information into the core database. The process is developed in the pseudo-code below.

```
BEGIN
Move to first record in control centre database
WHILE more records in control centre database
    Find the unique category name in the core database that represents the call code numbers (reverse of process 1)
    Find whether the call was received on a week or weekend day
    Calculate which hour the call was received in
    Calculate which 5 minute time slot the call was received in
    Increment the required 5-minute time slot, the required hour slot, and the total for that category by 1
    Calculate duration of call (difference between when the call was closed and answered)
    IF duration >0 then
        Calculate which hour the call was answered in
        Add duration of call to appropriate unique category and specified hour slot
```

```
        Increment counter for the category and hour slot where the duration was just entered
    END
    Move to next record
LOOP
WHILE duration >0
    Divide total duration time by counter for that category and hour
LOOP
END
```

The process is self explanatory with the exception of calculating the average duration of a call. This should be calculated by using the arithmetic mean as in Equation 8.1[408].

$$x = \frac{\sum_{i=1}^{n} X_i}{n} \tag{8.1}$$

x = sample arithmetic mean

n = sample size

Xi = $i^{th}$ observation of the random variable X

## 8.5 Process 1: Define Model Characteristics

Having created the core database Fig 8.1 indicated that it was an input into the first process (define model characteristics) and the purpose of this first process is therefore to define the model characteristics to be used for the particular simulation run. Options include which categories to include, how long the simulation is to run for etc. In order for the model to be flexible, and therefore be able to provide results under various circumstances, all of the model characteristics need to be capable of being manipulated, including:

1. Selection type of categories: As indicated in the core database calls are regarded as historical or predicted. The model needs the capability to indicate which categories are of which type, enabling the model to be run with just historical calls, just predicted calls or both. In a similar manner a distinction is required for operator and system calls, calls from sheltered housing or dispersed alarm users, and incoming or outgoing calls.
2. Selection of individual categories: Whatever selection type of categories is chosen, either all of the categories or particular ones should be chosen for inclusion in the simulation run.
3. Variation of the selected categories: Every chosen category in the simulation should be capable of being manipulated. The fields that should be changed for each category are:
   - Number of users (including number of schemes where appropriate).
   - Percentage change in the number of calls. For example, increasing the probability of a particular category of call occurring by 50%.
   - Percentage change in the duration of a call. This is only relevant for calls which are answered by an operator and can be used to investigate the sensitivity of the system to changes, perhaps as a result of a new operator who is not as efficient and may require 20% more time with callers.

   Each change should affect the simulation run but not the call profiles stored in the core database. In addition to individual categories being altered, a simple process should enable all of the categories in the simulation run to be altered together, therefore the model could, for instance, be used to investigate what would happen if there were 10% more calls etc.

4. Number of users: If the simulation run is to include sheltered housing then the simulation user must specify whether to base calculations on the number of sheltered housing schemes or the actual number of users for more accurate analysis[24]. If the number of dispersed alarm users is included in the simulation run then this information is also required.
5. Duration of simulation run: As previously indicated the call profiles vary depending on the time of year and on weekdays and weekends. In order to accurately model the variations a start date and an end date must be entered. Therefore, if the user runs the simulation from Friday 22nd December 2000 to Tuesday 2nd January 2001 the model must use the appropriate call profiles as indicated in Table 8.3.

Table 8.3: *Modelling variable day types*

| | Date | Model data |
|---|---|---|
| Fri | 22/12/00 | December week data |
| Sat | 23/12/00 | December weekend data |
| Sun | 24/12/00 | December weekend data |
| Mon | 25/12/00 | December weekend data* |
| Tue | 26/12/00 | December weekend data* |
| Wed | 27/12/00 | December week data |
| Thur | 28/12/00 | December week data |
| Fri | 29/12/00 | December week data |
| Sat | 30/12/00 | December weekend data |
| Sun | 31/12/00 | December weekend data |
| Mon | 01/01/01 | January weekend data* |
| Tue | 02/01/01 | January week data |

* Bank Holiday and treated as a weekend

6. Inclusion of calls: Analysis of calls may only be required at certain times of the day, perhaps during a particular shift or at identified busy times. Consequently an option must be available to constrain the model to generate results between the identified times, i.e. 8 am to 10 am. The model must also be constrained to include just weekdays, just weekends or all days of the simulation run.
7. Shift pattern: The model will generate the number of calls and when they are received at the control centre. However, in order to model the impact on calls and discover when calls are delayed the operator shift pattern is required.
8. Number of consoles: This is the number of positions where operators can physically answer calls and access a terminal. Discussions with Birmingham City control centre operators revealed that when shifts change then if calls are waiting to be answered the incoming operators would start their shift and answer calls, while the operators whose shift is ending will also answer calls. Clearly this can only occur if there are sufficient consoles available. The methodology of shift changes is discussed further in section 8.7.1.
9. Estimation of shift pattern: Section 8.1 indicated that one of the model outputs was an indication of the most efficient shift pattern. If this is required additional information is needed:

[24] The number of users on a scheme varies, a scheme could have 25 or over 100 users. Using the number of schemes is therefore based on the average number of users. For example, running the simulation with 3 schemes if the call profile for a category was based on just 2 schemes with 25 and 75 users would result in the 3rd hypothetical scheme having an average of 50 users ((25+75)/2). Using the number of users would enable the simulation user to enter the actual number of users on the 3rd scheme, for instance if there were 40 users on this 3rd scheme, the simulation user would enter 140 users (25+75+40).

- Required utilisation rate: This indicates how busy the operator(s) should ideally be. Therefore, if 70% is entered the model should suggest a shift pattern where 70% of the operator(s) time is spent answering calls.
- Minimum number of operators per shift: If a control centre does not receive many calls at certain periods of the day it may be that only 1 operator is required. However, due to possible health and safety regulations it may be that a minimum of 2 operators must be on duty at any one time. Therefore, the minimum number must be obtained from the simulation user.
- Maximum number of consoles: The model could be used to estimate the required number of operators at busy times that may exceed the number of consoles available. If a new control centre system is to be installed then the number of consoles available is not a constraint and the model could be used to indicate how many consoles should be available. However, other simulation users may have to work within the existing constraints and estimating a shift pattern which exceeds the number of consoles available would be of little benefit. In such circumstances the model must estimate the shift pattern with the maximum number of operators on duty at any one time specified by the number of consoles available.

## 8.6 Process 2: Generate Calls

Based on the model characteristics defined in process 1 (section 8.5), this process generates a list of simulated calls that can then be analysed in the remaining processes. The pseudo-code below indicates the structure.

```
BEGIN
IF data entered correctly from process 1 THEN
    Find the months required in the simulation run
    IF there is call data in the core database for all of the required months THEN
        Current_date = start day of simulation run
        Create database to store simulated call results and the model characteristics used to generate these calls
        Category_list = list of unique categories required for each month in simulation run*
        While Current_date <= end of simulation run date
            Generate list of calls for Current_date
            Current_date = Current_date + 1 day
        Loop
        Save model characteristics used in database
    Else
        Inform user that call data does not exist in the core database
    End
Else
    Inform user what information is required
End
End
```

* i.e. if a category is Pulled in Error (PIE) and both sheltered housing and dispersed users are included in the simulation run then there are 2 categories. PIE from sheltered housing and PIE from dispersed users

The key to this section and possibly the accuracy of the overall model is defined by 'Generate list of calls for Current_date' and therefore the processes involved merit particular attention.

1. The above pseudo-code contains a real calendar date (Current_date = 22/12/00) and in the first occurrence of the loop this is set as the start date for the simulation run. This first process must identify the particular month of the Current_date. In this example this is 'December'.
2. As data is stored in the core database under week and weekend day types, the type of day refereed to by Current_date must be obtained. In this example 22/12/00 would be a weekday.

3. Category_list contains a list of the unique categories defined by the 6 characteristics in section 8.4. A pointer is required to indicate which category in the list is being pointed at. In the first instance, the first unique category will be required and the corresponding call profile, stored in the core database, should be retrieved.
4. Having found the call profile, one of the fields must indicate the total number of calls received for week and weekend days. The 22/12/00 has been defined as a weekday, therefore the weekday field is retrieved from the core database. In addition the number of days over which the calls were generated must also be retrieved.
5. The total number of calls for this category can be calculated using Equation 8.2

$$\left[\frac{\left(\frac{[N_{calls:CDB} \times U_{mod}]}{N_{days:CDB}}\right)}{[N_{users:CDB}]}\right] \times U_{users:} \qquad 8.2$$

$N_{calls:CDB}$ = Average number of calls defined in the core database for this category, in this example for week days.

$U_{mod}$ = Any user defined percentage change in the number of calls, for example if 10% more were required $U_{mod} = 1.10$ if the user does not enter any change $U_{mod} = 1$.

$N_{days:CDB}$ = Number of days over which $N_{calls:CDB}$ was gathered, defined in the core database.

$N_{users:CDB}$ = Average number of users who generated $N_{calls:CDB}$, defined in the core database.

$U_{users}$ = The number of users defined in the simulation run for this category of call.

6. Equation 8.2 will indicate the average number of calls in a specific category received at the control centre on the Current_date. This number will be the same for each day type (week or weekend) but in practice the average number will not occur everyday and there will be some variation around the mean. In order to achieve this variation, the normal distribution is used to alter the number of calls received within defined limits of ±5% as indicated by Fig 8.4. This allows the majority of the calls to be distributed around the mean, with the reduced possibility that some will be subjected up to a 5% change.

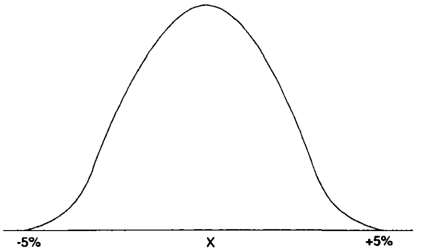



Figure 8.4: *The simulated number of calls subjected to the normal distribution*

7. Having calculated the number of calls that should be simulated for the category and day in question, when these calls occur should be based on the call profile indicated by the core database. The core database contains the call profile on an hourly basis (summation of the 12, 5 minute time slots for an hour) and a number can be assigned to the occurrence of each call as indicated in Table 8.4.

Table 8.4: *Generating the occurrence of simulated calls based on core database call profile*

| Hour | Frequency | Number range |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 0 | |
| 2 | 0 | |
| 3 | 1 | 1 |
| 4 | 0 | |
| 5 | 0 | |
| 6 | 1 | 2 |
| 7 | 0 | |
| 8 | 3 | 3,4,5 |
| 9 | 6 | 6,7,8,9,10,11 |
| 10 | 2 | 12,13 |
| 11 | 6 | 14,15,16,17,18,19 |
| 12 | 6 | 20,21,22,23,24,25 |
| 13 | 1 | 26 |
| ... | ... | ... |
| 22 | 4 | 43,44,45,46 |
| 23 | 2 | 47,48 |

Process 8 will generate a random number, in this example between 0 and 48, and the number generated will indicate the hour the call was received. For example, if the number 18 was randomly generated this would indicate the call should be received in hour 11. However, Table 8.4 indicates that some of the hour time slots contained no call data and consequently such a method would never simulate calls in these time slots. Although the core database may indicate that calls do not occur at certain hours of the day, in practice there is always the possibility of a call occurring. To resolve this issue, 1 is entered into any hour's frequency where no calls are evident with the frequency of the others is increased by 100%. This therefore, provides a small possibility that a call will occur in an hour time slot even if the core database indicates that non are present.

8. Having generated a suitable call profile, a random number generator can be used to identify the hour the simulated call is received at the control centre.
9. The 5-minute time slot in which the simulated call is received can be calculated in a similar fashion to that described in processes 7 and 8.
10. The actual minute can be calculated using a random number generator as this level of detail is not held within the core database. For example, if the 5-minute time slot was 10 to 14 then the result of a random number generator between 0 and 4 can be added to 10 and the actual minute known.
11. The actual second of the call can be based on a random number generator between 0 and 59. The actual time of the simulated call is now defined, for example '22/12/00 13:31:58'.
12. Section 8.1 indicated that the model should be used to generate results within a given time period, such as 08:00 to 10:00. In this example with the simulated call occurring at 13:31:58 the call should not be included and processes 13 to 20 ignored.
13. The duration of a call is only required when the operator is involved, therefore if it is a system call processes 13 to 20 can be avoided. The duration of operator calls is again based on the information provided in the core database. For example if the simulated call occurred in hour 13 of a week day, then the core database will contain a field indicating the average duration for this particular hour and unique category. However, it could be possible that no data is provided in this field and the duration unknown. If this situation arises the core database should be analysed for the duration of the first occurrence before the hour in question and the first after this. For example, using '22/12/00 13:31:58' if no duration data was available in hour 13, then the hours prior to and after hour 13 should be analysed and when a figure is found, an average of these taken.

14. If the simulation user suggests a percentage change to the duration of the call acquired in the previous process then this should be applied at this stage.
15. In a similar fashion to process 6, a 5% variation should be applied to the duration of the call to ensure that calls do not all have the same average duration. However, the duration of calls varies quite considerably in practice. For example, if an ambulance is sent to a users home the operator may inform the user and close down the call, or they may continue to talk and comfort the user until the ambulance arrives. Therefore, a 5% variance on the hourly average does not provide sufficient capability to model the real world. Consequently, in addition to the 5% variation it is suggested that 1 in 8 calls be exposed to a further 15% variance; again following the normal distribution.
16. The time the call is closed can be calculated by adding the duration to the time the simulated call was received. Having generated the call this information should be recorded in the results database.
17. The core database should be analysed and the probability of an outgoing call to a responder, doctor, or the emergency services obtained. This should be based on the time the simulated call was received, i.e. the probability during office and non-office hours. The duration of the outgoing calls should also be retrieved.
18. A random number generator can be used to establish if an outgoing call is made. For example, if there is a 20% chance of the police being contacted then a random number between 1 and 100 can be generated and if the number is <=20 then it can be suggested in this instance that the police are contacted.
19. If an outgoing call results, its start time can be indicated by the time the incoming call was closed, identified in process 16. The duration of the outgoing call can be based on the time defined in the core database with a 5% variance.
20. Processes 17 to 19 should be repeated for all outgoing call types.
21. Processes 8 to 20 should be repeated for the specified number of simulated calls occurring for the current category.
22. The pointer indicting the list of unique categories should be incremented to point at the next category.
23. If there are more categories that have yet to be simulated then processes 3 to 22 should be repeated.
24. The Current_date should be incremented and the category pointer reset to the first category.
25. Process 1 to 24 should be repeated until the Current_date is greater than the end date, indicating the end of the simulation run.
26. All of the simulated calls are entered sequentially into a table in the results database. These calls therefore need to be sorted based on the time a call was received.
27. If the simulation user requires an estimated shift pattern, the simulated calls table should be copied.

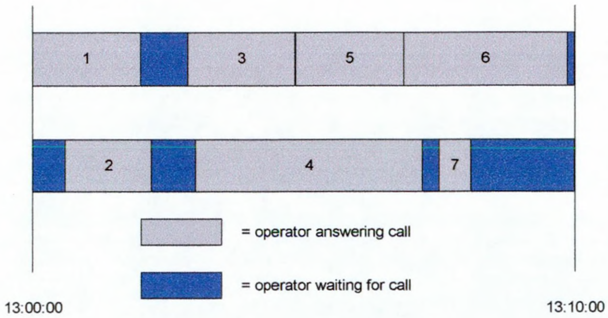
## 8.7 Process 3: Generate Results

### 8.7.1 Imposing the shift pattern on the simulated calls

The previous processes generate a list of simulated calls such as that indicated in Table 8.5.

| | | | | | |
|---|---|---|---|---|---|
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:03:22 | 125 | 13:05:27 | 0 |
| 6 | 13:06:00 | 13:06:00 | 178 | 13:08:58 | 0 |
| 7 | 13:07:25 | 13:07:25 | 35 | 13:08:00 | 0 |

The list of simulated calls are now exposed to the shift pattern and modified to reflect when the they were actually answered and any associated delays. Using the list of simulated calls in Table 8.5, Fig 8.5 indicates the outcome of this process if 2 operators are on duty and the shift pattern does not change during this period.



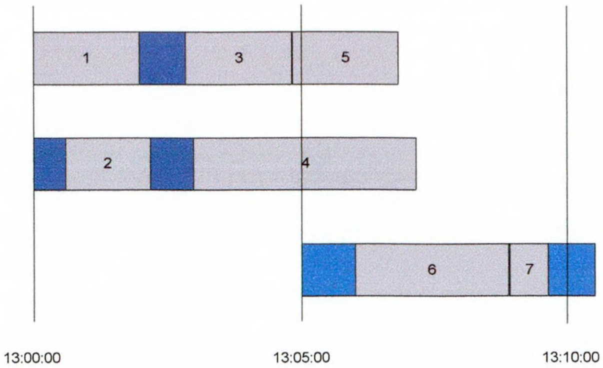

| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:55 | 178 | 13:09:53 | 55 |
| 7 | 13:07:25 | 13:07:25 | 35 | 13:08:00 | 0 |

Figure 8.5: *Imposing a shift pattern when the number of operators does not alter*

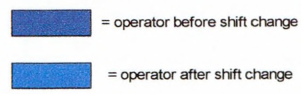
However, when the number of operators on duty changes then the situation is more complex. As part of Process 1 (section 8.5), the simulation user was required to enter the number of consoles available and indicate if the operators physically changed at the end of the shift. Assuming the number of consoles available is 3 and that 2 operators are on duty prior to a shift change at 13:05:00, then the impact is as described in Fig's 8.6, 8.7 and 8.8.

Fig 8.6a indicates that 2 operators are on duty prior to the shift change at 13:05:00 and at this time a single operator replaces them. Because the 2 operators are answering calls at the time the shift changes they continue with these calls until they are completed and leave their consoles at 13:06:55 and 13:07:10. If they were not answering calls then they would leave the console at the shift change, 13:05:00. Because there are 3 consoles available and 1 is not being used when the shift changes the new operator can commence at 13:05:00 on this free console and answer calls immediately. Thereafter all calls are answered by the single operator as the previous operators have left.

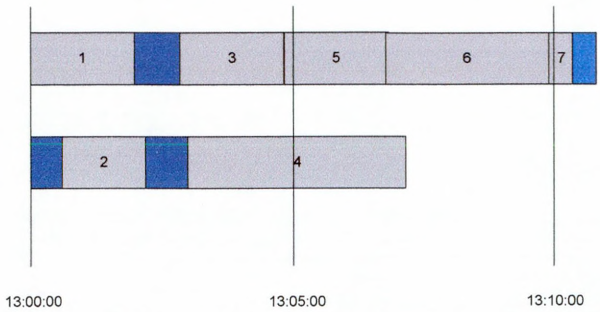
However, if the control centre had only 2 consoles and both of these were being used then the new operator could not answer calls until a console becomes available. In the example in Fig 8.6a, this occurs at 13:06:55 and the new operator replaces the previous operator at this time.




| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:00 | 178 | 13:08:58 | 0 |
| 7 | 13:07:25 | 13:08:58 | 35 | 13:09:33 | 93 |




(a): *Shift change with a free console and a reduction in the number of operators*



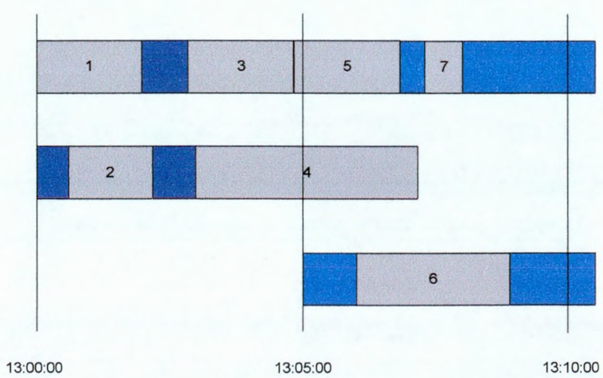

| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:55 | 178 | 13:09:53 | 55 |
| 7 | 13:07:25 | 13:09:53 | 35 | 13:10:28 | 148 |

(b): A *reduction in the number of operators at the shift change without any spare consoles available*

Figure 8.6: *Impact of shift changes where number of operators reduces*

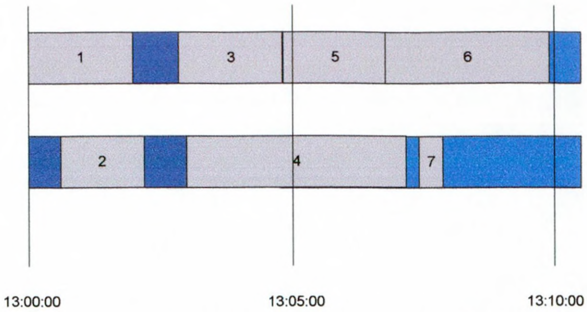
It could be possible that at a shift pattern exists where the operators do not physically change. Examples would include where 2 operators may be on duty from 06:00:00 to 13:05:00, but due to 13:05:00 to 14:00:00 being a period where few calls are received 1 of the operators leave and 1 of them continues to 14:00:00. As such, at 13:05:00 the operator does not physically change. If the model assumed that at the end of every shift the operators were replaced as indicated in Fig 8.6a the wrong result would be evident. Instead the appropriate result is that indicated in Fig 8.6b (assuming the first operator to finish at or after 13:05:00 is the operator who leaves).

Fig 8.7 indicates the appropriate response when the number of operators does not change at the shift change, while Fig 8.8 indicates the response when the number of operators increases by 1.



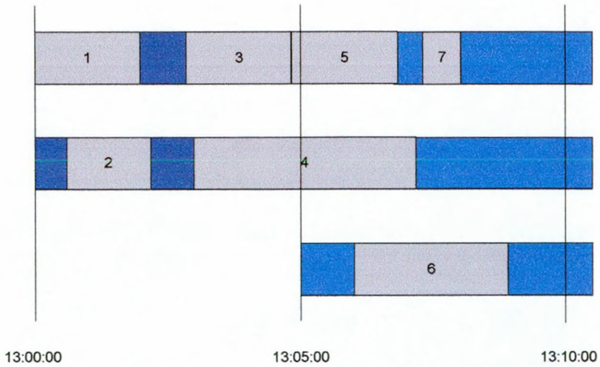

| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:00 | 178 | 13:08:58 | 0 |
| 7 | 13:07:25 | 13:07:25 | 35 | 13:07:50 | 0 |

Figure 8.7a: *The impact of a shift change where the number of operators does not change and operators physically change*




| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:55 | 178 | 13:09:53 | 55 |
| 7 | 13:07:25 | 13:07:25 | 35 | 13:07:50 | 0 |

Figure 8.7b: *The impact of a shift change where the number of operators does not change and operators do not physically change, i.e. in affect no change to the shift*




| Call no. | Received | Answered | Duration | Closed | Delay |
|---|---|---|---|---|---|
| 1 | 13:00:00 | 13:00:00 | 120 | 13:02:00 | 0 |
| 2 | 13:00:40 | 13:00:40 | 100 | 13:02:20 | 0 |
| 3 | 13:02:50 | 13:02:50 | 120 | 13:04:50 | 0 |
| 4 | 13:03:00 | 13:03:00 | 250 | 13:07:10 | 0 |
| 5 | 13:03:22 | 13:04:50 | 125 | 13:06:55 | 88 |
| 6 | 13:06:00 | 13:06:00 | 178 | 13:08:58 | 0 |
| 7 | 13:07:25 | 13:07:25 | 35 | 13:07:50 | 0 |

Figure 8.8: *The impact of a shift change where the number of operators increases from 2 to 3*

In the example of Fig 8.8, whether the operators physically change or not has no impact upon when calls are answered. This is because at the time of the shift change all 3 consoles are being used. If the operators physically changed then at 13:05:00 the 2 previous operators would continue with calls 4 and 5, while one of the three new operators could begin on the spare console. However, the remaining two new operators could not begin until 13:06:55 and 13:07:10 when the consoles became available. This in affect is the same position as the two operators continuing after the shift change with a single new operator commencing at 13:05:00, as the old operators are replaced at 13:06:55 and 13:07:10.

In order to enable this approach for each shift it is necessary for the simulation user to define:

- Shift pattern: The start and end time of a shift for both week days and weekends.
- Operators: The number of operators on duty during a specific shift.
- Physical change: Whether the operators physically change at the end of the shift.

Despite this level of detail, the model does not fully reflect the real world in several identifiable ways:

1. Calls are answered immediately: As soon as a call is completed the next call can be answered immediately. Therefore, if a call ended at 13:02:00, the same operator can answer the next call at 13:02:00. A delay could be entered but the delay would be arbitrary and hence is not included.
2. Logging on and off duty. Each operator must log on and off their console, therefore every call they answer can be recorded in the control centre database for accountability purposes. No provision is provided in the model for the time it takes to log on and off duty.
3. Shift breaks are ignored: In the model it is possible for an operator to be answering calls for their entire shift. Discussions with operators indicated that breaks tend to be taken when calls are not

present and therefore are not structured in the sense that after 4 hours, a 15 minute break will be taken. Because of variability of breaks they are not included in the model.

4. Changing shifts: If the operators physically change at a new shift it is probable that at busy times, the new operators may start prior to the shift change, while the operators whose shift has ended may continue and answer some of the calls after the time they were expected to leave. Such a possibility is not quantifiable and is therefore ignored in the model.
5. Additional unscheduled operators: At particular busy periods it may be that additional operators can assist the control centre that are not scheduled in the shift pattern. After the number of queued calls reduces these additional operators return to their previous work. Due to the variability of such a possibility no provision for this is provided in the model.
6. Leaving operators: In the model, if the number of operators at a shift change reduces then the first operator to end a call at, or after the shift change, is the person who leaves their console. In practice it may be an alternative operator who is scheduled to leave. For example, if a shift ends at 14:00:00 and 1 of the 2 operators leave if the times they finish calls is 14:02:00 and 14:05:00, the model suggests that the operator finishing at 14:02:00 leaves and the next call can be answered at 14:05:00. However, if the operator finishing at 14:05:00 is the operator who leaves, calls can be answered from 14:02:00.
7. Physical change of operators: Although Figs 8.7 to 8.8 indicate the provision for operators physically changing at the end of a shift they only allow all or none of the operators to leave. It may be that in certain circumstances this does not provide sufficient flexibly. For example, if a shift had 1 operator from 06:00:00 to 14:00:00 and during 07:00:00 to 09:00:00 an additional operator was present then at 09:00:00 one operator will physically change and the other will remain. However, discussions with operators revealed that at present, such a situation is rare as shifts tend to be for 8 or 12 hours and as such the operators will physically change at the end of their shift.

The overall process is described in the pseudo-code below and central to the process is an Operators_array. This must be a dynamic array to reflect the number of operators on duty and each element within it contain the time the operator finishes a call. For example, an array which is 3 elements large indicates 3 operators are on duty, and the information within the array indicates the finishing times, if an element does not contain any information then the operator is waiting for a call.

```
BEGIN
Move to first simulated call (Table 8.5)
Initialise Operators_array with 1 empty element
    WHILE not at end of simulated call list and call required operator
        Find the time the call was received
        Move to first element in Operators_array
        WHILE not at end of Operators_array
            If the time the call is received is greater than the time in Operators_array then delete that element in array
        LOOP
        If 1 or more operators free to answer call THEN
            Find the day type (week/weekend) when call was received
            Find the number of operators on duty when call was received
        ELSE
            Find the first operator to be free in Operators_array
            Find the day type (week/weekend) when first operator becomes free
    Find the number of operators on duty when first operator becomes free
        END
        If required number of operators differs to size of Operators_array THEN
            If required number of operators> Operators_array THEN
                Increase Operators_array to appropriate size
            ELSE
                WHILE require number of operators<> Operators_array THEN
                    Remove last operator to be free in Operators_array
                LOOP
            END
        END
        Operators_array(x) = first operator able to answer a call in Operators_array
        If operator waiting for call (Operators_array(x)=empty) THEN
            Move to next call in simulated call list
            WHILE call category = responder, doctor, police, ambulance or fire THEN
                Move to next call in simulated call list
            LOOP
            Move to previous call in simulated call list
            Enter closed time of current call in simulated call list into Operators_array(x)
        ELSE
            The answered field of current call in simulated call list = Operators_array(x)
            The closed field of current call in simulated call list = Operators_array(x) + duration of current call
            The delay field of current call in simulated call list = time call answered – time call was received
            Move to next call in simulated call list
            WHILE call category = responder, doctor, police, ambulance or fire
                The answered field of current call in simulated call list = closed time of previous call
                The closed field of current call in simulated call list = time call answered + duration of current call
                Move to next call in simulated call list
            LOOP
            Move to previous call in simulated call list
            Enter closed time of current call in simulated call list into Operators_array(x)
        END
    LOOP
END
```

### 8.7.2 Estimating an efficient shift pattern

The other main attribute of this third process (generate results) is the estimation of an efficient shift pattern. This should only be calculated if the simulation user requests it, and after estimating the required number of operators, this shift pattern can be applied to a copy of the simulated calls, as described in section 8.6, from which results can be generated.

The shift pattern should be estimated based on 30-minute time intervals. This provides the simulation user with a detailed analysis of the call workload while still providing an overview of the whole 24-hour cycle. Thirty minute time slots have also been used to report results in the IMAJ software described earlier[406]. In order to estimate the shift pattern 6 processes are required:

1. Calculate the required operator time. Based on the simulated call list for each 30 minute time slot this process should calculate how many seconds were spent answering calls. This should be based on both weekdays and weekends and can be calculated from the time each call was answered and its duration. Therefore, if a simulated call was answered on Friday 22/12/00 at 23:18:00 and was

completed the following day at 00:02:15, then this should be recorded as indicated in Table 8.6. This should be repeated for every simulated call that requires the operator.

Table 8.6: *Calculating the required operators time for an estimated shift pattern*

| Time slot | Contents of time slot |
|---|---|
| Week day 23:00:00 to 23:29:59 | Increment by 719 (11 min 59 sec) |
| Week day 23:30:00 to 23:59:59 | Increment by 1799 (29 min 59 sec) |
| Weekend 00:00:00 to 00:29:59 | Increment by 135 (2 min 15 sec) |

2. Calculate the number of days for which the simulation was run: In terms of the number of week and weekend days.
3. Estimate the required number of operator minutes: When estimating the shift pattern, the simulation user was required to enter a preferred utilisation rate, which indicates how busy the operator(s) should be, i.e. if 50% were entered, 50% of the time should be sent on calls and 50% waiting for calls/performing other tasks. This figure can be used to estimate the required number of operator minutes for each 30-minute time slot as indicated in Equation 8.3. The result of this equation indicates how many minutes are required for the particular time slot. For example, if the number of seconds on calls was 600 (10 minutes) and the required utilisation 50%, and the number of seconds on calls was based on two week days, then for the time slot in question 10 minutes of operators time would be required.

$$\frac{\text{Number of seconds spent on calls}/60}{\text{Required utilisation}} \Big/ \text{Number of days (week or weekend)} \qquad 8.3$$

4. Suggest the number of operators: The result from Equation 8.3 should be divided by 30 to indicate the required number of operators. The 30 representing the number of minutes a single operator is available in the 30-minute time slot. Because it is only possible to have a whole operator on duty the result should be rounded to the nearest whole number.
5. Ensure correct number of operators: If the suggested number of operators is below the minimum defined by the simulation user, then the suggestion should become the minimum. Conversely, the user could specify a maximum number of operators, and if so the suggested number of operators should not exceed this.
6. Process 27 in section 8.6 indicated that the list of simulated calls was copied and therefore the final process is to repeat section 8.7.1 with the estimated shift pattern. This can be used to indicate the impact of the estimated shift pattern on the calls received, and the results can be compared with the user entered shift pattern.

## 8.8 Display results

The list of simulated calls now provides details of when every call was received, answered, closed and any corresponding delay. If the simulation user requested an estimated shift pattern then an additional list of calls will also be evident. The final process can therefore analyse these lists, and the results of the simulation run obtained. The results can be categorised into three sections:

### 8.8.1 Call results

1. Summation of the number of calls: Analysis of when calls were received for example, for each category of call how many calls were received for each hour or half hour segment of the day. In addition to analysis on category name, the results should be grouped according to system or operator, and sheltered housing or dispersed user.

### 8.8.2 Operator results

For each half hour time slot (i.e. 00:00 to 00:30 etc.) the results should include:

1. Total number of operator minutes during simulation run: I.e. how many minutes of operator(s) time was available. Thus if the simulation covered 2 days and 1 operator was on duty for the particular half hour time slot during these 2 days then the number of available minutes would be 30 minutes * 2 days = 60 minutes.
2. Total time spent on calls: For the duration of the simulation run, how much of an operators time was spent speaking to callers.
3. Daily number of operator minutes: The average daily number of minutes that operator(s) were available to answer calls.
4. Daily number minutes spent on calls: The average daily amount of time operators spent speaking to callers.
5. Operators utilisation: Calculation of how much of the operator(s) time was spent speaking to callers.
6. Number of callers who had to wait: For the duration of the simulation run, the number of callers who had to wait before they could speak to an operator.
7. Average wait time: For the duration of the simulation run, for those callers who had to wait to be answered the average delay should be calculated.
8. Maximum delay: For the duration of the simulation run, the maximum that any one caller had to wait to be answered.
9. Details of every delay: For the duration of the simulation run for every caller who had to wait to be answered, the exact delay time should be displayed.
10. SQL interrogation: Using the Standard Query Language for interrogation of databases the list of simulated calls should be available for any user entered query.

### 8.8.3 Costing

The costs of the simulation run should be presented for the duration of the simulation run, for an average week and an annual figure. The results should be calculated from:

1. Telephone calls: The minimum telephone charge and the average charge per minute for peak and off-peak times can be obtained from the simulation user. Based on these costs the list of simulated calls can be analysed and the costs calculated.
2. Shift costs: For both the week and weekday shifts the cost of a single operator per shift should be provided by the simulation user.
3. Maintenance: The average weekly maintenance cost for equipment, based on dispersed users and sheltered housing users or schemes, depending on the parameters chosen for the simulation run.

4. Income: The average monitoring charge per user for dispersed users or sheltered housing users/schemes depending on the parameters chosen for the simulation run.

When generating the results it should be appreciated that calls could be evident after the intended end of the simulation run. For example, if the simulation was intended to end at 22/12/00 00:00:00 then if only 1 operator was on duty and a call was received at 21/12/00 23:34:12 lasting for 40 minutes, then all of the subsequent simulated calls after 23:34:12 but generated before the end of the simulation run will not be answered until after the end of the run. As the simulation user was only interested in calls within the time scale they defined, these calls should not be included in the results, however the user should be informed of such calls.

## 8.9 Conclusions

This chapter has indicated the relevance of a simulation package as it can be used to model future telecare systems and provide an indication of the impact on service delivery. Several 'off the shelf' simulation packages were identified and could be used to provide a general insight, however a simulation model was required that could be used to analyse any current control centres database. Having obtained data on a control centre's workload, the model could then be used to modify these historical categories or new categories added. For example, if a new device such as a fall detector became available and a field trial was performed then results of the trial could be added to the model and the impact of more users having the device investigated.

This chapter has sought to provide an overview of the design of the simulation model and highlights particular areas of importance including:

- How call categories are defined and the necessary data requirements to obtain a realistic model.
- What parameters are required from the simulation user to define a particular simulation run.
- How simulated calls are generated.
- How the simulation user's shift pattern is imposed onto the simulated calls.
- How an efficient shift pattern can be estimated.
- The results to return to the simulation user.

Despite this chapter covering the main aspects of the model, further more detailed comments are provided within the program code. This is best viewed in visual basic as the comments are identified in green. However, the program code is also provided in a rich text format (RTF) on the attached CD and can be viewed by most text editors. The automatic database analysis is refereed to as the 'Telecare_utility' program and the simulation itself, the 'Telecare_simulation', the appropriate files can be found in the 'Telecare_code' folder.

The actual programs have been tested on Windows 95 and 98 machines and can be installed following the onscreen instructions. The programs can be found in the 'Telecare_progs' folder on the attached CD. The destination folder chosen during the installation process will also install a help file, although the help files for both the utility and simulation program have been reproduced in Appendix A8.1 and A8.2 respectively.

Having created the model, Chapter 9 will validate it and run various scenarios indicating the impact that a $2^{nd}$ generation system may have on service delivery.

# 9 Model Results

***Chapter structure:*** *Having created the service delivery model, particular attention is given to validating the model to ensure it simulates the current system. Once this has been achieved the impact of the 2nd generation telecare system described in Chapter 5 is estimated and included in the model to discover the service delivery implications.*

The completed model of Chapter 8 provides an insight into the operation of what may be considered the focal point of the telecare system, the control centre. In a similar manner to the cost analysis model, this model can be used in a variety of ways to generate results and therefore this chapter provides an overview of the main outputs. The model as created simulates the current system and provides an indication of the possible impact of new technologies. For example, the use of a fall detector and its anticipated call profile can be included in the model to indicate the effect this may have on the loading of the control centre. It may be suggested that the creation of a model that simulates the current system is not particularly beneficial. However, the results of a model which cannot been validated are of doubtful value[401], while the analysis of the current system leads to a better understanding of the system and may therefore reveal improvements to that system during the modelling process.

## 9.1 Model Validation

This refers to determining whether the model accurately represents the intended system, it does not therefore test the programming of the model, but rather the results of the model in relation to the target system[401]. In order to ensure a models accuracy Law and Kelton suggest five techniques[401]:

### 9.1.1 Collect High quality information and data on the system

In order to model the present system it is necessary to understand how that system works. Throughout the duration of the research access has been granted to Birmingham City Council's control centre and the results of an analysis of this control centre have been previously reported[409]. Two of the project sponsors, TeleLarm and Pentyre, provided this system, while investigation of other control centres has also been conducted[25]. In addition to understanding how the control centre works from a manager's stance, informal discussions with operators have also been conducted. The role of the control centre and its information handling was also investigated from the warden's and community alarm users perspective, with the results reported in Chapter 3.

From a clear understanding of how the control centre system operates, the model can be created to reflect the changes and constraints under which it currently functions. Having created the model, in order to simulate its operation accurate data is required with this being obtained from Birmingham City Council and Pentyre. Access was granted to historical data held on the control centres database which contains details of every call received at the control centre and the response made by the operators[26]. In order to

[25] Investigation of the Jonteck system and call data was provided by Mr Roger Brett, Barking Community Centre manager and the then chair of the Association of Social Alarm Providers (ASAP). While investigation of the Tunstall call centre system and data was provided by Mr Vince Foot, Chichester Community Careline manager and Mrs Eileen Ganne, Orbit Housing Association control centre manager and then member of the executive committee of ASAP.

[26] This database with a file name of 'CC_database' is provided on the accompanying CD.

maintain confidentiality, this database only contains details of call occurrence and duration. At the request of the control centre manager the data covers the period from June 1999 to November 1999.

### 9.1.2 Interact with the business manager on a regular basis

Throughout the creation of the model regular input from interested parties has been sought. Quarterly meetings with the review group, consisting of Birmingham city's control centre manager, and the supplier and manufacturer of the control centre system used in Birmingham were maintained. While further meetings with the control centre designer have ensured that the database was understood and the contents accurately transferred to the model. For example, when seeking to transfer the real-world data to the model it became apparent that the database contained what may have been considered as incomplete data in three respects:

1. *Calls without an origin*: i.e. the database acknowledged a call but did not indicate whether the call originated from sheltered housing or a dispersed alarm user.
2. *No closing down comment*: The control centre system requires the user to indicate the action taken from a drop down menu and the call should not be able to be closed without this data. However, the database contained calls without this data.
3. *No duration of call*: The data indicated that an operator responded to a call but the duration of the call was zero seconds.

Discussions with the control centre manager and system designer revealed that these were calls where a member of the control centre staff had incorrectly opened a users record or 'pseudo calls' that were generated for training and information purposes. As such, these calls should not be included in the model as they do not result from callers, they should also not be held within the control centre's database as the results of any management information system analysis will contain these calls. In the transformation of the data into a form suitable for the model, these calls have been removed.

### 9.1.3 Maintain an assumption document and perform a structured walk-through

The assumptions of the model fall into 2 categories, generating the simulated calls and the operator's response to these calls. The assumptions used to generate simulated calls were highlighted in section 8.6 and centre around how calls are grouped into the 5-minute time slots. Alongside this is the assumption that the average duration of calls can be based on hour time slots.

Section 8.7.1 lists the assumptions associated with shift changes, indicating that provision is provided to include the possibility that operator(s) will continue on a call after the shift change, while new operators will only answer calls when consoles are available. The finial assumption is reported in section 8.8.3, which indicates that only calls answered within the end date of the simulation run are included in the results.

The structured walk-through refers to a paper exercise where the model and its assumptions are agreed prior to the commencement of programming. The majority of the assumptions in this model were agreed with the project review group prior to the commencement of programming, although as the understanding of the current system was enhanced further assumptions were included, for example in association with the shift change.

### 9.1.4 Validate components of the model by using quantitative techniques

In terms of ensuring that the model outcomes reflect anticipated figures, investigation is required for both the utility and simulation program. The utility program must be validated to ensure that the automatically generated core database reflects the original control centre data. While the model itself should be validated to ensure the simulated results reflect the core database. Having validated the model with known data, confidence can be given to the results of the model when hypothetical call profiles are investigated.

*The utility program*

As discussed, the control centre's database contains data that does not originate from a community alarm user. Table 9.1 therefore indicates the number of calls that should be included in the core database and the actual number generated as a result of the utility program.

Table 9.1: *Comparison of calls evident at the control centre and those generated in the utility program*

| Month | Number of calls in the control centre's database | Number of calls that should not be included, such as 'pseudo calls' | Actual number of calls to include in the model | Number of calls generated for the core database | Difference |
|---|---|---|---|---|---|
| June | 22,767 | 1,722 | 21,045 | 21,047 | +2 |
| July | 23,075 | 1,414 | 21,661 | 21,660 | -1 |
| August | 22,681 | 1,550 | 21,131 | 21,129 | -2 |
| September | 22,146 | 1,261 | 20,885 | 20,883 | -2 |
| October | 22,891 | 1,354 | 21,537 | 21,537 | 0 |
| November | 23,831 | 1,576 | 22,255 | 22,254 | -1 |

Clearly the utility program can analyse a control centre's database and generate a list of categories reflecting the required number of calls. With the exception of October, Table 9.1 indicates that for each month, the generated core database was slightly incorrect and it is unclear why this should be so, however as the error is so slight it can be ignored. However, to ensure that the calls are dispersed within the appropriate time slots further investigation is required and can be performed by an individual SQL statement on the control centre's database. For example, a typical statement may be:

"SELECT UNIT_CATEGORY, CALL_TYPE, RECEIVED FROM histlog WHERE ((month (RECEIVED) = "6" and call_type = "C" and comments_code = "1") and (hour (RECEIVED)="9"));"

For the month of June this SQL statement will indicate the number of calls received at the control centre where the caller requested a carer in the period 09:00 to 10:00. The result of this SQL statement can be compared with the generated core database and in both cases 25 calls were evident.

Similarly, the SQL statement:

"SELECT UNIT_CATEGORY FROM histlog WHERE ((month (RECEIVED) = "7" and call_type = "P") and (hour (RECEIVED)="11"));"

will obtain the number of pulled in error calls during the $11^{th}$ hour of the day for the month of July. A figure of 138 calls is obtained from this statement and the generated core database agrees with this figure. Such SQL statements can be repeated for all categories of call evident in the control centre's database. Analysis of the 5-minute time slots is not performed as the 1-hour total in the automatically generated core database is obtained by adding the appropriate 5-minute time slots together and therefore this verification is performed indirectly. A dozen random time periods and categories were selected and the appropriate results obtained. This indicates that the utility program successfully attributed a call in the real-world control centre database to the correct category and time slot in the generated core database.

The other attribute of the utility program is to automatically generate the duration of calls for specific hours and individual SQL statements again can verify this. For instance, the statement:

"SELECT avg (DateDiff ("s",[response],[cleared])) FROM histlog WHERE (call_type = "C" and comments_code = "1") and (hour(RECEIVED)="9" ) and month(response) = 6 and unit_category = "2" and ((day(RESPONSE) = 5 or day(RESPONSE) = 6 or day(RESPONSE) = 12 or day(RESPONSE) = 13 or day(RESPONSE) = 19 or day(RESPONSE) = 20 or day(RESPONSE) = 26 or day(RESPONSE) = 27));"

obtains the average duration of calls where a carer is requested during the $9^{th}$ hour of weekdays in June, with the call originating from users dispersed in the community. The result of this statement is a figure of 54.8 that compares favourably to a figure of 55 in the generated core database[27]. In a similar manner other random checks indicated that the utility program accurately obtained the average duration of calls.

*The simulation program*

Because the utility program accurately generates the core database, running the simulation with this created core database should reflect this data and indirectly the original control centre data. The simulation can be tested in a number of ways as described below:

Using the generated core database should result in the same number of calls being simulated. For example, during June the core database indicates that there were a total of 21,047 calls. Running the simulation for the month of June with all of the categories included should reproduce this figure. However, section 8.6 indicated that having generated the number of calls for a particular category, in order to ensure that the same call profile is not reproduced for every day in the simulation run, the number of calls are exposed to a 5% variable using the normal distribution. In order to compare like with like, this function was disabled during the analysis of the number of calls. Also, the probability of outgoing calls to the doctor, responder, or emergency services, was disabled as the total number of calls in the core database does not include these calls. Instead it indicates the probability of an outgoing call for each unique category based on the control centre's actual data. When every category of call is

[27] The field where the duration is stored is an integer field and therefore only whole numbers are permitted in the database. The utility program therefore rounds the figure of 54.8 to the nearest whole number. The alternative would be for the duration field to be stored as a single or double which require 4 and 8 bytes respectively, compared to 2 bytes for an integer.

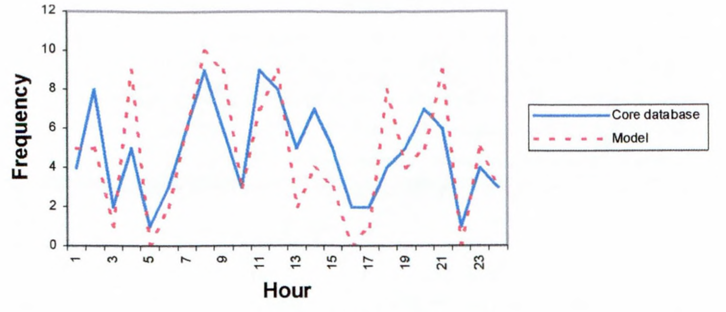
included, Table 9.2 indicates the expected number of calls for each month (from the core database and therefore from the actual control centre's data) and the corresponding results from the model.

Table 9.2: *Comparison of the core database and simulated model results*

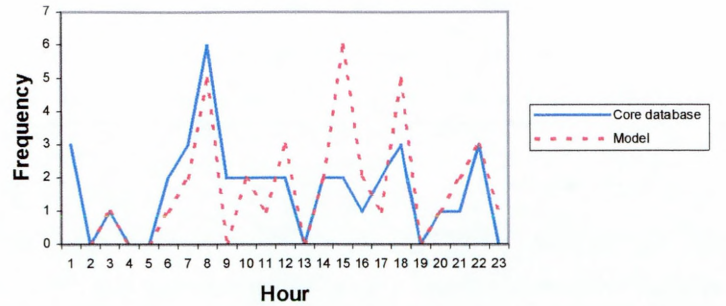
| | Core database | | | Model results | | |
|---|---|---|---|---|---|---|
| Month | Total | System | Operator | Total | System | Operator |
| June | 21,047 | 14,518 | 6,529 | 20,996 | 14,504 | 6,492 |
| July | 21,660 | 15,401 | 6,259 | 21,678 | 15,403 | 6,275 |
| Aug | 21,129 | 14,457 | 6,672 | 21,058 | 14,428 | 6,630 |
| Sept | 20,883 | 14,728 | 6,155 | 20,894 | 14,734 | 6,160 |
| Oct | 21,537 | 14,690 | 6,847 | 21,461 | 14,690 | 6,771 |
| Nov | 22,254 | 15,301 | 6,953 | 22,214 | 15,322 | 6,892 |

The model results were obtained by running the simulation twice, and as would be expected the same model outcomes were obtained in both runs. It is clear from Table 9.2 that the model does not reproduce the exact number of calls as indicated by the core database and this is due to rounding calls to whole numbers. For example, the core database indicates that in June there were 115 calls from users dispersed in the community categorised as 'No response - closed down', i.e. the alarm was raised but the operator could not communicate with the caller, and these calls were received during 22 work days. Therefore, the number of calls per day is 5.23 (115/22). As a control centre cannot receive a fraction of a call the model rounds the number to the nearest whole number, indicating a figure of 5 calls. As the model analyses and creates calls on a daily basis, over the 22 week days the number of calls will be calculated as 5 * 22 = 110; 5 less than is evident in the core database. This occurs for all categories in the simulation run and therefore accounts for the slight discrepancy between the core database and model outcomes.

Having generated the correct number of calls, when these calls occur in the model should also be validated and follow the trend indicated in the core database. The model should not produce an identical match as the model is designed to introduce some variability, however the model should reflect the general trend of the core database. The comparison of the call profiles can be seen in Fig. 9.1.




(a): *Weekdays only*




(b): *Weekends only*

Figure 9.1: *Comparison of call profiles*

It can therefore be suggested that the model reflects the core database, and by implication the real control centre data.

The probability of outgoing calls to the doctor, responder, or emergency services should also be verified and this can be achieved using the model. The real-world control centre database indicates the actual number of outgoing calls using an SQL statement such as:

"SELECT * FROM histlog WHERE (AMBULANCE<>0 or POLICE<>0 or FIRE<>0 or RESPONDER<>0 or DOCTOR<>0) and month(response) = "11" and (unit_category = "1" or unit_category = "2" or unit_category ="3" or unit_category = "4") and (call_type ="C" and comments_code<>"") and datediff("s", response, cleared)<>0;"

The 5% variance on the number of calls simulated during the run was disabled to ensure the same numbers of simulated calls were generated. Table 9.3 therefore indicates the expected number of outgoing calls and the number generated from the model, this is based on the average of 6 simulation runs for each month, the results of the actual runs are provided in Appendix A9.1 Tables A9.1.1 to 6.

Table 9.3: *Comparison of the actual number of outgoing calls with those simulated in the model*

| Month | Actual number | Model results | Difference |
|---|---|---|---|
| June | 358 | 376 | +18 |
| July | 376 | 389 | +13 |
| Aug | 373 | 398 | +25 |
| Sept | 397 | 428 | +31 |
| Oct | 420 | 438 | +18 |
| Nov | 395 | 433 | +38 |

Generally the model simulates a greater number of outgoing calls than would be anticipated. This is because the number of outgoing calls is small. Because of this a ±0.5 represents a significant variance, for example if the base number is 1 then there is a 50% change, whereas if the base number was 10 ±0.5 represents only a 5% change. It should also be appreciated that outgoing calls account for only a small percentage of the total calls. For the month of June the model simulated a total of 6,492 calls requiring the operator and of these only 376 were outgoing calls, approximately 6%. The duration of outgoing calls was agreed with Birmingham City Council's control centre manager[240]. The average duration of all call types for the doctor was suggested at 270 seconds, a responder 90 seconds and the emergency services 45 seconds. The actual duration of outgoing calls is not withheld within the control centre database.

The duration of the simulated calls must also be validated. The core database maintains a list, for each unique category, of the average duration of a call for each hour of the day. This can then be compared with the simulated results using the SQL statement:

"SELECT avg(Duration) FROM Calls WHERE (Category= "No response - closed down") and hour(answered)=0 and day = "W""

For the selection in question the core database indicates a figure of 75 seconds, while the model results indicate an average of 74 seconds. This was repeated for 12 random categories and time periods and suitable results were obtained.

### 9.1.5 Validate the output of the overall simulation model

In order to test the model fully all 6 months of the data obtained from Birmingham City Council can be included in a single simulation run. Table 9.4 presents the expected numbers of calls in the core database and the model outputs when the 5% variance on the number of simulated calls and generation of outgoing calls are both disabled. The model results were obtained by 2 simulation runs with the results being identical, as would be expected.

Table 9.5: *Comparison of the expected and generated results when all 6 months worth of data is used*

| | Core database | | | Model results | | |
|---|---|---|---|---|---|---|
| Month | Total | System | Operator | Total | System | Operator |
| 6 months | 128,510 | 89,095 | 39,415 | 128,291 | 89,081 | 39,210 |

Clearly the model generates the anticipated number of calls. The slight difference being explained by the rounding issue explained in section 9.1.4.

The validation performed above is a summary of the main aspects, other areas include ensuring:

- the number of simulated calls from sheltered housing and the community is correct.
- that the model works effectively using the number of sheltered housing users or number of schemes.
- changes in parameters are modelled correctly, for example, a change in the number of users, duration or number of calls.

In addition to the validation of the model, the program itself has been tested to ensure that it behaves consistently. For example, ensuring that the impact of the shift pattern works correctly or that the correct information is displayed when requested. Law and Kelton suggest that '*a simulation model and the corresponding results have integrity if the manager and key personnel accept them as correct*[401].' After the model and accompanying documentation was completed the model was tested with the review group and then provided for their own verification. All members of the review group, including the control centre manager, have verified that the model accurately reflects the current system and therefore have confidence in the results it generates.

## 9.2 Results For The Current System

When generating results from the model the shift pattern must be applied to the simulated calls. However, the shift pattern currently used does not correspond to the data stored on the control centre database. Prior to June 1999, the first month of the control centre data, the community alarm control centre and the out-of-hours repair centre were merged. This centre receives calls from tenants across the city requesting emergency repairs to their properties, calls are only received out-of-hours as at all other times a recorded message informs the caller to contact their neighbourhood office.

When an out-of-hours repair operator answers a call they log the information provided by the caller and inform the appropriate tradesmen. Prior to the merger, the community alarm control centre had 2 operators on duty 24-hours a day, while the out-of-hours repair centre also had 2 operators on duty during non-office hours. When the 2 control centres merged the shift pattern changed so that between 16:30 and 20:30, 3 operators were available during weekdays with 3 operators being available between 09:00 and 20:00 at weekends. At all other times 2 operators are available.

Although the 2 centres have been merged, the number of calls received regarding repairs is unknown, and this information also does not exist prior to the merger. Calls regarding repairs are likely to absorb a significant proportion of the operators time but because the occurrence and duration of calls regarding repairs is unknown, in consultation with the review group these calls have been disregarded. Section 9.2.1 indicates the possible impact that such calls may have on the control centre.

Analysis of the core database reveals that there is a category called 'Repairs reported' that accounted for 185 calls during June. As the name suggests these calls relate to a community alarm user who activated their alarm to report that repairs were necessary. However, the caller should have used the designated out-of-hours telephone number. Prior to the merger the control centre operator would inform the caller of the appropriate telephone number or nearest neighbourhood office, however such calls can now be responded to immediately.

When the model is used to reflect the current system the 5% variance on the number of simulated calls and the occurrence of outgoing calls has been reinstated. Consequently the model will generate calls based around the core database but with some variability to reflect the real world. The effect is presented in Table 9.6 where the model has been used 6 times to generate the results.

Table 9.6: *Analysis of the control centre for June*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 21,418 | 14,571 | 6,847 | 158 | 7:43 | 0:46 |
| 2 | 21,413 | 14,533 | 6,880 | 153 | 3:52 | 0:36 |
| 3 | 21,366 | 14,478 | 6,888 | 188 | 11:45 | 0:36 |
| 4 | 21,313 | 14,447 | 6,866 | 181 | 3:30 | 0:36 |
| 5 | 21,411 | 14,542 | 6,869 | 204 | 4:17 | 0:41 |
| 6 | 21,311 | 14,461 | 6,850 | 198 | 4:37 | 0:42 |
| **Avg** | **21,372** | **14,505** | **6,867** | **180** | **5:57** | **0:40** |

Due to the relatively large number of calls it can be seen that the model consistently generates a similar number of calls around the mean. With 3 of the simulation runs being above the mean and 3 below it; this reflects the normal distribution used in the generation of simulated calls. It is apparent that despite calls regarding repairs not being included that there were on average, 6,867 calls during June. This number includes both the incoming and outgoing calls, which were defined in Table 9.3. Therefore, the model estimates that on average 6,491 community alarm users contacted the control centre during June, approximately 216 incoming calls a day.

The purpose of the community alarm system is to provide timely and appropriate assistance to callers. Therefore, analysis of the number and duration of delays is significant, however analysis and comparison with the real control centre is not possible as the staff preferred to keep this information confidential. Nevertheless, Table 9.6 indicates that on average 180 callers had to wait for an operator to become available, representing almost 3% of calls. Table 9.6 also indicates the average delay but it is also important to know the range that calls are typically delayed. For example, calls which are delayed but are answered within 10 seconds represents an almost immediate response, whereas a high percentage of calls being answered after 30 seconds may not be considered so immediate. Table 9.7 indicates the range of delayed calls for each of the June simulation runs.

Table 9.7: *Delayed calls for each of the 6 simulation runs during June*

| June | Delay (seconds) | | | | | |
|---|---|---|---|---|---|---|
| | <10 | >10 & <=30 | >30 & <=60 | >60 & <=120 | >120 & <=180 | >180 |
| 1 | 42 | 59 | 28 | 17 | 2 | 10 |
| 2 | 42 | 54 | 36 | 16 | 4 | 1 |
| 3 | 41 | 76 | 36 | 22 | 6 | 5 |
| 4 | 45 | 64 | 38 | 25 | 9 | 2 |
| 5 | 47 | 68 | 59 | 21 | 7 | 2 |
| 6 | 40 | 72 | 44 | 23 | 8 | 11 |
| **Total** | **257** | **393** | **241** | **124** | **36** | **31** |

The majority of the delayed calls, 60%, are answered within 30 seconds with 82% answered within a minute. Therefore, the maximum delays indicated in Table 9.6 can be considered as rare. It should also be appreciated that the 6 simulation runs generated 41,200 calls requiring an operator with 40,118 being answered immediately. Including all of the calls reveals that 97% were answered immediately and 99% within 30 seconds. Investigation of the particular delays reveals that more calls are delayed on weekdays but the longest delays are experienced at weekends, as revealed in Table 9.8.

Table 9.8: *Investigation of the change on weekdays and weekends*

| June | Weekdays | | | Weekends | | |
|---|---|---|---|---|---|---|
| | No. delayed (daily) | Delay > 180 sec | Max delay (when call received) | No. delayed (daily) | Delay > 180 sec | Max delay (when call received) |
| 1 | 147 (7) | 8 | 9:33 (23:50:45) | 11 (1) | 2 | 4:40 (00:44:11) |
| 2 | 139 (6) | 1 | 3:52 (04:18:19) | 14 (2) | 0 | 1:26 (22:08:24) |
| 3 | 166 (8) | 0 | 2:41 (11:27:27) | 22 (3) | 5 | 11:45 (14:41:43) |
| 4 | 167 (8) | 0 | 2:32 (12:55:31) | 14 (2) | 2 | 3:30 (14:41:43) |
| 5 | 179 (8) | 0 | 2:57 (15:16:04) | 25 (3) | 2 | 4:17 (10:28:42) |
| 6 | 178 (8) | 8 | 4:09 (00:34:24) | 20 (3) | 3 | 4:37 (22:24:10) |

Analysis of when calls are delayed also indicates a clear trend that may suggest that at particular times of the day the shift pattern should change. Fig. 9.2 shows the delayed calls for the 6 simulation runs in June.

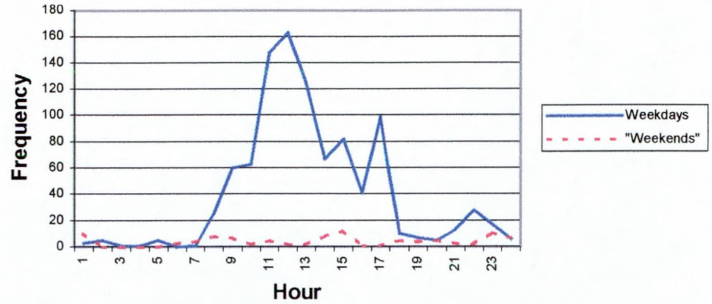



Figure 9.2: *Delayed calls for the 6 simulation runs during June*

Despite Table 9.8 suggesting that the largest delays are experienced at weekends, the number of calls that are delayed is relatively small. When analysing the delayed calls it should be remembered that the weekend shift has 3 operators on duty from 09:00 to 20:00 and that the model will tend to over-estimate the maximum delay. As previously discussed, if in practice the control centre is busy then operators will tend to place callers on hold while they answer new incoming calls. The model does not provide this function and instead requires the operator to finish a call before commencing a new call.

The weekday shifts operate with 2 operators on duty at all times except between 16:30 to 20:30 when 3 are available. However, Fig. 9.2 suggests that this shift pattern arrangement may not be satisfactory as a significant proportion of the delayed calls occur around 11:00 and 16:00. It could therefore be suggested that in order to reduce the likelihood of delayed calls, the additional operator commencing work at 16:30 should begin at 16:00, while an additional operator should assist between 11:00 and 13:00. However, although this would reduce the likelihood of delayed calls at these times, Table 9.8 indicates that on a daily basis only a few calls are delayed, and in only 2 of the 6 simulation runs did the maximum delay occur at these times.

What is evident from this analysis is that the control centre and therefore the community alarm system, is highly sensitive to calls. The control centre receives on average 216 calls a day with the majority occurring during daylight hours. But because the control centre generally operates with only 2 operators during weekdays[28] if both operators are answering calls requiring a significant amount of time, perhaps resulting in an outgoing call, then calls can quickly become queued. However, the majority of the time the operators are available and waiting for calls. Investigation of the operators utilisation rates, an expression which indicates the percentage of time operators were answering calls, reveals that much of the time they are waiting for calls, indeed rarely does the utilisation figure for a given hour exceed 10%. Therefore, despite the operators having in excess of 90% of their time waiting for calls, because the control centre is so sensitive to calls of any significant length, on occasions callers must wait for a considerable length of time. Table 9.9 further reveals the sensitivity of the control centre when the number of calls changes. The results of Table 9.9 are the average from 6 simulation runs, with the exact details provided in Appendix A9.1 Tables A9.1.7 to 12.

Table 9.9: *Sensitivity of the community alarm control centre to changes in calls during June*

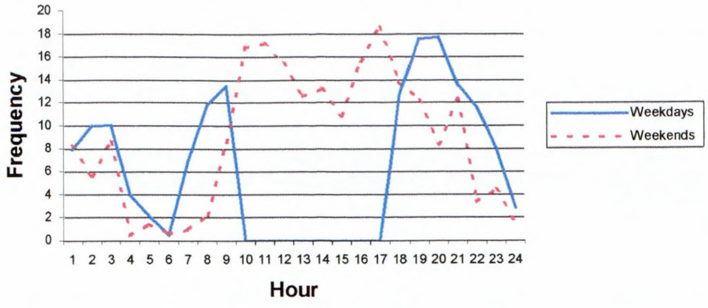
| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **Model characteristic** | **Total** | **System** | **Operator** | **Delayed** | **Max delay** | **Avg delay** |
| *Present system* | *21,372* | *14,505* | *6,867* | *180* | *5:57* | *0:40* |
| 20% more sheltered housing schemes | 25,719 | 17,407 | 8,313 | 306 | 11:51 | 0:50 |
| 20% fewer sheltered housing schemes | 17,091 | 11,609 | 5,482 | 81 | 4:36 | 0:38 |
| 15% more community and sheltered housing users | 24,656 | 16,668 | 7,990 | 254 | 9:06 | 0:51 |
| 15% fewer community and sheltered housing users | 18,175 | 12,345 | 5,830 | 97 | 5:04 | 0.39 |
| Duration of calls increased by 10% | 21,365 | 14,495 | 6,870 | 181 | 7:59 | 0.46 |
| Duration of calls reduced by 10% | 21,332 | 14,465 | 6,867 | 140 | 6:59 | 0:47 |

Increasing the number of operators and number of users should result in improved efficiency without adversely affecting the number of callers who experience delays. In effect merging the community alarm control centre and the out-of-hours repair centre sought to achieve this.

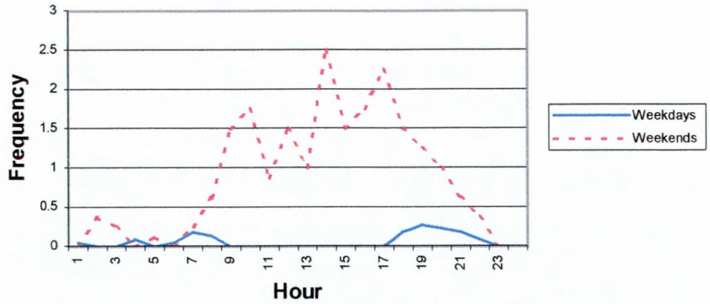
## 9.2.1 The impact of out-of-hours repairs

Because the actual data is not know the number of calls is based on discussions with the present staff. The city has in the order of 80,000 dwellings in addition to the community alarm users living in sheltered housing with approximately 5,250 calls received each month. Only a minority of the calls originate from sheltered housing as the warden or caretaker on the scheme will normally be contacted rather than the out-of-hours centre. Fig 9.3 indicates the anticipated dispersion of out-of-hours emergency repair calls.

[28] The control centre effectively functions with 2 operators at all times, the 3rd operator is primarily added for out-of-hours repair calls which are not included in the core database, and therefore these results.




(a): *Community dwellings*




(b): *Sheltered housing*

Figure 9.3: *Out-of-hours daily call profiles for June*

The duration of these calls was calculated from the core database that contains repair calls from community alarm users who have used the alarm instead of the designated telephone number. Because the data may contain calls where the operator informed the caller to contact the neighbourhood office, an average of all of the calls across the 6 months of data available has been taken, giving an average of 181 seconds. Table 9.10 indicates the call volume for the out-of-hours repair centre when 2 operators are available to answer calls, i.e. prior to the merger. While Table 9.11 indicates the community alarm control centre prior to the merger, i.e. operating with 2 operators on duty at all times.

Table 9.10: *The call volume at the out-of-hours control centre when 2 operators are available*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **June** | **Total** | **Sheltered** | **Dispersed** | **Delayed** | **Max delay** | **Avg delay** |
| 1 | 5,264 | 197 | 5,067 | 1,247 | 8.40 | 1.53 |
| 2 | 5,254 | 192 | 5,062 | 1,248 | 9.34 | 1.52 |
| 3 | 5,248 | 193 | 5,055 | 1,324 | 12.54 | 2.03 |
| 4 | 5,196 | 190 | 5,006 | 1,157 | 9.38 | 1.52 |
| 5 | 5,220 | 192 | 5,028 | 1,190 | 9.41 | 1.47 |
| 6 | 5,275 | 192 | 5,083 | 1,328 | 10.25 | 1.59 |
| **Avg** | **5,243** | **193** | **5,050** | **1,249** | **10.09** | **1:54** |

Table 9.11: *Investigation of the community alarm control centre with 2 operators on duty at all times*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **June** | **Total** | **System** | **Operator** | **Delayed** | **Max delay** | **Avg delay** |
| 1 | 21,430 | 14,533 | 6,897 | 286 | 4:30 | 0:46 |
| 2 | 21,341 | 14,462 | 6,879 | 265 | 12:49 | 1:08 |
| 3 | 21,307 | 14,438 | 6,869 | 279 | 16:37 | 1:14 |
| 4 | 21,430 | 14,538 | 6,892 | 252 | 6:14 | 0:43 |
| 5 | 21,397 | 14,529 | 6,868 | 278 | 8:59 | 1:00 |
| 6 | 21,375 | 14,510 | 6,865 | 243 | 9:57 | 0:51 |
| **Avg** | **21,380** | **14,502** | **6,878** | **267** | **9:50** | **0:57** |

For each of these control centres there is a health and safety requirement for a minimum of 2 operators to be on duty at any one time. The community alarm control centre operates 24 hours a day, 7 days a week with 2 operators, while the out-of-hours repair centre functions with 2 operators at all times except 09:00 to 17:00 during weekdays when in effect it is closed and no operators are available. Consequently, during periods of inactivity, for example in the early hours of the morning, 2 operators are on duty for each centre, while only a few calls are received. The merging of the two control centre's allows this inefficiency to be removed. However, Tables 9.10 and 9.11 indicate that callers to both centres experienced significant delays. In particular, when the community alarm centre is modelled with 2 operators as compared to the shift pattern with 3 operators in Table 9.6, the number of callers experiencing a delay increases by 87, or 50%. The maximum delay increases from 5:57 to 9:50 and the average delay from 40 to 57 seconds.

Table 9.12 indicates the effect if the two control centres were merged to allow all of the operators on duty to answer calls relating to either community alarm users or repairs. The shift pattern used is the same as that for the 2 individual centres[29]; therefore 4 operators are still on duty during the early hours of the morning. However, the merging of the centres prevents the community alarm control centre operators being busy and experiencing delayed calls while the out-of-hours repair operators may be waiting for a call, or vice-versa.

Table 9.12: *The merged control centre, functioning with the same shift pattern as prior to the merger*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **June** | **Total** | **System** | **Operator** | **Delayed** | **Max delay** | **Avg delay** |
| 1 | 26,625 | 14,482 | 12,143 | 627 | 4:37 | 1:02 |
| 2 | 26,640 | 14,857 | 12,053 | 604 | 5:04 | 0:58 |
| 3 | 26,607 | 14,523 | 12,084 | 615 | 6:58 | 1:10 |
| 4 | 26,780 | 14,634 | 12,146 | 727 | 5:05 | 1:11 |
| 5 | 26,661 | 14,503 | 12,158 | 682 | 6:23 | 1:10 |
| 6 | 26,633 | 14,518 | 12,115 | 678 | 7:56 | 1:14 |
| **Avg** | **26,658** | **14,586** | **12,117** | **656** | **6:01** | **1:08** |

Clearly merging the centres and allowing both sets of operators to answer any of the calls reduces the delays experienced by the individual control centre's identified in Tables 9.10 and 9.11. In practice such a merger would also allow prioritisation of calls, where potentially life threatening community alarm calls could be answered while repair calls were left queued on the system. However, due to the merger it is not necessary to have 4 operators on duty during periods of inactivity, especially the early hours of the morning. Consequently the merged control centre now in place operates with 2 operators at all times, with the exception that 3 operators are available between 16:30 and 20:00 during weekdays and between 09:00 and 20:00 at weekends. The impact this has on calls is indicated in Table 9.13 and can be compared to Table 9.6 where the same shift patterns were used but the out-of-hours repair calls were not included.

[29] The combined shift pattern for weekends is 4 operators on duty at all times, while for weekdays between 00:00 and 09:00 4 are on duty, between 09:00 and 17:00 2, and between 17:00 and 00:00 4.

Table 9.13: *The merged control centre functioning with a reduced number of operators*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **June** | **Total** | **System** | **Operator** | **Delayed** | **Max delay** | **Avg delay** |
| 1 | 26,556 | 14,486 | 12,070 | 2,045 | 13:50 | 1:43 |
| 2 | 26,545 | 14,461 | 12,084 | 2,169 | 9:49 | 1:48 |
| 3 | 26,651 | 14,525 | 12,126 | 2,154 | 10:17 | 1:42 |
| 4 | 26,520 | 14,478 | 12,042 | 1,952 | 10:50 | 1:40 |
| 5 | 26,690 | 14,577 | 12,113 | 2,253 | 11:30 | 1:52 |
| 6 | 26,602 | 14,484 | 12,118 | 1,799 | 9:51 | 1:24 |
| **Avg** | **26,596** | **14,502** | **12,092** | **2,062** | **11:01** | **1:42** |

Changing the shift pattern to this degree clearly has a detrimental affect on the quality of the service to the end user. However, the efficiency of the operators is improved while costs are significantly reduced, indeed the number of operator hours is reduced from 592 per week to 378, a reduction of 36%. The impact on service delivery must be recognised and was evaluated on the current community alarm survey reported in Chapter 3. Of those who had used the alarm in the previous 12 months, 29% were dissatisfied with the response time of the control centre, 23% were only occasionally satisfied, 23% indicated they were normally satisfied and 25% were always satisfied. However, such a measure is subjective with one participant suggesting they were always satisfied with the response time of the control centre, although when they have used it they have had to wait for 10 minutes or more to be answered. However, others commented that waiting this long is unacceptable. Many of those who were dissatisfied with the response time indicated they have had to wait for 30 minutes and more for a response, with one person suggesting they waited over an hour. The possible motivation behind the responses must also be recognised; participants in the survey may have indicated dissatisfaction to ensure the number of operators does not reduce in the future.

In practical terms the merged control centre is constrained by only having a maximum of 3 consoles available, although further consoles could be added. The results of the model and the user survey indicate that it may be beneficial to amend the merged control centres shift pattern or increase the number of consoles available. One of the attributes of the model is to estimate appropriate shift patterns based on a target utilisation rate. Interestingly, if the model is based on a system where the target optimisation is set at 60% then there are only a few occasions where 3 operators are required. At all other times the minimum imposed minimum number of 2 operators is suggested but because the control centre is sensitive to long calls, delays can be significant when operating with this shift pattern. Fig. 9.4 indicates the model suggested shift pattern based on a target operator utilisation of 60%. The actual results from these 6 simulation runs is provided in Table 9.14.

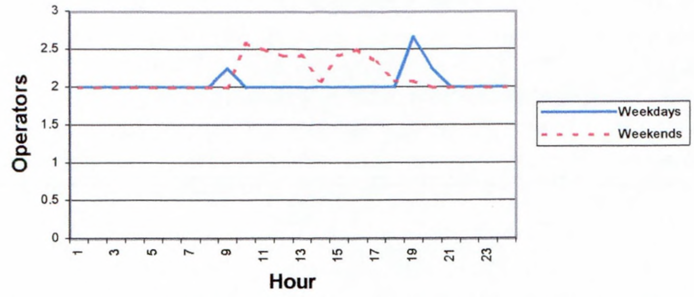



Fig 9.4: *Estimated shift pattern for June when the target operator utilisation figure is set at 60%*[30]

Table 9.14: *The results of the estimated shift pattern of Fig 9.4 including repair calls*

| | Number of calls answered | | Number of calls delayed | | Maximum delay | | Average delay | |
|---|---|---|---|---|---|---|---|---|
| June | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend |
| 1 | 8,707 | 3,436 | 1,743 | 1,111 | 10:01 | 12:40 | 1:25 | 2:14 |
| 2 | 8,656 | 3,397 | 1,525 | 1,080 | 14:43 | 14:55 | 1:29 | 2:14 |
| 3 | 8,643 | 3,441 | 1,795 | 1,017 | 10:55 | 13:18 | 1:33 | 2:14 |
| 4 | 8,709 | 3,436 | 1,710 | 1,114 | 13:58 | 13:23 | 1:33 | 2:01 |
| 5 | 8,738 | 3,420 | 1,629 | 1,170 | 11:44 | 11:04 | 1:21 | 2:20 |
| 6 | 8,670 | 3,444 | 1,681 | 1,124 | 16:24 | 14:15 | 1:38 | 1:58 |
| **Avg** | **8,687** | **3,429** | **1,681** | **1,103** | **12:58** | **13:16** | **1:30** | **2:10** |

The shift pattern used to create the results in Table 9.14 was similar to that of the current shift pattern and therefore the results are similar to those in Table 9.13. In order to reduce the number of callers delayed, and perhaps more importantly the average duration of delayed calls, the number of operators on duty must be increased. The net result will be a reduction in the utilisation rate of operators when reducing the target utilisation figure to 40% suggests an average shift profile as indicated in Fig. 9.5. The corresponding results are indicated in Table 9.15.

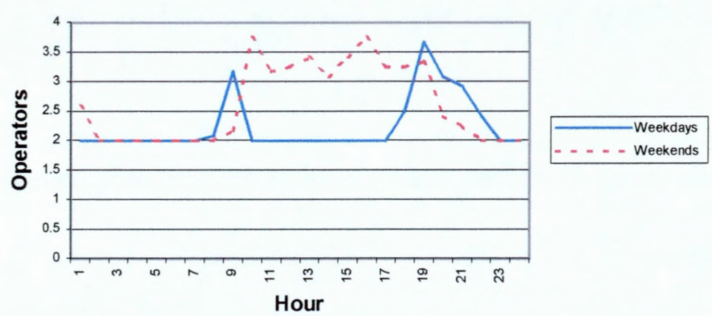



Fig 9.5: *The estimated shift pattern for June when the target operators utilisation figure is set at 40%*

Table 9.15: *The results of the estimated shift pattern of Fig 9.5*

| | Number of calls answered | | Number of calls delayed | | Maximum delay | | Average delay | |
|---|---|---|---|---|---|---|---|---|
| June | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend |
| 1 | 8,599 | 3,443 | 905 | 503 | 8:38 | 9:50 | 1:11 | 1:30 |
| 2 | 8,960 | 3,441 | 1,023 | 572 | 8:00 | 7:36 | 1:10 | 1:36 |
| 3 | 8,661 | 3,451 | 1,032 | 470 | 11:31 | 6:22 | 1:21 | 1:30 |
| 4 | 8,674 | 3,400 | 892 | 480 | 8:40 | 8:38 | 1:16 | 1:43 |
| 5 | 8,677 | 3,419 | 1,202 | 605 | 7:59 | 13:16 | 1:19 | 1:50 |
| 6 | 8,710 | 3,460 | 969 | 581 | 7:23 | 6:39 | 1:13 | 1:36 |
| **Avg** | **8,713** | **3,436** | **1,004** | **535** | **8:42** | **8:44** | **1:15** | **1:38** |

[30] It is possible to suggest 0.5 of an operator as the graph is the average of 6 simulation runs and some runs will suggest 3 operators and others 2. In the model itself only whole numbers of operators is permitted.

In terms of the average weekly number of operators hours, the shift pattern used in Fig 9.4 was 349 hours per week, while for Fig 9.5 it was 395. This increase of 46 hours has a dramatic affect on the quality of the service provided with the average weekly delay reducing by 15 seconds and with a reduction of 32 seconds at weekends. Having more than 3 operators on duty at busy times, as indicated in Fig 9.5, enables the majority of these savings. The additional 46 operator hours a week also reduces the percentage of delayed calls from 23% to 13%, and reduces the maximum call delays for both week and weekend days, a significant improvement in terms of service delivery.

Despite the improvement due to the shift pattern described in Fig. 9.5, it would be impractical to use this in reality. The model generates the most efficient shift pattern based on the target operator utilisation, reporting these results in half-hour time segments. Consequently the model may suggest that over 3 consecutive half-hour time segments, 4 operators are required for the first, 2 for the second and 4 again for the third. It would therefore be problematic to staff the control centre at these varying staffing levels and a compromise must be sought. Based on the model results and an apperception of the staffing issues in order to minimise the delays it would seem appropriate that the shift pattern suggested in Table 9.16 be used.

Table 9.16: *Suggested shift pattern for calls including out-of-hour repairs*

| Weekdays | | | Weekends | | |
|---|---|---|---|---|---|
| **Start time** | **End time** | **Number of operators** | **Start time** | **End time** | **Number of operators** |
| 23:00 | 07:00 | 2 | 23:00 | 07:00 | 3 |
| 07:00 | 09:00 | 4 | 07:00 | 15:00 | 4 |
| 09:00 | 15:00 | 2 | 15:00 | 23:00 | 4 |
| 15:00 | 23:00 | 4 | | | |

The total number of operator hours per week for this shift pattern is 856, some 304 hours or 51% more than prior to the merger of the 2 centres. However, prior to the merger Tables 9.10 and 9.11 indicate that 13% of calls were delayed, whereas the results of the suggested shift pattern in Table 9.17 indicates that this is reduced to 6%. It could be further reduced if an additional operator were available between 01:00 and 03:00 as in all of the simulation runs of Table 9.17 the maximum delay occurred during this time period. However, it would be unlikely that an additional operator would be available to work for this 2 hour period only.

Table 9.17: *The results of the model based on the suggested shift pattern in Table 9.16*

| | Number of calls answered | | Number of calls delayed | | Maximum delay | | Average delay | |
|---|---|---|---|---|---|---|---|---|
| **June** | **Weekday** | **Weekend** | **Weekday** | **Weekend** | **Weekday** | **Weekend** | **Weekday** | **Weekend** |
| 1 | 8,695 | 3,429 | 494 | 214 | 6:58 | 6:02 | 1:08 | 1:00 |
| 2 | 8,654 | 3,425 | 544 | 268 | 14:41 | 4:02 | 1:08 | 1:17 |
| 3 | 8,673 | 3,409 | 470 | 229 | 6:49 | 6:19 | 1:06 | 1:11 |
| 4 | 8,691 | 3,418 | 481 | 269 | 10:29 | 5:15 | 1:10 | 1:15 |
| 5 | 8,657 | 3,446 | 512 | 249 | 6:10 | 6:51 | 1:06 | 1:20 |
| 6 | 8,685 | 3,447 | 473 | 225 | 9:58 | 4:41 | 1:08 | 1:08 |
| **Avg** | **8,676** | **3,429** | **496** | **242** | **9:11** | **5:32** | **1:08** | **1:12** |

The suggested shift pattern provides an efficient use of resources whilst minimising the effects of delayed calls. However, in financial terms because it requires more operator hours it is more costly to operate than prior to the merger. A decision must therefore be made as to whether the additional cost merits the improved quality of the service to the end user. Consideration must also be made to the priority of calls in the model. Attention has previously been given to calls being placed on hold while new community alarm calls are answered and this will reduce the number and duration of delayed calls. In addition, community alarm calls will also have priority and be answered prior to repair calls.

It is therefore feasible that at busy times repair calls will encounter significant delays, with some calls being lost as callers try again latter, while the potentially life threatening community alarm calls are answered and only encounter small delays.

The results of the suggested shift pattern in Table 9.16 seeks to minimise the delay for all call types and therefore, although it provides an effective service, it is possible to reduce the number of operator hours while maintaining an effective service for community alarm users at the detriment to the repair calls. The shift pattern currently used and modelled in Table 9.13 provides this 'half-way house'. The model enables various shift patterns to be investigated and therefore allows an informed decision to be made. If a shift pattern is required that answers community alarm and repair calls effectively then the shift pattern described in Table 9.16 would be appropriate.

## 9.2.2 Month by month analysis

Much of the preceding analysis has been based on June, the first month of real data in the core database. However, this is comparable with the other months of data as indicated in Table 9.18. The actual results from 6 simulation runs are provided in Appendix Tables A9.1.13 to 17. The results from the model include all categories of calls with the exception of the hypothetical repair calls.

Table 9.18: *Analysis of the 6 months of data included in the core database*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| **Month** | **Total** | **System** | **Operator** | **Delayed** | **Max delay** | **Avg delay** |
| **July** | 22,061 | 15,404 | 6,657 | 180 | 5:10 | 0:43 |
| **Aug** | 21,471 | 14,438 | 7,033 | 182 | 10:47 | 0:42 |
| **Sept** | 21,274 | 14,728 | 6,546 | 137 | 6:00 | 0:45 |
| **Oct** | 21,909 | 14,717 | 7,192 | 151 | 5:06 | 0:37 |
| **Nov** | 22,623 | 15,292 | 7,331 | 368 | 4:27 | 0:43 |

Table 9.1 indicated that a similar number of calls were received at the control centre each month and the model reflects this trend. In terms of the number of calls which are delayed, all of the months are comparable with the exception of November. The model reflects the real data accurately but for this month there are both more system and operator involved calls than for any of the other months. It is unclear why this should be so as no one particular category has a significant increase when compared to the previous months. It may be that November had bad weather and this affected the call rate but there is no evidence to support this hypothesis.

## 9.3 Results For The 2$^{nd}$ Generation Telecare System

The 2$^{nd}$ generation system was defined in Chapter 5 and the impact on service delivery can be investigated in the model. Because the 2$^{nd}$ generation system does not currently exist it is not possible to use real-world data as with the preceding investigation. Therefore, for each call type evident in this new generation the call details are explained below however, the duration of outgoing calls to the doctor, responder or emergency services in the 2nd generation system do not differ from those in the 1st generation system. For example, when a user has fallen and requires attention, the time it takes to inform a responder does not differ in either generation as the same information is relayed.

For each of the modules defined below the call characteristics are based on anticipated profiles defined in discussion with the review group. However, each category can easily be modified within the model or different categories included if new data becomes available; for example the results of field trials of elements of a 2nd generation system.

### 9.3.1 Fall detection

The percentage of people aged 65 and over who fall at least once each year is approximately 33%[255-258]. Analysis of the core database reveals that over the 6 months of data there were 192 calls of this nature from sheltered housing and 237 from alarms dispersed in the community. In terms of the percentage of users calling the control centre this represents 13% and 2% respectively. The higher figure from sheltered housing may be explained by the general trend that users in these locations are generally more frail and therefore more likely to experience a fall.

The requirement is for a fall detection unit which will detect the majority of the above falls and which will contact the control centre if the user does not cancel the call within a given time interval. The majority of falls cause either no injury or bruising and abrasions only; fractures occur in about 5% of falls[410]. The majority of the falls will not therefore require medical attention and will be cancelled by the user. Hence it can be estimated that some 12% of user systems will contact the control centre during a year.

Having identified the number of calls associated with a feature of a 2nd generation system, when these calls occur is assumed to follow the call distribution profile from the 1st generation system. Because some calls will occur where the user has fallen but does not require attention, i.e. did not cancel the call, the duration of these calls is set at 10% less than for the 1st generation system. In terms of outgoing calls, it is anticipated that the probability of such a call occurring will also be 10% less than the 1st generation system. In a similar fashion to the 1st generation system this type of calls is refereed to as 'Tenant on floor' in the '2nd_gen_system' core database supplied on the accompanying CD.

### 9.3.2 Fire detection

This 2nd generation module will detect the presence of a fire in the home and inform the occupant(s). If a fire continues to be detected or the user does not cancel the call then the control centre will be contacted. In the 1st generation system calls requesting the fire brigade are so rare that a specific category name does not exist. Indeed, even if a fire was detected with the 1st generation system, Chapter 3 indicated that 56% of users would use the telephone to contact the fire brigade.

In the 2nd generation system the onset of fire is detected and the control centre contacted automatically, all fire calls will thus be routed through the control centre. The model estimates that 0.007% of users will generate a fire alarm call during a normal year as the user will cancel the majority of false alarms before the control centre is contacted. Such calls are assumed to occur randomly throughout the day. The duration of the call is estimated at 25 seconds with a further 45 seconds for a call to the fire brigade. The fire brigade is contacted in 90% of instances. This call is refereed to as 'Fire detection' in the '2nd_gen_core_db' core database.

### 9.3.3 Lifestyle monitoring

In the Anchor/BT lifestyle monitoring trial around 60 alert calls were generated from 22 users over a period of about 6 months[108]. Improvements in reliability are required as all of these alert calls were generated due to unusual behaviour but in no case was external assistance required[108]. It is therefore suggested that for each user the probability of such a call is 0.025% per annum assuming that the user can cancel a call they feel is not necessary.

The main focus of lifestyle monitoring is to detect unusual behaviour in the mornings, i.e. to detect that the user has not got out of bed and followed their normal morning routine. Other periods where calls are likely to be generated are late in the morning and afternoon when a user may be unable to get out of a chair, and at night when it would be anticipated that they would have gone to bed. The call profile reflects these anticipated periods of higher alert generation. Because the likely output from this call is to contact a carer or responder, the duration of calls is based on the present 1st generation carer call duration, where the caller requests their carer to provide assistance. It is currently anticipated in the model that 25% of calls would result in an outgoing call to a responder, 8% to a doctor and 3% to the ambulance service, with these outgoing calls lasting for 90, 270, and 45 seconds respectively. This call is refereed to as 'Lifestyle monitoring'.

### 9.3.4 Security

The module generates a call when a burglar is present and also when an unrecognised individual tries to gain access to the users EPR. Overall, it is anticipated that the probability of a call of this nature is 0.02% per user per annum, with the call requiring 26 seconds. It is anticipated that the majority of calls occur randomly during the hours of 08:00 and 18:00. The probability of contacting the police is estimated at 15% with the duration of this call being set at 45 seconds. This call is refereed to as 'Security'.

### 9.3.5 Gas detection

This module will detect the level of gas in the users home and suspend the supply if above a dangerous level. The gas supply will only be re-connected when below a defined threshold and the user is present. The control centre is not contacted, instead the presence of gas is recorded in the users EPR (Electronic Patient Record) and updated on a regular basis by the Intelligent Home Alarm System (IHAS).

### 9.3.6 Water detection

In a similar fashion to the gas detection module, the detection of 'flooding' is recorded in the users EPR and does not result in a call to the control centre directly.

### 9.3.7 Temperature analysis

In a similar fashion to the gas detection module, the user is informed when an inadvisably low room temperature is detected with the action taken recorded in the users EPR. The control centre is not contacted directly.

### 9.3.8 Drug dispenser

The users EPR stores details of the drug regime and dispensing instructions. If the user has poor drug compliance then the GP is contacted directly. It would be anticipated that only a minority of users would acquire this module and few calls would be received at the GP surgery. No calls are generated that are evident at the control centre.

### 9.3.9 Medical monitoring

If when using medical monitoring equipment parameters fall outside of the defined GP limits, the GP is contacted and can respond with a virtual consultation if necessary. If the equipment is used outside of surgery hours and immediate assistance is required, then the control centre is contacted and responds by contacting a doctor or NHS Direct for advice and assistance. It is anticipated that the probability of such calls is 0.025% per user per annum, with the majority of the calls occurring during the weekends and 18:00 and 22:00 on weekdays. The duration of the call is estimated at 50 seconds. The probability of contacting a doctor or NHS direct is estimated at 95% and the duration of this call is said to be 200 seconds. This call is refereed to as 'Medical monitoring'.

### 9.3.10 Incontinence monitoring

Details of incontinence are stored in the users EPR and do not result in a call directly to the control centre.

### 9.3.11 Virtual consultations/neighbourhood

No calls are presented to the control centre through this medium.

### 9.3.12 Intelligent Home Alarm System (IHAS)

The IHAS contacts the control centre once a week to update the users EPR at the control centre with the latest data, while also verifying that the equipment works correctly. Alternatively, if an authorised person access's the users EPR during a visit, then when they leave the control centre is contacted and the EPR updated. The user survey of Chapter 3 indicated that 22% received formal home care for an average of 3 hours, which it may be assumed is 3 visits per week. Chapter 3 also indicated that on average each user would have 2 GP home visits that would result in the EPR being updated. Assuming

22% of all community alarm users have 3 carer visits a week and each user has 2 GP home visits a year then the number of calls for sheltered housing (with 9,937 users) per week can be estimated as:

Routine backup calls + (additional carer visits) + (additional GP visits) 9.1

= 9,937 + (22% * (9,937) * 2) + ((1 / 52) * 9,937)

= 9,937 + 4,372 + 191

= 14,500

However, 9% of users Birmingham's control centre live with another alarm user[240] and therefore both of the users EPR's can be updated at the same time. This can also occur for sheltered housing schemes, where 1 call to the control centre can be used to update every users EPR from that scheme. It is therefore suggested, as sheltered housing users represent 87% of users in the core database, that the number of calls can be reduced by 35% giving a weekly total of 10,150 calls, representing the weekly probability of a call as 1.02%.

The number of calls per week originating from users dispersed in the community can be calculated in a similar manner to Equation 9.1:

Dispersed user calls = 1,484 + (22% * (1,484) * 2) + ((1 / 52) * 1,484)

= 1,484 + 653 + 29

= 2,166

A 9% reduction can be made for occupancies where 2 or more users live together giving a weekly total of 1,971 or the probability of a call per user per week as 1.33%.
The majority of the calls occur during the day when carers and doctors update the EPR, although some will also occur during the night if the user's EPR has not been accessed during the week. Because it is a system call the duration of the call and the probability of an outgoing call are not necessary. This call is refereed to as 'IHAS'.

In addition to these system IHAS calls this module also allows the user to contact the control centre and request information or generate an alarm for assistance themselves. The user survey of Chapter 3 indicated that 54% of users activated their alarm during the previous year. Therefore, it is estimated that each user per annum has a 70% of contacting the control centre. This figure is higher than the 54% to include the possibility that some users contact the control centre more than once a year. These calls are expected to occur randomly during the day and require 20 seconds of the operators time. The probability of contacting a responder is 15% and the duration of this call 90 seconds. This call is refereed to as 'IHAS user alarm'.

### 9.3.13 GP surgery

The GP contacts the control centre whenever they have a consultation with an alarm user. Chapter 3 indicated that, on average, each user would have 5 surgery based consultations and 2 home visits per annum. The home visits have been previously accounted for in the IHAS module. When the GP consults with a user in the surgery they will obtain the users EPR from the control centre with the control centre contacting the home for the most up to date information. Assuming each user receives 5 consultations per annum, then for each user there will be 5 system calls to contact the control centre that also include a call to acquire the data from the users home. These calls are referred to as 'GP access EPR' and occur randomly during surgery hours.

A further call is made when the GP changes the parameters in the home, for example a change in the drug regime for the drug dispenser or placing the lifestyle monitoring module into an 'ill mode'. This call is from the control centre to the users home and again is a system call performed through the control centre. It is suggested that in 8% of GP consultations such a call will be made. The call is refereed to as 'GP updates home EPR'.

This module will also contact the control centre if the GP has not responded to calls that require immediate medical attention. These are obtained from the medical monitoring equipment in the users home and if immediate medical attention is required then the GP is contacted during surgery hours. However, if the GP does not respond by a defined time, the control centre is contacted and the doctor or NHS Direct contacted on the user's behalf. It is suggested that each user will generate only 0.005 calls per annum as the GP should respond to these calls before they leave the surgery. All of the calls will require 90 seconds of operator time. In 99% of instances it is suggested that the doctor will be contacted which will require a further 270 seconds. This call is refereed to as 'GP default - medical attention'.

### 9.3.14 EPR

The EPR stored in the users home updates the control centres version on a weekly basis, as described in section 9.3.12. However, the home EPR will occasionally need to be modified, for example if the surgery hours change or telephone numbers are altered. In such circumstances it is believed that when the IHAS contacts the control centre this update can be performed at the same time, not requiring an additional call from the control centre. In the example of a change in a telephone number, it would be necessary to function with both telephone numbers until all home EPR's were updated.

### 9.3.15 Control centre

The added functionality of the 2nd generation system monitors when home helps etc. leave a users home and the control centre's EPR is updated. It is therefore possible to track the whereabouts of staff and if a home help fails to log on at their next location within a defined limit, verification of their well being can be sought. It is anticipated that the number of calls generated by this monitoring would be insignificant and that the control centre operators can absorb any such calls.

### 9.3.16 Hospital health services

Whenever an alarm user enters hospital their details can be retrieved from the control centre and any care arrangements suspended while the user is in hospital. Prior to discharge the control centre can be contacted and a start date for any new care arrangements entered. These calls do not require a control centre operator and as such are system calls. During a normal year it would be anticipated that 32% of older people would be admitted to hospital[251]. Therefore, because each user would generate 2 calls, the annual probability of such a call is 64%. Calls occur randomly during the day with this call being refereed to as 'Hospital access'.

In addition to the above 2nd generation modules, several of the 1st generation calls will still be present in the 2nd generation system. These are:

- 'Smoke alarm': These are generally generated from fire detectors in communal areas of sheltered housing schemes. For example lifts, corridors and the common room. The 2nd generation telecare system does not impact upon these.
- 'Battery': Pendant's that require a replacement battery. When defining the 2nd generation system in Chapter 5 pendants were continued from the 1st generation system.
- 'Installation by': Test call when a new alarm is installed into a users home.
- 'NHO/Housing Assoc. contacted': NHO refers to Neighbourhood Housing Office and this call type relates to an alarm which has been activated in a property belonging to someone other than Birmingham City Council, such as a small housing association. In the 6 months of real data there were only 53 of these calls.
- 'Repairs reported': In the 1st generation system the control centre was contacted regarding repair calls that should have been routed to the repairs centre. They are included in the 2nd generation system as many of them occur during office hours. At such times the operator should inform the caller of the correct telephone number and close the call. However, because the majority of alarm users are older and frail, in practice the operators tend to deal with the call and consequently they are included in the 2nd generation system.
- 'Service work order': A call from an engineer for the specific job number of a repair job.
- 'Testing/programming by': Contacting the control centre to test the alarm, normally due to a request from a user who feels that the alarm is not functioning correctly.
- 'Warden': The automatic logging on and off of wardens, these calls are performed by the control centre system without the operator.
- 'Warden off duty': Wardens logging off duty; this call requires the operator as opposed to the automatic warden call because the warden scheme equipment is not capable of performing the automatic call. The 2nd generation system does not alter the warden server and therefore in order to compare like with like these calls are included.
- 'Warden on duty': The reverse of the 'Warden off duty' calls.
- 'Xtra comments': The call does not easily fit within one of the standard types of call commonly received and the control centre. The operator then describes the call for the management information system as 'Xtra comments'. Because the nature of these calls is unknown they are included in the 2nd generation system.
- 'Yearly PR visit by': A call by a member of the control centre staff to ensure the equipment is working correctly and the user is content with the service. This does not occur for every user, indeed in the 6 months of real-data there were only 40 of these calls.

However, several of the 1st generation categories are not included:

- 'Mains': These are calls from sheltered housing schemes and occur every 25 hours to verify that the equipment is working correctly. In the 2nd generation system these are replaced with a weekly EPR update from the IHAS. It would be anticipated that an IHAS call would be generated every day either due to the weekly update or a home help or other professional's visit.
- 'No response – close down', 'Non call' and 'Pulled in error': These are all calls where the user has mistakenly activated the alarm, effectively they are removed in the 2nd generation system due to the IHAS seeking verification from the user prior to contacting the control centre.
- 'Low temperature', 'Intruder', 'Inactivity': In the actual control centre database these categories generated 12 calls during the 6 months of data and are rarely used. They are replaced in the 2nd generation system with 'EPR update', 'security', and 'lifestyle monitoring', respectively.
- 'Carer', 'Wanted warden': These are requests for a carer or warden and are replaced by 'IHAS user alarm'.
- 'Weather damage': These calls occur when the alarm is believed to have been activated by the weather, especially true with thunder storms. This can be a problem with old equipment but the new equipment of the 2nd generation system would not be as susceptible to such false alarms.

The 'support services contacted' category in the 1st generation system is retained in the 2nd generation system but is altered to reflect the greater access to information that the control centre operators have. This category of call is used when a caller seeks information on the whereabouts of their carer or conformation that the police or other service should be contacted. This call is in addition to the 'IHAS user alarm' and in the 2nd generation system the duration of the call has been reduced by 40%. This reduction is primarily due to the reduced need to contact outside agencies for information on a users care package; the probability of contacting external organisations has therefore been reduced by 10%.

In a similar manner to the 1st generation analysis described in section 9.2 onwards an investigation of the 2nd generation system has also been conducted on June. Table 9.19 indicates the results for the 2nd generation system based on the call profiles defined above. The shift pattern employed is the one currently used at the control centre, i.e. 2 operators on duty at all times except 16:30 to 20:30 for weekdays and 09:00 to 20:00 for weekends, when 3 operators are available. The call profiles are provided in the database '2nd_gen_profile' on the accompanying CD.

Table 9.19: *Analysis of the 2nd generation system*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| *Present* | *21,372* | *14,505* | *6,867* | *180* | *5:57* | *0:40* |
| 1 | 68,623 | 64,717 | 3,906 | 29 | 7:37 | 1:06 |
| 2 | 68,760 | 64,855 | 3,905 | 29 | 5:27 | 0:43 |
| 3 | 68,545 | 64,638 | 3,907 | 26 | 1:08 | 0:17 |
| 4 | 68,723 | 64,796 | 3,927 | 31 | 4:28 | 0:52 |
| 5 | 68,503 | 64,595 | 3,908 | 36 | 1:55 | 0:29 |
| 6 | 68,547 | 64,656 | 3,891 | 17 | 1:54 | 0:18 |
| **Avg** | **68,617** | **64,710** | **3,907** | **28** | **3:45** | **0:38** |

In comparison to the activity of the 1st generation community alarm control centre as set out in Table 9.6, it is seen that the 2nd generation system dramatically increases the number of calls seen at the control centre. Indeed, for June the overall increase is from 21,372 to 68,617, a 321% increase in call volume. However, this system is believed to be much more robust and provides more relevant information with this information being shared between organisations, while the equipment contacts the control centre on a weekly basis to update the EPR and ensure it is working correctly. In addition the 2nd generation system automatically calls for assistance when the user is unable to do so, a significant improvement in comparison with the technology currently used.

Because of the greater access to information for hospitals and GP's, and the weekly contact from the home to the control centre, the majority of the increase is due to system calls which are dealt with automatically, without the direct knowledge of the control centre operator. Indeed, the number of system calls in the 2nd generation system increases by 446%.

With respect to service delivery the number of system calls is not as important as the number of calls involving the operator. As long as there are sufficient telephone lines for the control centre to function effectively and sufficient call handling is available at the control centre then the system calls occur in the background without affecting the quality of the service delivered.

Referring to the 1st generation system, Table 9.6 indicates that there are 6,867 operator calls for the month of June, while the 2nd generation system receives 3,907 for the same time period, a 57% reduction. This reduction is primarily achieved by the IHAS communicating with the alarm user prior to contacting the control centre. They therefore have the capability to cancel calls initiated in error. Such calls accounted for 1,874 calls during the 1st generation system and are effectively removed in the 2nd generation.

Of more significance than the number of calls answered by the operators is the amount of time spent with callers and by implication the corresponding effect on the number and duration of calls that are delayed. In relation to the 1st generation system, operators spent 144 hours 46 minutes on calls while for the 2nd generation system this falls to 79 hours and 11 minutes, a reduction of 55%. Clearly as less time is required speaking to callers, the operators in the 2nd generation system have more time available to answer calls and this results in a reduction in delayed calls. Indeed, the number of callers who experienced a delay reduces from 180 to 28 while the maximum delay reduces from 5:57 to 3:45 and the average delay, for those who experienced a delay, reduced from 40 to 38 seconds.

The preceding chapters have defined what a 2nd generation system should consist of and indicated that users would welcome it as it is more timely and effective in detecting emergency situations; it can also be delivered in a more cost-effective manner. The purpose of the model was to investigate the impact on service delivery and the evidence from the model clearly demonstrates that the 2nd generation can be delivered within the existing service levels. Indeed, the 2nd generation system reduces the workload on the control centre operators and therefore improves service delivery, further adding to the evidence for 2nd generation telecare systems should be implemented.

Nevertheless, the 2nd generation system modelled above may not be an accurate reflection of the actual call profiles that may exist when such a system is implemented. It is therefore necessary to perform the extreme scenario analysis as introduced in Chapter 7 for the cost analysis model. Using Table 9.19 as the anticipated results of the 2nd generation system, Table 9.20 indicates the results if the number of calls is reduced or increased by 20%. This best and worst case scenario is presented in Table 9.20 and are the average of 6 simulation runs, the actual results of each of the runs is provided in Appendix A9.1 Tables A9.1.18 and 19.

Table 9.20: *Extreme scenario analysis of the 2nd generation telecare system*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1st generation | *21,372* | *14,505* | *6,867* | *180* | *5:57* | *0:40* |
| Anticipated 2nd gen. | 68,617 | 64,710 | 3,907 | 28 | 3:45 | 0:38 |
| 20% fewer calls | 54,924 | 51,787 | 3,137 | 15 | 3:46 | 0:47 |
| 20% more calls | 82,587 | 77,888 | 4,698 | 52 | 8:49 | 1:02 |

The extreme scenario analysis indicates that even if 20% more calls were received than anticipated in the 2nd generation system then the overall result is that there are still fewer calls delayed in comparison with the 1st generation system (Table 9.6). If the out-of-hours repairs calls are included then Table 9.21 indicates again fewer calls are delayed as compared to Table 9.13. Applying the extreme scenario analysis also indicates that the 2nd generation system is more effective, or at least comparable with that in use today. The actual model results for Table 9.21, are provided in Appendix A9.1 Tables A9.1.20 to 22.

Table 9.21: *Analysis of the 2nd generation system including out-of-hours repair calls*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| *1st generation* | *26,596* | *14,502* | *12,092* | *2,062* | *11:01* | *1:42* |
| Anticipated 2nd gen. | 73,971 | 64,662 | 9,142 | 1,322 | 9:32 | 1:35 |
| 20% fewer calls | 59,179 | 51,854 | 7,325 | 671 | 7:49 | 1:25 |
| 20% more calls | 88,625 | 77,604 | 11,021 | 2,235 | 13:07 | 1:54 |

## 9.4 Model enhancements

Despite the model providing a significant insight into service delivery, as with the cost analysis model enhancements can be made to further increase understanding. The enhancements can be made within two categories, most importantly within the model, but also the program itself.

### 9.4.1 Model enhancements

- *Prioritising calls*: When modelling the community alarm control centre with out-of-hours repair calls, the model in its current state will answer calls on a first-in-first-out basis. In practice it would be more appropriate to answer calls in order of priority settings. For example, at busy times it may be acceptable to have repair calls queued, while potentially life threatening community alarm calls are answered. The model should then report the delays in terms of the community alarm calls and the repair calls. It may also be advantageous to enter a maximum time that a caller will wait before hanging up and calling again later. The model must then report the 'loss rate' of calls.

Call prioritisation could also be modelled for community alarm calls. Thus, 'Tenant on floor' may have a high priority while the 'IHAS user alarm' may have a low priority. The model could then answer the higher priority call first and report the delays according to priority.

- *Placing calls on hold*: At busy times control centre operators place non urgent calls on hold to enable them to answer other calls. The model does not provide this functionality and as such could tend to overestimate both the number of callers delayed and the maximum delay time. However, defining when an operator places a call on hold and which calls they will answer is subjective, depending both on the operator and the call volume.

- *Greater distinction between days*: The model currently categorises days as weekdays or weekends, however greater flexibility may be required. For example, the introduction of out-of-hours calls could result in a different shift pattern for Friday's as more calls may be received prior to the weekend. Distinction between different weekend days may also be advantageous as GP surgeries operate on Saturday mornings but not on Sundays. In the model's current state when specifying GP access to the users EPR, because weekend days have been grouped together the model will generate calls for both the Saturday and Sunday.

- *Shift pattern estimation*: Currently the model analyses the amount of time required for every half-hour segment of the day and estimates the shift pattern based on this. It could be beneficial to estimate the shift pattern on a required service level, for example what shift pattern would be required to ensure that the number of callers delayed or maximum delay, did not exceed a defined level.

- *Estimate number of users*: Because of health and safety regulations it may be necessary for the control centre to function with a minimum number of operators on duty at any one time. It may therefore be useful for the model to estimate the number of actual users that would be necessary to meet target operator utilisation figures.

- *Telephone usage:* The control centre is clearly reliant on telephone lines, therefore calculating the maximum number of telephone lines used at any one time may be advantageous when introducing 2$^{nd}$ generation systems. In order to effectively achieve this an estimation of the duration of system calls would be required.

- *Additional centres*: In addition to the modelling of the control centre, which is the focal point of the whole telecare system, modelling of the GP surgery may also be beneficial. Investigation can then be performed on the impact that the 2$^{nd}$ generation telecare system has on their workload.

### 9.4.2 Program enhancements

- *Profile enhancements*: The model generates a table with details of the calls in the simulation run, however the specific results such as, number of calls for a specific category or the number of delayed calls, is not stored. Therefore, whenever a profile is loaded the results must be generated again. In order to improve the efficiency of the program it would be better if the results were saved and then quickly displayed.

- *Printing*: The ability to produce a hard copy of the results may be beneficial and is not currently included in the model.

- *SQL enhancements*: When wishing to view details of every call in the SQL section of the program the data is entered separately into every cell. When a large number of calls have been generated this can take a considerable length of time and it would be more appropriate if the records could be 'pasted' into the grid in a similar manner to Microsoft Access. This would also remove the data grid limit that constrains the number of lines that can be displayed to 27,000.

## 9.5 Conclusions

The development of a model to investigate the feasibility of delivering telecare is an important consideration of any system such as that being proposed. However, in order to make decisions it is necessary to have confidence in the model and the results it generates. The model created accurately reflects the real world data which Birmingham City Council, Housing Department gave access to. In addition the review group has tested the model and are confident that the results generated are sufficiently accurate to base decisions upon.

Having accurately modelled the current system, a possible call profile for the 2$^{nd}$ generation system has been suggested and indicates that the call volume at the control centre dramatically increases. Indeed, the total number of calls increases from approximately 256,000 per annum to 823,000 or 321%. However, what is important in terms of service delivery is the impact on calls requiring operator involvement and these reduce from 82,000 per annum to 47,000 or 43%. In terms of the time operators are dealing with calls the reduction here is from 144 hours 46 minutes per month to 79 hours and 11 minutes, a reduction of 55%.

The model gives the confidence that the introduction of 2$^{nd}$ generation telecare systems will not over-burden the control centre. Whenever a new system is introduced there are often concerns as to the effect on workload and the ability to provide a satisfactory service within the current resources. The model gives the confidence that 2$^{nd}$ generation telecare systems can work within the existing resources, and indeed the quality of the service delivered is improved. Aided by the preceding evidence of the desire of users to obtain 2$^{nd}$ generation systems and the results of the cost analysis, there would appear to be a clear message that assistive technologies, and in particular telecare, could support the delivery of enhanced services to older and disadvantaged people.

# 10 Discussion And Conclusions

***Chapter structure:*** *The final chapter brings together the preceding chapters and based on the evidence presented in this thesis answers the original research question. Consideration is also given to how this research can be taken forward in the next 2 years, 3 – 5, and 6 – 10 years.*

Ever since the introduction of the NHS and Community Care Act 1990 governments have emphasised a desire to move resources from hospitals and institutions to the community. Indeed, the NHS plan of 2000 would appear to give a clear mandate for the use of technology to assist people to live independently in their own homes via the statement:

> *'New technology in the home will make independent living easier for people who are elderly or disabled*[411]'

However, details of what this technology should be and how it should be incorporated into the health system are not forthcoming. Over recent years, research and development has tended to focus on specialist areas of telemedicine, for example ECG measurements[183, 280] or on videoconferencing[412] based systems. Chapter 2 indicated that there has been relatively little research in either telecare or telehealth. Considerable sums of money have been invested in smart homes, but again there is little evidence to suggest what technologies should be used in health care. It would appear that the focus for telemedicine and smart homes has been based on expensive specialist areas and demonstration pilots such as Edinvar and the Joseph Rowntree Foundation[137, 139]. They therefore seek to address particular markets, for instance in the example of ECG measurements patients suffering from ventricular tachycardia[187] may be targeted. The target customers of smart homes may be the financially well off or people with motor impairments.

Developments in smart homes and telemedicine may be particularly beneficial to the groups identified; however it may be that greater benefits would be achieved through an approach to technology that enabled more people to live independently. The community alarm system provides the basis for a wider platform and has been in place since 1948[16] with now over 1 million users in the UK[119], yet developments have tendered to centre on technical and reliability improvements rather than additional features. The community alarm system provides a readily available infrastructure that it could be argued is under utilised at present. If the community alarm system, or 1st generation telecare system, was developed in a way similar to the 2nd generation system defined in Chapter 5 then it could be that more people would be enabled to live independently in the community.

The 2nd generation telecare system meets the objectives of the NHS plan by adopting a reactive and preventative approach. It could be used to automatically recognise situations that require immediate assistance, such as a fall, and call the appropriate centre for assistance. In addition, medical parameters could be measured and analysed and used to indicate circumstances where medical intervention would be beneficial.

The evidence to support greater emphasis on telecare is not substantial. Details of projects currently taking place are held on the National Database for Telemedicine[413] but many of the projects do not relate to the present community alarm system and are often focused on specialities. An exception is the Anchor Trust/BT trial which Tang *et al* have described as '*a leading trial in telecare to the home*[341]'. The results of this trial were considered in Chapter 2 and the system as developed can be seen as complementary to the community alarm which could be used to generate an immediate alarm while the lifestyle monitoring system (LMS) would generate an automatic alarm if the user were unable to use their community alarm. The LMS was not therefore an immediate response mechanism but provided a valuable safety net and the two systems in combination provided a significant enhancement on the basic community alarm. If the other system elements considered in Chapter 5 were also included, then a 2nd generation system could be implemented to further assist the 1 million plus community alarm users currently in the UK.

## 10.1 Motivators For Change

Over recent years considerable attention has been paid to assistive technologies, the primary motivations for this interest can be summarised as:

- The present health, care and support mechanisms are unable to truly meet the demands made upon it as services become rationed. Between 1992 and 1996 the total number of home care hours increased by 50% while the number of households receiving the service declined by around 7%[18]. A more intensive service is being delivered to fewer people.
- Older people absorb the greatest resources. Health spending on people aged 75 and over is 6 times that of the average for the rest of the population[147].
- The number of older people is growing and as they absorb a significant proportion of the resources this will necessitate an increase in the available resources or an even more intensive service will result. Between 1995 and 2025 the UK can anticipate a 43.6% increase in the 60 and over age range[23]. A similar trend is apparent across much of the developed world[414].
- Brodie-smith has suggested that informal carers save the state between £15-24 billion per annum[44] while Griffith suggests the figure is £34 billion[46]. However, due to smaller family sizes, migration, divorce and greater numbers of potential carers entering the workforce, the potential for this to continue has been questioned. Any reduction would dramatically affect the current situation as society ages.
- The majority of people (80%[79]) who need support would prefer to stay in their own homes for as long as possible and this trend is reflected in government policies that seek to enable home-based alternatives to acute hospital/institutional care.
- Older people already use technology to support their independence and the Royal Commission for long term care expects older people in future to be as comfortable with computer controls as the present generation are with telephones[100].
- The increasing cost burden of high technology hospital healthcare and medicine.
- Increased user expectations of the health service and greater consumer choice.
- Better utilisation of resources, for instance reducing bed blocking.

## 10.2 Answering The Original Research Question

In order to address these issues and improve the current health, care and support mechanisms telecare must offer operational and financial incentives and be able to integrate seamlessly into current healthcare systems. The research reported in this thesis is believed to add greatly to the evidence base.
The original research question was:

**Are assistive technologies an enhancement to the present health, care and support mechanisms?**

In order to address this question four objectives were originally defined as follows:

1. **User requirements:** To define what users would like from a 2nd generation telecare system.
2. **System architecture:** To present models of the information flows in 2nd and 3rd generation systems.
3. **Financial considerations:** To undertake, based on the present and future systems as defined in objectives 1 and 2, an evaluation of the costs involved/expected.
4. **Service delivery:** To investigate the changes that will result from the introduction of the healthcare model identified under objectives 1 and 2. In particular, attention should be given to changes at the community alarm control centre.

These objectives sought to answer the questions "Should we do this?'' and "What is it we should do?". On the evidence presented in the preceding chapters it is believed that telecare has significant potential and attempts should be made to deliver an enhanced telecare service.

### 10.2.1. User requirements

Based on an understanding of technologies that could be included in a 2nd generation system, the user survey of Chapter 3 indicated that present users were receptive to the options discussed. Indeed, there was overwhelming support with 57% interested in obtaining at least 3 of the 4 options available. Namely, automatic fall detection, lifestyle monitoring, telemedicine and videoconferencing. Future potential users were also receptive to 2nd generation telecare systems and the results of the Anchor/BT trial indicated that such monitoring was welcomed with 69% of the trialists believing the LMS was of importance to them[108].

### 10.2.2 System architecture

In order to move from the present community alarm system to reactive and preventative systems it is necessary to define an achievable target system. Based on a review of the technology available and the views of users this target system was defined in Chapter 4. However, to move from the current community alarm system to the target system represents a considerable change in terms of the attitudes of users, in technology, and has infrastructure and service delivery considerations. It is therefore necessary to move incrementally and stepping stone systems have been defined in Chapter 5.

Attempts have been made at defining, in general terms, future systems by Doughty *et al*[166] and subsequently by Tang *et al*[341] who attempted to develop the work of Doughty. However, these attempts provided little detail and talk in generalities, the actual components and system architecture where not considered. In order to provide a framework for future developments, Chapter 5 defined the 2nd, 3rd and 4th generation systems, indicating both the technologies required and the data flows that would result.

### 10.2.3 Financial considerations

Perhaps the single greatest reason why telecare has not been implemented on a larger scale is that the evidence of the financial position of telecare has not been demonstrated. Indeed, there is little to suggest that telecare, telemedicine or smart homes are cost-effective. Whitten *et al* attempted a mata-analysis of telemedicine research and cost-effectiveness, concluding that there were only 38 papers that contained any real data and these were unsuitable to perform the analysis[358]. Chapters 6 and 7 have sought to address this issue with the development of a model that can be used to generate costings based on a range of scenarios. The model developed conforms to standard health economic conventions with the exception of intangible benefits, which would tend to increase the return on the initial investment. When compared to the present community alarm system, the results from the model clearly indicates that 2nd generation systems are cost-effective with the anticipated implementation generating a saving of £8.3m at the end of the 10-year system life cycle.

### 10.2.4 Service delivery

The introduction of new technology and systems will inevitably impact upon service delivery and change the way in which people work. The 2nd generation system brings together data from various organisations into one central resource held at the control centre and encompassed is collaborative working between health, social services and housing. The control centre is currently the first point of contact when a community alarm is activated and has therefore been investigated in detail. The model developed accurately simulates the current system and confidence can therefore be given to the results it generates when simulating future systems. The 2nd generation system described in Chapter 5 has been modelled and it has been shown that the system is deliverable within the current resources. However, it may be necessary to change shift patterns to reflect the change in workload.

The research described in this thesis has indicated that 2nd generation telecare systems are a logical progression from the 1st generation system, while 3rd and 4th generation systems could have an even greater impact. These systems have been defined and there is evidence to suggest that users are keen to embrace them. In addition, it has been demonstrated that such systems are cost-effective and can be delivered with current resources. However, it should be appreciated that while this research has demonstrated that there is significant potential, much of the research is based on relatively small sample sizes or theoretical models. For instance, the cost analysis work contains many assumptions due to data not being available, the expected model uses a home equipment cost of £700, but the exact cost of the technology is unknown as the technology is not currently available.

The service delivery model is based on assumptions of possible 2nd generation call profiles because the data does not exist. However, having developed these models when data does become available the models can be readily updated and the appropriate conclusions drawn. The research presented here therefore provides a base from which further research can be conducted and the results of this further research incorporated into the models.

Therefore, when considering the original research question, the general trend from all aspects of the research would indicate that assistive technologies are an enhancement to the health, care and support mechanisms.

## 10.3 Inhibitors To Change

Incorporating telecare into the existing health, care and support mechanisms will almost inevitably involve a change to current working practices. Despite everyone in healthcare provision relying on one another for the quality and timeliness of key data and information, some stakeholders are likely to perceive the introduction of telecare as a threat to their legitimate power[415]. In considering the use of the power concept in evaluating the impact of telecare on the patient or user, and care providers, a number of power related inhibitors to change are noted:

- Insufficient focus and communication: Top-down management may not have the drive and focus to clearly define operational goals and organisational targets. This coupled with ineffective communication between all levels of stakeholders may lead to resistance by the 'grass roots' workforce who perceive management as imposing the technology to control, monitor and limit their movements.
- Status removal: Through technically enhanced collaboration between different facets of the system user or patient information is readily available and the hierarchical management structure can be reduced, eliminated or changed. A computer illiterate senior clinician may need to rely on a junior member of staff to provide information with the status of the clinician being reduced while that of the computer operator is enhanced.
- Reduction of patient/clinician interaction: Discussions with and information retrieval from the patient by the clinician will be reduced as more reliable data will be held within the computer system and in particular the EPR. As a consequence, analysis of the EPR may become more important than discussion and information retrieval from the patient and would be opposed by both the patient and the clinician.
- Technical illiteracy: Without additional training professionals who have difficulty using technology may be reluctant to use the new technology and their apprehensive attitudes may be transferred to other potential users. It may also be that due to their difficulties with technology, they may not provide a telecare system to a user while it may be clear to others that the user could benefit from acquiring such a system.
- Collaboration and co-operation: A financial and organisational structure that allocates responsibilities and resources in a way that inhibits co-operation and collaboration. This is particularly apparent where expenditure by one organisational cost centre generates savings not for itself but for other cost centres as is identified in the cost analysis of Chapter 7.

Chapter 4 indicated that much of the technology of a 2$^{nd}$ generation telecare system currently exists, or could be developed within a relatively short period of time. The inhibitors to change are therefore largely operational rather than technical, however technical considerations must be considered and these relate to the need for low cost, plug-and-play intelligent sensors. Despite the welcoming of technology in the previously identified NHS plan, perhaps the greatest inhibitor to the development and introduction of telecare is that the government will only introduce telecare when there is a clinical need and where evidence exists to support its effectiveness[416]. However, few companies will invest in the development of systems and technologies until a clear return on the investment can be identified. Yet while projects continue to operate in isolation and no strategic Government plan is in place to focus research and development, enhancements are likely to continue in a piecemeal and ad-hoc fashion.

It is suggested that what is required is a large-scale study or randomised control trial. Many of the telecare, telemedicine and smart homes projects have tended to be small scale without sufficient attention to a research methodology. In order to influence decision-makers in Government and manufacturing of the real potential of telecare, concrete evidence is required on the success of technology intervention. The results presented have made a significant contribution to the supporting evidence for telecare but until the verified results of a large-scale trial have been gathered, it is unlikely that telecare will be developed and introduced in the way suggested in Chapter 5.

However, there is some evidence to suggest that the Government is giving greater attention to the use of technology to support older people independently in the community. The NHS plan clearly identified technology as a way of enabling older people to live independently in their homes, while a new Government post has been created focusing on older people. By 2004 a total of £1.4 billion will be available to invest in improving health and social care services specifically for older people[417]. With continued Government emphasis on prevention and support for older people in their own homes, aided by the creation of the new older person 'Tsar' it may be that the Government foresees assistive technologies, and perhaps specifically telecare, as a way of reducing costs while improving service delivery.

## 10.4 The Positioning Of Telecare[31]

Currently the health care service can be said to operate at three levels as indicated in Fig. 10.1. The primary care level is normally the first point of contact and is typically provided by GP's and community health centres. The second level provides specialist care in community hospitals, normally for people referred from the primary care level, although emergency admissions can enter directly at this level. Tertiary or superspeciality level care is provided by major medical centres for people who require specialist treatment[418]. At this higher level the fewest number of people are treated, as others have been dealt with at previous levels.

[31] This section is based on the paper Bradley DA, Williams G, Brownsell SJ. Levy S. "Community alarms to telecare: a systems strategy for an integrated telehealth provision." Currently in preparation.

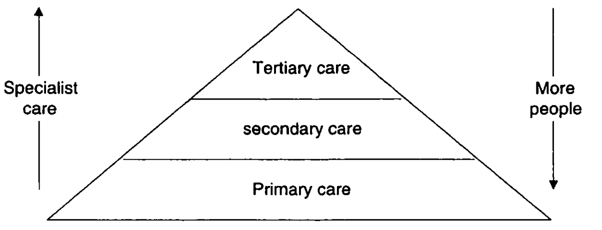



Figure 10.1: *The present care pyramid*

In addition to these established levels of care, the NHS plan introduced the concept of intermediate care which provides a '*bridge between hospital and home....This will speed up discharge from hospital when patients are ready to leave. The new services will give older people more independence rather than being forced to choose a care home*[411]'. This level of care therefore seeks to address a current shortfall where 24-hour care may be provided in hospital one day and the next day no assistance is provided for the person in their own home.

Telecare could be positioned as a form of intermediate care where people could be discharged from hospital, enter intermediate care and then be provided with a telecare system in their own home. Alternatively for some people, perhaps with carers or family at home, they could be discharged from hospital and be provided with a telecare system with certain modules of the system then being withdrawn as recovery takes place. In the overall context of health, care and support, telecare can be located towards the centre of the care cycle as indicated in Fig. 10.2.

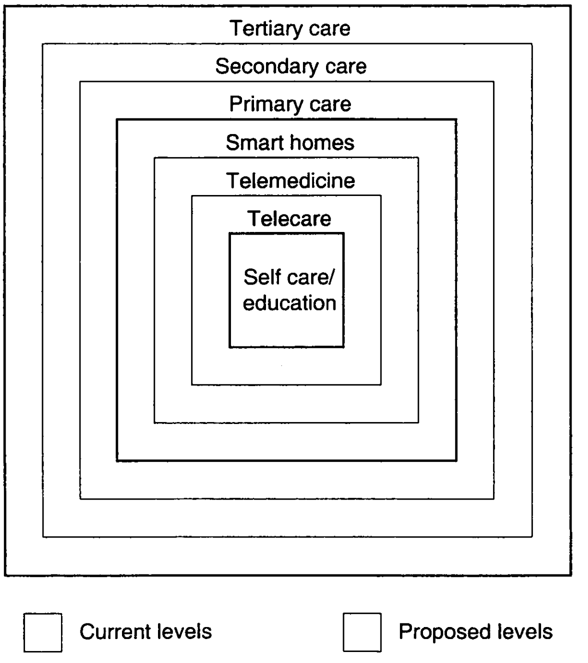



Figure 10.2: *The positioning of telecare in the health, care and support system*

Clearly at the centre of the system is self-care and education, enabling people to support themselves. At the next level a telecare system, perhaps consisting of lifestyle monitoring, may be appropriate, while the following level could contain elements of telemedicine. Assistive technologies, for instance environmental controls and door openers may be part of the smart homes level. These first 4 levels are supported by community care, NHS Direct, and informal support networks. The three more accepted levels of care and support can then be positioned around these new levels.

It is also recognised that individual levels can be accessed directly without going through preceding levels. For example, a user with a telecare and telemedicine system can go directly to hospital if appropriate. Nevertheless, Fig. 10.2 does provide an indication of increasing assistance and need the further away from the centre a particular user is positioned.

In future it may be that the 3 levels of telecare, telemedicine and smart homes are grouped together, as the boundaries between these can become blurred. A telecare system provides a basic monitoring system intended for many users but as indicated by Chapter 5, one of the components of a 2$^{nd}$ generation system is the presence of medical monitoring which falls within the remit of telemedicine. Further, the attributes of smart homes could also be considered as part of an environmental control system for a telecare user. The distinction between these three levels is thus an artificial one, as far as the user in concerned they may need a certain level of monitoring and assistance, but which of the levels provides it, is in many respects irrelevant to the user. It can therefore be suggested that the term telehealth should be used to include the attributes of telecare, telemedicine and smart homes, as telehealth has been defined as '*the use of telecommunication technologies to make health and related services more accessible to health care consumers and providers in rural, or otherwise undeserved areas*[419].'

Table 10.1 indicates some of the possible user groups to whom assistive technologies might be directed and indicates the wide diversity of provision required, suggesting an equally diverse range of telehealth services.

Table 10.1: *Telecare user groups*

| User Group |
|---|
| People supplied with equipment as part of their hospital discharge plans to support early release. |
| People who find themselves temporarily incapacitated. |
| People who require some basic assurances and support in order to lead an independent lifestyle in their own homes - the 'well elderly' or current community alarm users. |
| People with mild forms of dementia that require some support to lead an independent lifestyle in their own homes. |
| People undergoing needs assessment, perhaps following a change in personal circumstances. |
| Terminally ill people receiving palliative care at home. |
| People considered being at risk of accident or relapse. |
| Physically disadvantaged people. |
| People suffering from chronic ailments such as diabetes, hypertension, bronchitis or asthma. |
| People addicted to heroin or other drugs and who are taking part in a controlled course of treatment to enable them to control and manage their addiction. |

Fig. 10.3 and Table 10.2 represent telehealth provision as a combination of responsive, supportive and preventative services and depending on the needs of an individual the relevant services can be provided. Provision in zones A & B are essentially sensor based while those in zone C are more system intelligence based using parameters derived from data provided by the sensors of zones A and B.

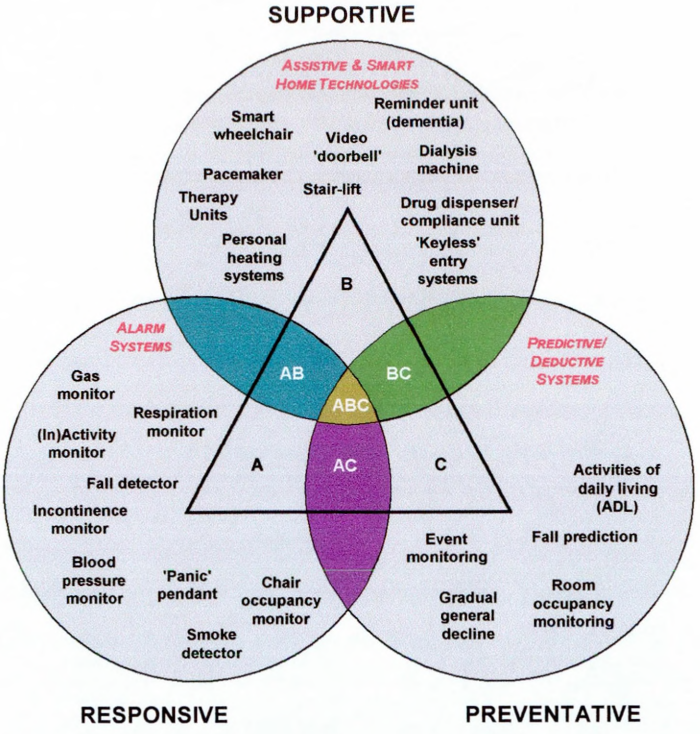



Figure 10.3: *Options available under the telehealth provision*

Table 10.2: Care *provision for the zones identified in Fig. 10.2*

| Zone | Situation | Provision |
|---|---|---|
| A | A middle aged person discharged from hospital following cardiac surgery | Blood pressure monitor<br>Fall detector<br>Panic pendant |
| B | A person suffering from multiple-sclerosis | Smart wheelchair<br>Some automated house functions |
| C | A person being assessed for living alone following a change in personal circumstances | Activities of daily living |
| AB | Older person living at home | Panic pendant<br>Fall detector<br>Video doorbell<br>Drug compliance monitor |
| BC | Older person suffering from mild dementia | Reminder unit<br>General long-term monitoring |
| AC | Older person living alone requiring reassurance | Panic pendant<br>Chair occupancy monitor<br>Room occupancy monitor<br>Security system<br>Event analysis system<br>Fall Detector |
| ABC | A person post stroke | Activities of daily living<br>Reminder unit<br>Fall detector<br>Chair occupancy monitor<br>Room occupancy monitor<br>Drug compliance monitor<br>Virtual consultations |

In practice, many of these devices and systems are reliant on other systems in order to function. For example, in order to accurately generate a fall prediction index, it may be necessary for the user to have a fall detection unit and also to monitor the users walking and movement.

### 10.4.1 Responsive Systems

Sensors and systems that fall within the remit of responsive systems monitor the user and automatically generate a call for assistance if the user is unable to do so. These systems therefore function in combination with the 1st generation community alarm system and react to situations that require immediate assistance or intervention.

### 10.4.2 Supportive Systems

Supportive systems are used where users require aids to support them in living independently in their home environment and may well be a means of breaking out of the 'cycle of dependency' of Fig. 10.4.

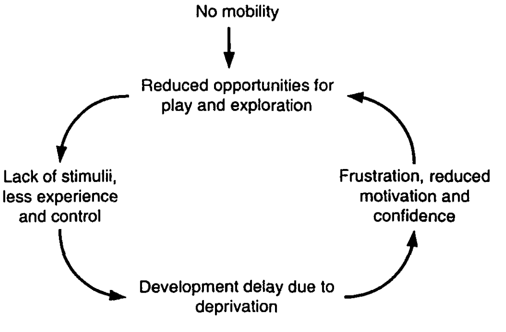



Figure 10.4: *The cycle of dependency*[420]

Supportive systems are likely to be particularly suitable for people who suffer from some form of motor or mental incapacity and would include devices such as:

- Smart wheelchairs.
- Reminder systems for users suffering from dementia.
- Drug delivery and compliance monitoring units.
- Voice recognition systems to control various assistive technologies such as door entry systems.

### 10.4.3 Preventative Systems

Preventative care relates to situations where the local or system intelligence is responsible for deducing the current, and possibly future, status of the user from the available data as provided by the responsive and supportive systems. For instance, by employing predictive indices based on the multi-variable analysis of the users data it may become possible to indicate high-risk situations. By setting appropriate intervention thresholds in consultation with the user, occupational therapist and clinician if appropriate, it could then be possible to target resources to those most in need. For example, if a particular user is at a high risk of falling then it may be appropriate for them to wear hip protectors that have been shown to reduce the risk of a fracture by as much as 50%[421]. It may also be beneficial to remove environmental hazards such as poor lightening, loose rugs and electrical cords, although evidence that removing these hazards reduces the risk of falling is slight[354, 410].

Such preventative systems may well form the basis of a more proactive and interventionist strategy for care in the community. This must however take place in the context of consultation and discussion with users and be capable of accommodating user choice.

### 10.4.4 System Integration

System integration operates at various levels and addresses the means by which the various elements and technologies in the telehealth system are brought together. At the users home level, this requires the combination of the home-based communications network and local intelligence to provide the analysis and decision making capability. At this level parallels can be drawn with smart home technology and it may be appropriate to share communications protocols, for example the new 'Convergence' protocol which merges BatiBus, EIB and EHS[140] as indicated in Chapter 2.

At a higher level system integration refers to ensuring that data and information is provided from the home to all of the stakeholders in the system. However, various issues must be addressed.

- User acceptance of what data should leave the house under which conditions. Chapter 3 indicated that this was not perceived as a problem with the current users, but conformation and agreement with individual users must be secured.
- Data security and access validation to ensure that confidential information is only available to the appropriate stakeholders.
- Appropriate links between human and machine based intelligence in decision making. For example, determining at what level a human should be informed that intervention might be beneficial.

Perhaps one of the key considerations when designing the telehealth system is to ensure that the system can adapt and change with the user. Therefore, devices and systems can be added or removed depending on the status of the user, a modular, plug-and-play system is therefore essential. The concepts of universal design are summarised in Table 10.3[422] and represent a series of goals by which the system may be evaluated.

Table 10.3: *The principles of universal design*

| Design Principle | | Description |
|---|---|---|
| 1 | Equitable use | Allows users to operate device or system with ease without stigmatising them. |
| 2 | Flexibility in use | Ensures that people with varying abilities, preferences and skills can use the product or system. |
| 3 | Simple and intuitive use | Employ a consistent user interface. Provide suitable prompting and feedback during and after task completion. Above all keep it simple. |
| 4 | Perceptible information | Multi-sensory approach to the presentation of information supporting user definition. Keep messages simple and clear. |
| 5 | Tolerant of error | Fail-safe approach with suitable and appropriate warnings and checks. Minimise adverse consequences of accidental or unintended actions. |
| 6 | Low physical effort | Easy to use and ergonomically effective design. |
| 7 | Size and space for approach and use | Access must be suitable for all users irrespective of personal circumstances. |

## 10.5 Developing Telecare And Future Research

As described earlier, the research presented in this work has laid a foundation on which further research can be built. However, it is believed that only a large-scale field trial will secure the necessary evidence to persuade Government, policy makers and manufactures of the potential of telecare and telehealth in general. Demonstration projects have been useful in showing the potential, but demonstrable facts are needed on cost-effectiveness and the benefits to real users. In order to perform such a trial various developments must take place both prior to, during, and after the trial to enable telecare to successfully develop along the lines indicated in Chapter 5.

### 10.5.1 Introduction (0-2 years)

*Year 1*

In the first year, developments are centred on the creation of the sensors required for a $2^{nd}$ generation system. In particular technical developments are needed for:

*Lifestyle monitoring system (LMS)*: The appropriate algorithms need to be defined along with a system capable of functioning when two or more occupants are present, perhaps by electronic tagging. Attention must also be given to learning and adapting as user(s) behaviour changes over time. For example, if the user initially gets up at 8am but over a period of time this becomes latter and latter, then the LMS must recognise this change and alter its parameters accordingly so as not to generate an alert when not necessary. The LMS should also be linked to factors such as the television listings and maintain a 'favourites' list of programs to ensure false alerts are not made when a television program is moved to a different time.

*Drug dispenser*: As indicated in Chapter 5 there are various dispensers available but non of them have the functionality or system integration required.

*Medical monitoring*: Various elements of this system component are available, for example ECG monitoring. However, a formal study of what is required from a medical professionals perspective does not appear to have been performed. It is therefore suggested that a formal study of GP's, hospital clinicians, district nurses and other health workers should be carried out to formulate an understanding of the elements to measure for general use. When the appropriate parameters have been agreed, a package should be created to monitor these requirements.

*Electronic Patient Record (EPR)*: The EPR needs to be created with appropriate gatekeeping to ensure that professionals can only see and edit fields which are appropriate for them to view and no more. Efforts must also be made in the control and locking procedures to ensure that the same record is not being viewed or amended by two or more people at the same time.

Alongside these technical developments, the views of professionals and users should be sought. Chapter 3 indicated that current users in sheltered housing in Birmingham were receptive to $2^{nd}$ generation systems, but it must be established if this view is reflected by alarm users dispersed within the community and in other areas of the country. The views of medical professionals has been suggested in relation to the development of medical monitoring but what are the views of occupational therapists, carers, informal carers and family members? Each of these groups plays a role in the support and care of older people and other user groups, and they should be consulted and where appropriate efforts made to accommodate their wishes.

As previously indicated, it is believed that a field trial is required to quantify the success of the telecare intervention. Therefore, during the first year the appropriate user groups should be identified with initial consideration being given to older people, community alarm users and disabled users. In order to calculate and demonstrate the ability to assist people in the community rather than in residential care, or to alleviate a move 'up the care ladder', it will be necessary to recruit people of relatively high dependency who may require greater intervention in the future. Appropriate ethical approval must be obtained.

Having decided upon the appropriate user group(s), recruitment of the participants should take place and contain enough people to enable both a control group and an intervention group to be established. It will therefore be necessary for those selected to be of a similar dependency level, age, social group and so forth.

*Year 2*

During the second year of the project the other elements of the 2nd generation system defined in Chapter 5 which were not started in year 1 must be developed. These elements require less time to develop as they are more simplistic or already exist in a suitable form for adaptation. Testing procedures must be identified and performed to ensure that each of the elements operates correctly when included in a system context, rather than a stand-alone element.

The medical monitoring unit should be investigated and trialed to discover at what stage a change in the measured parameters should instigate a call for assistance. For example, for each user what combination of levels of blood pressure, ECG or breathing characteristics should generate an alarm. This level should be based on when intervention would have a positive outcome on the user. Defining this point for every potential user may prove difficult and attention must be given to the appropriate algorithms for alarm generation so as to only generate calls when necessary.

During the second year, the users identified for inclusion in the trial should be monitored. For example, records should be kept on interactions with the GP or other healthcare professionals, the amount of formal and informal care received, any time spent in hospital, ADL and other appropriate assessments. At the end of the second year the participants should be divided into two groups, the first group or control group are then monitored during the next year without any intervention and the intervention group should be provided with a 2nd generation telecare system. Based on the scores from various assessments both groups should seek to include similar people, it may therefore be necessary to not consider certain people if their health or assessment scores are substantially different to the rest of the participants. All costs and professionals time should be recorded along with any interactions with professionals, carers and others. This should continue throughout year 2.

At the end of year 2 when providing a 2nd generation system to the intervention group consideration should be given to which people were likely to benefit from certain elements or modules of the system. As described in Chapter 5, certain people may require medical monitoring while for others this would not be necessary. A sub-element of this trial should include a review of the various assistive technologies available and an attempt made to discover at which point certain groups of people would benefit. For instance, when would be the ideal time for a fall detection unit to be provided, an index could be developed, based on age, dependency score and so forth. In essence this could be described as a technology prescription.

### 10.5.2 Development (3-5)

During year 3 both the intervention and control group are assessed on a quarterly basis using standard health and well being tests, such as the Activities of Daily living (ADL) assessment. All interactions with health care professionals and carers must be recorded and at the beginning of year 4 the results from the intervention year can be analysed. For the intervention group comparison can be made with the assistance and care they required during the year prior to receiving a 2nd generation telecare system and one year after the intervention. Comparison can also be made with the control group and the intervention group to identify if dependency or a 'move up the care ladder' has be averted or postponed. In addition the intervention group should be surveyed to discover their attitudes towards the system and highlight its benefits and difficulties. In a similar manner the carers, health professionals and relatives should be surveyed to discover the performance of the system from their perspectives.

One of the interesting results from the Anchor/BT trial was that 54% of users felt more confident[108] as a consequence. However, without a long term field trial it is difficult to know the benefits that contributed to this feeling. It could mean that as people feel more confident they are better able to support themselves in the community. However, it could be that because of this greater feeling of confidence, activities which previously were left to someone else, for example changing a light bulb, may now be undertaken by the person themselves, knowing that the system will generate an automatic alert if necessary. It could therefore mean that this feeling of greater confidence could actually result in an individual putting themselves at risk. However, due to the limited trials currently performed the actual answer is unknown.

When the various assistive technologies and elements of the 2nd generation system are used during the field trial this information should be recorded and stored. As part of the technology prescription, identification of the commonly used technologies can then be performed to assist in the development of the algorithms which define at which point intervention should occur and which technologies should be prescribed. This should continually evolve as more and more technologies become available.

Having analysed the results from the trial, the technology used should be enhanced to incorporate improvements suggested by the various user groups. In addition, during this development period efforts should be made to develop and enhance the technology so as to move towards the 3rd generation telecare system described in Chapter 5.

During the trial all interactions with health and care providers should be recorded and costed. An evaluation of the technology costs aided by any savings in a reduction of care or hospital admittance can then be used to perform a cost analysis and discover the true costs of the intervention.

At the end of the field trial both user acceptance issues and the results of the cost analysis should be disseminated to various government agencies and the equipment used should be made commercially available if benefits arise. The 3rd generation system of Chapter 5 should be re-defined based on the practical experience of the trial and new technologies created. Having developed the appropriate technology a new trial, following the same methodology should then be performed but as well as containing highly dependant people, less dependant people should be included and the benefits afforded to wider user groups, such as community alarm users, calculated.

### 10.5.3 Research (6-10 years)

The cycle of the previous 5 years, namely define the system, develop the technology, perform quantifiable evaluation and redefine the system, should continue in this phase. The result of this research is to move towards the target, $4^{th}$ generation system defined in Chapter 5. Based on the availability of EPR's by 2005 at the latest[334], developments in this period (2006-2010) should include the evaluation of intelligent software agents to analyse each user's EPR to define what intervention should take place and when it should occur. Remote assessment and data gathering is seen as critical to this process and accurate algorithms must be developed. These software agents or expert systems do not currently exist, however before attempts can be made at defining when intervention should take place, results from the previous trials are necessary.

## 10.6 Final Thoughts

Telecare is a new and emerging area of research but as the health, care and support system currently in place becomes ever more burdened as society ages, telecare provides the potential to deliver a robust, preventive and assistive system. This research has demonstrated that:

- The current system has difficulty delivering the required levels of support and the burden will increase.
- Potential and current users welcome telecare initiatives.
- Providers have shown willingness, although greater research is required to establish medical professionals requirements.
- The qualitative benefits of telecare have been widely accepted and have been reported during this research.
- Despite telecare being discussed for some time, little attention has been given to defining what a $2^{nd}$, $3^{rd}$, and $4^{th}$ generation system should incorporate. Based on the views of users and providers and an investigation of the current technology trends, these future generations have been defined and are targets to work towards.
- Research into the cost-effectiveness of telecare is almost negligible. However, this thesis has suggested that when comparing the present community alarm system to a $2^{nd}$ generation telecare system, savings in the order of £8.3m are evident at the end of the 10 year system life cycle.
- There has been concern over the impact of telecare on service delivery but there appears to be nothing on this reported in the literature. The model developed indicates that the current resources could provide the envisaged telecare system.

It is therefore believed that the original components of this research can be defined in four areas:

- Highlighting the views of current community alarm users and the likely acceptance level of telecare components.
- Defining the specific contents of the $2^{nd}$, $3^{rd}$, and $4^{th}$ generations of telecare.

- Creating a financial model of the telecare system and demonstrating that telecare could be cost-effective.
- Creating a service delivery model and indicating that telecare could be delivered within the current resources.

## 10.7 Dissemination Of Knowledge

Due to the relatively limited amounts of published research, throughout the duration of this research project attempts have been made to disseminate knowledge throughout the project group at quarterly meetings and invited internal seminars, and to the wider research community. This has been achieved both nationally and internationally through various publications and presentations as indicated in Appendix A10.1.

# References


1. Royal Commission on Long Term Care, *"With respect to old age: long term care - rights and responsibilities - Appendix 4"* London: The Stationery Office, 1999: p. 325.
2. Turner-Smith A, *"Help required: what is assistive technology?"* Review17 [ The Newsletter of the Centre of Rehabilitation Engineering], (Spring 2000): p. 5.
3. Tinker A, *"Older people in modern society."* Longman, 1997.
4. Townsend P. Wedderburn P, *"The aged in the welfare state."*. 1965: G Bell and Sons. London.
5. Tinker A, *"Older people in modern society."*. 1997: Longman. 40-42.
6. Clegg J, *"Dictionary of Social Services."*. 1971: Bedford Square Press. London.
7. Home Office. Department of Education and Science. Ministory of Housing and Local Government and Ministry of Health, *"Report of the committee on local uthority and allied personal Socail Services (Seebohm Report)"* 1968.
8. Department of Health, *"Caring for people: community care in the next decade and beyond."* HMSO. London, 1989: p. 3.
9. Nolan M. Grant G. Caldock K. Keady J, *"A framework for assessing the needs of family carers: a mutli-disciplinary guide."* Rapport Productions, 1994.
10. Department of Health, *"Long-term care for elderly people: purchasing, providing and quality."* HMSO. London, 1992.
11. Jones K. Brown J. Brodshaw J, *"Issues of social policy."* 1978.
12. Office of population Census and Surveys, *"Living in Britain: results from the 1994 general household survey."* HMSO. London, 1996: p. 71.
13. (DoHSB) Department of Health statistical bulletin. Community care statistics 1998, *"table A1.2 (Households receiving home care or home care, by sector and age)"* http://www.ace.org.uk/, 1998.
14. David Heurdon Personal communication, *"BCC Social Services figures from 1997/98."* 1999.
15. Goldring M, *"Goldring: the age of rationing."* Channel 4, 28 June 1998.
16. Parry I. Thompson L, *"Effective sheltered housing: a handbook."* Longman, Institute of Housing, 1993.
17. BBC News, *"Social Services face acute cash shortage." http://www.news.bbc.cu.hi/english/health/newssid_119000/119224.stm* June 24 1998.
18. Godfrey M, *"Preventive strategies for older people: mapping the literaure on effectiveness and outcomes."* Anchor research, 1999: p. 11-13.
19. Department of Health and Social Security/Social Services Inspectorate. DHSS/SSI, *"From home help to home care: an analysis of policy, resourcing and service management."* DHSS. London, 1987.
20. Allen I. Hogg D. Peace S, *"Elderly people: choice, participation and satisfaction."* PSI. London, 1992.
21. Alber J, *"Health and Social Services. Summarised from older people in Europe: social and economic polices."* Ageing International, December 1993. **XX**(4): p. 15-19.
22. Department of Health, *"Commons health committee"* HMSO. London, 1996.
23. The Guardian, The Guardian, 5 March 1996.
24. Age Concern England, *"Expectation of life [in years] at birth and selected age."* http://www.ace.org.uk/stat_print/default.htm.
25. Ermisch J, *"Fewer babies longer lives."* Joseph Rowntree, July 1990: p. 26.
26. Salvage A, *"Who Will Care? Future prospectives for family care of older people in the European Union."* European Foundation for the Improvement of Living and Working Conditions. Dublin., 1995.
27. Warnes A, *"The demography of Ageing in the United Kingdom of Great Britain and Northern Ireland."* Age Concern Institute of Gerontology and the Department of Geography, Kings College, University of London, 1993.
28. Centre for International Research 1991 figures". Eurolink Age Bulletin from "International Database, Eurolink, November 1992.
29. Formosa S, *"Age vault"* International Institute on Ageing, 1995.
30. http://www.aeiveos.com/library.htm.
31. Office of population Census and surveys, *"General household survey: carers in 1990."* Office of population Census and surveys. Monitor SS92/2. OPCS. London, 1992.
32. Ermisch J, *"Fewer babies longer lives."* Joseph Rowntree, July 1990.
33. Age Concern, *"A guide to the debate of the age. Your say in the future."* Age Concern, 1998.
34. Law and Ethics Exchange on Ageing, *"Debate on the age: 10 Key facts."* Apr/May 1998. **6**(5): p. 7.

35. Green H, *"Informal carers, general household survey 1985 series."* Generald Houshold Survey. No. 15. Supplement 16. OPCS. Social Survey Division. London, 1988.
36. Evandrou M. Arber S. Dale A. Gilbert G.N, ed. *"Who cares for the elderly? Family care provison and reciept of statutory service."*. "Dependency and Interdependency in old age.", ed. P.C.B.M.S. P. 1986, London. Croom Helon.
37. Wenger C, *"Conference. The sociology/anthropology of ageing."* 1997.
38. Jarvis C, *"Family and friends in old age and the implications for informal support: evidence from the british social attitudes survey."* ACIOG. London, 1993.
39. Berthold H, *"Assisting carers using telematic interventions to meet older person's needs."* Borås University College of Health Sciences. Box 551 40S-500 05 Borås, Sweden, 30th June 1997.
40. Bulmer M, *"The social basis of community care."* Allen and Unwin. London, 1987.
41. Tunstall Telecom, *"Home alone 97: independence and isolation."* Tunstall Telecom, 1997.
42. Bengston V. Rosenthal C. Burton L, *"Families and ageing: diversity and heterogeneity."* in Binstock R. and George L. (Eds.). "Handbook of Ageing and Social Sciences." Academic Press. London, 1990: p. 263-287.
43. Wenger C, *"The supportive network: copeing with old age."* Allen and Unwin. London, 1984: p. 190.
44. Brodie-Smith A, *"A grey Area: a critical deconstruction of the burden of elderly people."* Generations review, June 1993. **3**(2): p. 6-8.
45. Office of Population Censuses and Surveys, *"1992 general household survey."* HMSO. London, 1994.
46. Griffiths D, *"Politics of health."* Public Publications, 1996.
47. Concise Oxford Dictionary, Oxford at the Clarendon Press, 1964.
48. The Times Interface Telecoms extra, *"The phone revolution."* The Times Interface, 8/7/1998.
49. Myers G. Coltrane L, *"Social implications of ageing in developing countries"* in Short term training in the demographic aspects of population ageing and its implications for socio-economic development policies and plans. International Institute on ageing United Nations - Malta, 1993.
50. Tinker A, *"Older people in modern society."* Longman, 1997: p. 197-98.
51. Martin J. Roberts J, *"Women in employment: a lifetime perspective."* HMSO. London, 1984.
52. Wenger C, *"The ageing world, longevity, culture and the individual."* Generations Review, Sept 1993: p. 4.
53. Eurostat, *"Labour force supply."* Eurostat, 1991.
54. Glending C. Mclaughlin E, *"Paying for care: lessons from europe."* Social Security Advisory Committee, research paper 5, 1993: p. 14-27.
55. Grundy E, *"Demographic influences on the future of family care."* in Allen I. Perkins E (Eds) "The future of family care for older people." HMSO. London, 1995: p. 1-18.
56. Butler J. Madeley P, *"Depression in carers."* in Geriatric Medicine. Feb, 1995: p. 41-43.
57. Department of Helath an Social Security. DHSS, *"A happier old age. A discussion document."* HMSO. London, 1978.
58. Curry RG. Norris AC, *"A review and assessment of telecare activity in the UK and recommendations for development."* New College, University of Southampton, 1997.
59. The Joseph Rowntree Foundation, *"The costs of independent living."* Ref 059, http://www.jrf.org.uk/, October 1999.
60. Abbott S. Fisk MJ, *"Maintaining independence and involvement: older people speaking."* St Albans: Abbeyfield Society, 1997.
61. Fisk M, *"Telecare at home: factors influencing technology choices and user acceptance."* Journal of Telemedicine and Telecare, 1998. **4**(5): p. 80-83.
62. Knipscheer K, *"Elderly, elderly disabled and technology."* Brussels, 17 -18 January 1994.
63. Tinker A, *"Older people in modern society."* Longman, 1997: p. 110.
64. Phillips M, *"Embrace the potential."* Housing Today, 6/11/1997.
65. Victor C.R, *"Health and healthcare in later life."* Open University press. Milton Keynes, 1991.
66. Inside Housing, *"Fatal flaw."* Inside Housing, 14/4/1997.
67. Housing Today, Housing Today, 26/6/1997: p. 2.
68. English House Condition Survey, *"Table no 11.26."* English House Condition Survey, 1991.
69. Townsend P, *"The last refuge."* Routledge and Kegan Paul. London, 1962.
70. Ministry of Housing and Local Government, *"Housing standards and costs: accommodation specially designed for old people."* (cirular 82/69). London, 1969.
71. Audit Commission, *"Home alone: the role of housing in community care."* Audit Commision, 1998: p. 24-32.
72. Association Social Alarm Providers (ASAP), *"Newsletter"* ASAP, March 1998.

73. National Federation of Housing Associations, *"Challenging times: the changing role of the warden."* National Federation of Housing Associations, 1996: p. 1.
74. *"Housing Act 1985."* Schedule 5, paragraph 10, 1985.
75. Tinker A, *"Older people in modern society."* Longman, 1997: p. 124.
76. Tinker A. Wright F. Zeilig H, *"Difficult to let sheltered housing."* HMSO. Age Concern Institute of Gerontology, 1995.
77. Falshaw R. Gallagher L, *"Diffuclt to let? A regional study of difficult-to-let sheltered accommodation for older people."* Hanover Housing Association/Housing Corportaion, 1997.
78. Graham S, *"Once just 'good neighbours', wardens are playing a pivotal role in community care."* Housing, April 1997: p. 32-33.
79. McCafferty P, *"Living independently: a study of the housing needs of elderly and disabled people."* HMSO. London, 1994.
80. Audit Commission, *"Balancing the care equation: progress with community care."* HMSO. London, 1996.
81. Audit Commission, *"Making a reality of community care."* HMSO. London, 1986.
82. Tinker A, *"Staying at home: helping elderly people."* HMSO. London, 1984.
83. Tinker A, *"An evaluation of very sheltered housing."* HMSO. London, 1989.
84. Office of population Census and Surveys, *"Living in Britain: results from the 1994 general household survey."* HMSO. London, 1996: p. 138.
85. Arber S. Ginn J, *"Connecting gender and ageing."* Open University Press. Buckingham, 1995.
86. Fletcher R, *"The family and marriage in Britain."* Penguin. London, 1966.
87. Sugisawa H. LainG J. Liu X, *"Social networks, social support, and mortality among older people in Japan."* Journal of Gerontology, 1994. **49**(1): p. 3-13.
88. The relatives Association, *"Separated but not abandoned."* Exchange on Ageing Law and Ethics, 1992. **5**: p. 12.
89. Halamandaris Val J, *"Twenty reasons for home care"* Caring magazine, October 1995. **IV**(10).
90. Diederiks J Van Haastregt J, van Rossum E, de Witte L, Crebolder H, *"Effects of preventive home visits to elderly people living in the community: systematic review."* British Medical Journal http://www.bmj.com/cgi/content/full/320/7237/754, 18 March 2000.
91. IEEE, *"An instrumentation system for the remote monitoring of changes in functional Health Status of the elderly at home."* Proc of the 16th Annual International Conf. of IEEE Eng. in Media & Biol. Society Baltimore. USA, November 3-6 1994: p. 908-9.
92. Robins S. Wittenberg R, *"The health of elderly people: economic aspects."* in DoH Central Health Monitoring Unit. "The Health of Elderly People: an epidemiological review." Companion papers. HMSO. London, 1992: p. 10-19.
93. McGlone, from Census and Government Actuary data, 1992.
94. Owen K, *"Caring for the elderly"* Exchange on Ageing Law and Ethics, 1996. **5**(1): p. 14-15.
95. Department of Health, *"Promoting Independence: partnership, prevention and carers - conditions and allocations 1999/2000."* (LAC (99) 13). London: Department of Health, 1999.
96. Prophet H, *"From consumerism to citizenship: new european perspectives on independent living in older age."* HOPE (Housing for Older People in Europe). Oxford, 1998.
97. Grundy E, *"Ageing, Ill, health and disapility, in Tallis, R (ed) Increasing logevity: medical, social and political implications."* Royal College of Physicians of London. London, 1998.
98. Prophet H, *"Fit for the future: the future for public services - 2008."* London, 1998.
99. Brownsell S. Bradley DA. Bragg R. Catlin P. Carlier J, *"Do users want telecare and can It be cost-effective?"* Presented at the EMBS/BMES International Conference, Atlanta USA. And unpublished data, 16th October 1999.
100. Royal Commission on Long Term Care, *"With respect to old age: long term care - rights and responsibilities."* London: The Stationery Office, 1999.
101. Department of Health, *"Better services for vulnerable people."* EL97/62, 1997.
102. Department of Health, *"Modernising Social Services."* HMSO. London, 1998.
103. Department of Social Security, *"Supporting people: A new policy and funding framework for support services."* DSS. Crown, 1998.
104. H Lewis, *"Promoting well-being, developing a preventative approach with older people."* Anchor Research, 1999.
105. Social Exclusion Unit, *"Bringing Britain together: A national strategy for neighbourhood renewal."* HMSO. London, 1998.
106. Dahrendorf R, *"Life chances: approaches to social and political theory."* University of Chicago Press. Chicago, 1979.
107. Welin L. Larsson B. Svardsudd K. Tibblin B. Tibblin G, *"Social network and activities in relation to mortality from cardiovascular diseases, cancer, and other causes: A 12-year follow*

*up of the study of men born in 1913 and 1923."* Journal of Epidemiology and Community Health, 1992. **46**: p. 127-32.

108. Porteus J. Brownsell S, *"Using telecare: exploring technologies for independent living for older people."* Anchor research, 2000.
109. Workshop on Home Care Technologies for the 21st Century, *"Topic A: interactive "home" telehealth future technologies and services."* http://www.hctr.be.cua.edu/HCTworkshop/HCTr_A.htm, 1999.
110. Department of Social Security, *"A new policy and funding framework for support services. Interdepartmental review of funding for supported accommodation."* Crown. London, 1998.
111. Department of Health, *"Community Care (Direct Payments) Act 1996: a draft guide for people who receive direct payments, consultation paper."* HMSO. London, January 1998.
112. Brownsell S. Bradley D. Bragg R. Catlin P. Carlier J, *"Do community alarm users want telecare?"* Journal of Telemedicine and Telecare, 2000. **6**: p. 199-204.
113. Thompson L, *"The role of central control in dispersed alarm systems."* 1980.
114. Audit Commission, *"Home alone: the role of housing in community care."* Audit Commision, 1998: p. 65-73.
115. Thie J, *"A pan-Eurpean social alarm system."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 60-61.
116. Association of Social Alarm Providers, *"ASAP newsletter."* ASAP, Febrary 1997: p. 7.
117. Calling for Help Group, *"Community alarm services: a national survey."* Anchor research and Help the Aged. National Housing and Town Planning Council. Research Institute for Consumer Affairs. London, 1994.
118. Riseborough M, *"Community alarm services today and tomorrow."* Anchor research, 1997.
119. Audit Commission, *"Home alone: the role of housing in community care."* Audit Commision, 1998: p. 6-7.
120. Fisk M, *"Telecare equipment in the home. Issues of intrusiveness and control."* Proc. TeleMed 96. London, 1996.
121. Housing Department internal user survey Birmingham City Council, *"Sheltered housing survey: The views of residents."* Birmingham, 1997.
122. Dibner A, *"Personal emergency response systems: communication technology aids elderly and their families."* Journal of Applied Gerontology, 1990. **9**: p. 504-10.
123. Clapham D. Munro M, *"The role of sheltered housing wardens: conflict and change."* Discussion paper no 21 University of Glasgow: Centre for Housing Research, 1989.
124. Butler A, *"The growth and development of alarm systems in sheltered housing"* in Fisk M. (ed). "Alarm systems and elderly people." Glasgow: The Planning Exchange, 1989.
125. Breen T, *"Community alarm systems."* In Dibner AS, ed. "Personal Response Systems: An International Report of a new home care service." New York: Haworth, 1992.
126. Research Institute for Consumer affairs (RICA), *"Dispersed alarms: a guide for organisations installing systems."* RICA: London, 1986.
127. Levine DA. Tideiksaar R, *"Personal emergency response systems: factors associated with use among older persons."* Mt Sinai J Med, 1995. **62**(4): p. 293-97.
128. Fennell G, *"Anchor's older people."* Anchor research, 1984: p. 37.
129. Thornton P. Moutain G, *"Please ring for service."* Community Care, June 1992. **11**: p. 20-21.
130. Fisk M, *"Alarm systems and elderly people."* London:Planning Exchange, 1989.
131. Journal of the Royal College of Physicians of London, Journal of the Royal College of Physicians of London, November/December 1997. **31**(6): p. 694.
132. Advisor on Informatics of the World Health Organisation, *"Report by the WHO director general to the 99th sesion of the executive board."* World Health Organisation, 6th January 1997. **Ref: EB99/30.**
133. Journal of Telemedicine and Telecare, *"Guidence for authors."* Journal of Telemedicine and Telecare, 1996: p. 2.
134. Department of Health, *"Supplementary information on the ICT research inititave."* Department of Health. http://www.doh.gov.uk/ict.htm, 1998: p. 6.
135. Wright D, *"Telemedicine and developing countries."* Journal of Telemedicine and Telecare, 1998. **4**(2).
136. Berlo A, *"International conference on smart homes and telematics."* Program Abstracts, 1999: p. 1.
137. Edinvar Housing Association, *"AID house: assisted interactive dwelling - house."* Publicity leaflet, Edinvar Housing Association, 2000.
138. Roof, *"Chips with everything."* Roof, November/December 1998: p. 34.
139. Joseph Rowntree Foundation, *"Smart moves."* SEARCH, 1998. **31**: p. 14-15.

140. Gann D. Barlow J. Venables T, *"Digital futures."* Joseph Rowntree Foundation & Chartered Institute of Housing, 1999: p. 108-25.
141. Dixon P, *"Futurewise: six faces of global change."* Harper Collins, 1999.
142. Burley R, *"Old folk's homes making way for care home through smart home technology."* International Conference on Smart Homes and Telematics, 1999: p. 13.
143. Brownsell S, *"Personal search."* Medline - http://www3.infotrieve.com/medline/infotrieve/, 2000.
144. Murlow C.D, *"Rationale for systematic reviews."* In: Chalmers I, Altman D.G., (eds) Systematic Reviews London: BMJ Publishing Group, 1995.
145. Clark H. Dyer S. Hartman L, *"Going home: older people leaving hospital"* Joseph Rowntree Foundation, 1996: p. 30.
146. Rodr'iguez MJ. Arredondo MT. del Pozo F. G'omez EJ. Mart'inez A. Dopico A, *"A home telecare management system."* Journal of Telemedicine and Telecare, 1995. **1**(2): p. 86-94.
147. Cameron K. Doughty K, *"The role of electronic sensors in future telecare systems."* University of Wales, Bangor, 1996.
148. Landerman L. Fillenbaum G, *"Differential relationships of risk factors to alternative measures of disability."* Journal of Ageing and Health, 1997. **9**(2): p. 266-279.
149. Lawerence RH. Assmann SF, *"Do proxy evaluations of health status predict mortality?"* Journal of Ageing and Health, 1997. **9**(2): p. 185-203.
150. Doughty K, *"FRED, EMMA and INGRID - watching over you."* Old age Pschiatrist, 2000: p. 9.
151. Doughty K. Lewis R. McIntosh A, *"The design of a practical and reliable fall detector for community and institutional applications"* Presented at TeleMed 99, London, 1999.
152. Celler BG. Earnshaw W. Ilsar ED, *"Remote monitoring of health status of the elderly at home. Preliminary results of a 5 months trial."* Medical and Biological Engineering and Computing, 1997. **35**(2): p. 1286.
153. Williams G. Doughty K. Bradley DA, *"A systems approach to achieving CarerNet - An integrated and intelligent telecare system."* IEEE Trans on Information Technology in Biomedicine, 1998. **2**(1): p. 1-9.
154. Brownsell S. Williams G. Bradley D. Bragg R. Catlin P, *"Future systems for remote health care."* Journal of Telemedicine and Telecare, 1999. **5**: p. 141-152.
155. Wilson LS. Sharp IF. Gill RW. Heitmann SA. Chen CF. Dadd MJ. Kajan A. Gunaratnam M. Tam E, *"Hospital without walls - home telecare using vital signs monitoring."* http://www.coh.uq.edu.au/research/homecare/pap99_Wilson_HWW.html, 1999.
156. Johnson P, *"The clinical and economic advantages of remote, community-based physiological assessment."* Journal of Telemedicine and Telecare, 1998. **4**: p. 64-66.
157. Trott P. Blignault I, *"Cost evaluation of a telepsychiatry service in northen Queensland."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 66-68.
158. Hawker F. Kavanagh S. Yellowlees P. Kalucy SR, *"Telepsychiatry in South Austrlia."* Journal of Telemedicne and Telelcare, 1998. **4**: p. 187-94.
159. Doze S. Simpson J. Hailey D. Jacobs E, *"Evaluation of a telepsychiatry pilot project."* Journal of Telemedicine and Telecare, 1999. **5**(1): p. 38-46.
160. Loane MA. Gore HE. Corbett R. Steele K. Mathews C. Bloomer SE. Eedy DJ. Telford RW. Wootton R, *"Preliminary results from the Northern Ireland arms of the UK multicentre teledermatology trial: effect of camera performance on diagnostic accuracy."* Journal of telemdicine and telecare, 1997. **3**(1): p. 73-75.
161. Lowitt MH. Kessler II. Kauffman CL. Hooper FJ. Siegel E. Burnett JW, *"Teledermatology and in-person examinations: a comparison of patient and physician perceptions and diagnostic agreement."* Archives Dermotology, 1998. **134**(4): p. 471-76.
162. Kirby B. Lyon CC. Harrison VP, *"Low-cost teledermatology using Internet image transmission."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 107.
163. Journal of Telemedicine and Telecare, *"Index vols 1-5 1995-9."* Journal of Telemedicine and Telecare, 2000.
164. Anonymous, *"Clasic episodes in telemedicine."* Journal of Telemedicine and Telecare, 1997. **3**: p. 233.
165. Bashshur R. Lovett J, *"Assessment of telemedicine: results of the initial experience."* Aviation, Space and Environmental Medicine, 1977. **48**: p. 65-70.
166. Doughty K. Cameron K. Garner P, *"Three generations of telecare of the elderly."* Journal of Telemedicine and Telecare, 1996. **2**: p. 71-80.
167. Doughty K. Cameron KH. Matthews M, *"The virtual neighbourhood."* Geriatric Medicine, 1995. **25**: p. 18-19.
168. Tang P. Venables T, *"Smart homes and telecare for independent living."* Journal of Telemdicine and Telecare, 2000. **6**(1): p. 8-14.

169. Hyer K. Rudick L, *"The effectiveness of personal emergency response systems in meeting the safety monitoring needs of home care clients."* Journal of Nursing Administration, 1994. **24**(6): p. 39-44.
170. Rudel D. Premik M. Hojnik-Zupanc I, *"Caring network based on community social alarm centres in Slovenia: a country in transition."* Medinfo, 1995. **8**(2): p. 1503-05.
171. Roush RE Teasdale TA Murphy JN Kirk MS, *"Impact of a personal emergency response system on hospital utilisation by community residing elders."* South Medical Journal, 1995. **88**(9): p. 917-22.
172. Erkert T, *"High-quality television links for home-based support for the elderly."* Journal of Telemedicne and Telecare, 1997. **3**(1): p. 26-28.
173. Lindberg CC, *"Implementation of in-home telemedicine in rural kansas: answering an elderly patients needs."* J Am Med Inform Assoc, 1997. **4**(1): p. 14-17.
174. Allen A. Roman L. Cox R. Cardwell B, *"Home health visits using a cable television network: user satisfaction."* Journal of Telemedicine and Telecare, 1996. **2**(1): p. 92-94.
175. Whitten P. Mair F. Collins B, *"Home telenursing in Kansas: patients perceptions of uses and benefits."* Journal of Telemedicine and Telecare, 1997. **3**(1): p. 67-69.
176. Electronic Telegraph, *"GPs house calls go virtual."* Electronic Telegraph, 28 January 1997(613).
177. Watts L. Monk A, *"Telemedical consultation: task characteristics."* CHI 97, 1997: p. 534.
178. Wright D, *"Appendix 1: telemedicine experience."* Journal of Telemedicine and Telecare, 1998. **4**(2): p. 49-61.
179. Ball C. McLaren P, *"The tele-assessment of cognitive state: a review."* Journal of Telemdicine and Telecare, 1997. **3**(3): p. 126-31.
180. The Telegraph, The Telegraph. http://www.telegraph.co.uk, 9 October 1995.
181. The Times, *"Fingertip chips can reveal all to doctors."* The Times, 21 May 1997.
182. Celler BG. Earnshaw W. Ilsar ED. Betbeder-Matibet L. Harris MF. Clark R. Hesketh T. Lovell NH, *"Remote monitoring of health status of the elderly at home. A multidisciplinary project on aging at the University of New South Wales."* Int Biomed Comput, 1995. **40**(2): p. 147-55.
183. http://www.shahal.co.il/html.
184. Roth A. Carthy Z. Benedek M, *"Telemedicine in emergency home care - the Shahal experience."* Journal of Telemedicine and Telecare, 1997. **3**(1): p. 58-60.
185. http://www.telemed-care.com.
186. http://www.tevital.com.
187. http://www.instromedix.com.
188. Bjørneby S, *"Using technology in houses for people with dementia."* The BESTA flats in Tonsberg. Human Factors Solutions, 1997.
189. Carlijn VC. BoutenTM. Koekkoek M. Verduin K. Janssen JD, *"A triaxial accelerometer and portable data processing unit for the assessment of daily physical activity."* IEEE Transactions on Biomedical Engineering, 1997. **44**(3): p. 136-147.
190. Laporte RE. Montoye HJ. Caspersen CJ, *"Assessment of physical activity in epidemiological research: problems and prospects."* Public Health Rep, 1985. **200**: p. 131-46.
191. Ageing Well, *"Health promotion with older people"* Ageing Well, 1994: p. 18.
192. Wolfson LI. Whipple R. Amerman P. Tobin JN, *"Gait assessment in the elderly: a gait abnormality rating scale and its relation to falls."* Journal of Gerontology, 1990. **45**: p. 12-19.
193. Miyazaki S, *"Long-Term unrestrained measurement of stride length and walking velocity utilising a piezoelectric gyroscope."* IEEE Transactions on Biomedical Engineering, 1997. **44**(8): p. 753-59.
194. force measuring system." in Proc. Annu. Symp. Comput. Appl. Med. Care. Vol 7. PG 897-899. Polchninoff M. (1983). "Gait analysis using a portable, *"Gait analysis using a portable, force measuring system."* in Proc. Annu. Symp. Comput. Appl. Med. Care. Vol 7, 1983.
195. Harris GF. Riedel SA. Webber RC, *"Validation evaluation and preliminary study of the AAMRL/BBD portable force dosimeter."* in Proc 34th Int. Inst. Symp. (ISA), 1988: p. 391-96.
196. Zhu H. Harris GF. Wertsch JJ. Tompkins WJ. Webster JG, *"A microprocessor-based data-acquisition system for measuring plantar pressures from ambulatory subjects."* IEEE Transactions on Biomedical Engineering, 1991. **38**: p. 710-14.
197. Personal communication with Andy McIntosh - Safe 21 representative for Tunstall Telecom, October 2000.
198. Rix I, *"Enlisting technology to help the elderly."* Housing Today, 1 May 1997: p. 11.
199. Anchor Trust, *"Press release - 28 August 1997."* Anchor Trust, 1997.
200. Woollacott E, *"Caring computers give senior service."* The Times interface, 23 July 1997.
201. Gann D. Barlow J. Venables T, *"Digital futures."* Joseph Rowntree Foundation & Chartered Institute of Housing, 1999.

202. http://dbs.cordis.lu/cordis-cgi/srchidadb?ACTION=D&SESSION=112152000-4-29&DOC=2&TBL=EN_PROG&RCN=EN_RCN:275&CALLER=PROGADVANCEDSRCH.
203. TIDE, *"Council decision on a community technology initiative for disabled and elderly people ."* 1993-1994. OJ L240/42 of 25.9.1993, 1993.
204. http://www2.echo.lu/telematics/disabl/backgr-1.html#over.
205. http://www2.echo.lu/telematics/disabl/obj-dis.html.
206. Brownsell S. Poole P. Brownsell G, *"New alarm technology: will it lead to data overload?"* Preecedings of the Centre for Sheltered Housing Studies, The Technical Future for Sheltered Housing, June 10th 1998.
207. Murphy E, *"With respect to old age."* British Medical Journal, 1999. **318**: p. 681-82.
208. Metz D, *"Innovation to prevent dependency in old age: technological innovations may reduce the cost burden of an ageing population."* British Medical Journal, 2000. **320**: p. 460-61.
209. Kinsella A, *"Home telecare in the United States."* Journal of Telemedicine and Telecare, 1998. **4**: p. 195-200.
210. Council on Competitiveness, *"Highway to health: transforming US health care in the information age."* Washington, DC. Council on Competitiveness, 1996.
211. Remington L, *"1998 business predictions: surviving the home care revolution."* Remington Report, 1997: p. 16-19.
212. Anchor Trust, *"Using telecare: the experiences and expectations of older people."* Anchor Trust, ISBN 0 906178 54 1, 1999.
213. Ruggiero C. Sacile R. Giacomini M, *"Home telecare."* Journal of Telemedicine and Telecare, 1999. **5**: p. 11-17.
214. Togawa T. Tamura T. Kimura Y. Ogawa M, *"Attempts at fully auotmated home health monitoring systems."* Medical and Biological Engineering and Computing, 1996. **34**: p. 31-2.
215. Allen A. Doolittle CG. Boysen DC. Komoroski K. Wolf M. Collins B. Petterson DJ, *"An analysis of the suitability of home health visits for telemedicine."* Journal of Telemedicine and Telecare, 1999. **5**: p. 90-96.
216. Wootton R. Loane M. Mair F. Allen A. Doolittle G. Begley M. Mclernan A. Moutray M. Harrison S, *"A joint US-UK study of home telenursing."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 83-85.
217. http://www.ist.cc/EN.
218. http://www.tech-healthcare.demon.co.uk.
219. Doughty K, *"Technology in Healthcare christmas newsletter 1999."* Technology in Healthcare, 1999.
220. Doughty K, *"My vision for e-care to support older people in their own homes."* Technology for Living Forum UK Newsletter, 2000.
221. British Telecom, *"Keeping in touch: BT's favourite products for the home."* British Telecom, 2000: p. 7-8.
222. British Telecom, *"Security for stay-at-homes with BT's carer phones."* Living in retirement, April/May 2000: p. 6.
223. http://www.tunstallgroup.com/news.
224. http://www.cordis.lu/fp5/src/budget.htm.
225. http://www.cordis.lu/fp5/src/budget1.htm.
226. BBC, *"NHS set for IT revolution"* http://news.bbc.co.uk/hi/english/health/newsie%5f179000/179024.stm, 24 September 1998.
227. CallCentre Europe, *"NHS Direct means health advice is just a phone call away/"* 1998. **17**: p. 20.
228. Department of Health, *"The new NHS."* London: Stationery Office (Cmd 3807.), 1997.
229. Channel 4, *"No waiting room."* 1998.
230. Department of Health, *"98/279"* http://www.open.gov.uk/, Sunday 5th July 1998 (Issued 6th July 1998).
231. O'Cathain A. Munro JF. Nicholl P. Knowles E, *"How helpful is NHS Direct? Postal survey of callers."* British Medical Journal, http://bmj.com/cgi/content/full/320/7241/1035, 2000.
232. Roulestone A, *"Enabling technologies: disabled people, work and new technology."* Buckingham. Open University Press, 1998.
233. Wooton R, *"Telemedicine in the National Health Service."* Journal of the Royal Society of Medicine, 1998. **91**: p. 614-21.
234. Wootton R, *"Telemedicine and isolated communities: a UK perspective."* Journal of Telemedicine and Telecare, 1999. **5**(2): p. 27-34.
235. Wootton R, *"Telemedicine: a cautious welcome."* British Medical Journal, 1996. **313**: p. 1375-7.
236. Wootton R, *"Possible use of telemedicine in developing countries."* Journal of Telemedicine and Telecare, 1997: p. 23-26.

237. Kinsella A, *"Costs and reimbursement for home telemedicine services."* http://tie.telemed.org/homehealth/kinsella2costs.asp, 1999.
238. Mair FS. Haycox A. May C. Williams T, *"A review of telemedicine cost-effectiveness studies."* Journal of Telemedicnie and Telecare, 2000. **6**(1): p. 38-40.
239. Mann CW. Ottenbacher JK. Fraas L. Tomita M. Granger VC, *"Effectiveness of assitive technology and environmental interventions in maintaining independence and reducing home care costs for the frial elderly."* Archives of Family Medicine, 1999. **8**: p. 210-17.
240. Personal communication. Pauline Poole Careline manager Birmigham City Council. Housing Department.
241. Fisk M, *"Telemedicine, new technologies and care management."* International Journal of Geriatric Psychiatry, 1997: p. 1057-59.
242. OECD - Organisation for Economic Co-operation and Development, *"Caring for frail elderly people."* Social policy studies no 19, OECD, Paris, 1996.
243. Makinnon M, *"Bradband Multimedia for education."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 48.
244. Cowie I, *"Guide to long term care."* The daily Telegraph and PPP Health care., 1997: p. 24-25.
245. MORI, August 1996.
246. Government Statistical Service, *"DoH statistical bulletin community care statistics 1995: personal social services: day and domiciliary services for adults England."* Department of health, 1996.
247. Census and Government Actuary Data, HMSO. London, 1992.
248. Palmore EB. Burchett BM, *"Predictors of disability in the final year of life."* Journal of Ageing and Health, 1997. **9**(3): p. 282-97.
249. Wilson BA. Evans JJ, *"A memory aid for patients suffering from head injuries."* Journal of Neurology, Neurosurgery and Psychiatry, 1997. **63**: p. 113-15.
250. Doughty K. Williams G. Holloway L, *"TEMPEST - An intelligent reminder and delivery system for telecare applications."* 1998.
251. Personal communication. Chauman D. Department of Health. Statistical division 2 and 3 from Hospital Episode Statistics, June 1998.
252. Personal communication. Hurnden D. Birmingham City Council. Social Services, June 1998.
253. General Household Survey, *"Table no 3.28 and 3.33."* General Household Survey, 1994.
254. Close J. Ellis M. Hooper R. Glucksman E. Jackson S. Swift C, *"Secondary prevention of falls in elderly accidental and emergency attendees by means of an interdisciplinary approach."* 1997.
255. Prentice J, *"Prevention of falls in the elderly - Key messages from literature: review."* 1993.
256. Richardson S, *"Mobility and falls in the elderly."* The Canadian Journal of Geriatrics, 1993. **9**(5): p. 17-24.
257. Baker SP. Harvey AH, *"Fall injuries in the elderly."* Clinical Geriateric Medicine, 1985: p. 501-12.
258. Wright F, *"Accident prevention and risk taking by elderly people: the need for advice."* ACIOG. London, 1994: p. 66.
259. Campbell AJ. Borrie MJ. Spears GF. Jackson SL. Brown JS. Fitzgerald JL, *"Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study."* Age Ageing, 1990. **19**: p. 136-41.
260. Lord SR. Ward JA. Williams P. Austey KJ, *"An epidemiological study of falls in older community dwelling women: The Randwick falls and fracture study."* Aust J.Publications. Health, 1993. **17**: p. 240-45.
261. Nevitt MC Cummings SR, *"Risk factors for recurrent non-syncopal falls. A prospective study."* JAMA. **261**: p. 2663-68.
262. Office of National Statistics, *"Living in Britain: results from the 1995 generald houeshold survey."* London: The Staionery Office, 1997.
263. op cit Family Expenditure Survey, *"Table no 9.4 and 9.5"*.
264. Living in Retirement, *"Safe and secure."* Living in Retirement, 2000: p. 6.
265. Swartz D, *"The multiservice network: addressing the need for voice/data intregration."* Telemedicine Today, 1999. **April**: p. 38-42.
266. Fisk M, *"The technological future for sheltered housing."* Centre for Sheltered Housing Studies, June 10th 1998.
267. Anchor Trust, *"The Anchor/BT Telecare Project: Can new technology assist older people to maintain independent living?"* Publicity leaflet, 1998.
268. Department of the Environment, *"Living independently."* HMSO. London, 1994.
269. Ashton G, *"The legal dilemmas of risk and restraint."* Exchange on Ageing Law and Ethics, 1997. **5**: p. 8.
270. http://www.bt.com.

271. Personal communication. Mrs Eileen Gain. Orbit Housing Association control centre manager.
272. Personal communication. Mr Vince Foot. Chichester control centre manager.
273. Thornton C. Mountain G, *"A possitive response: developing community alarm services for older people."* Joseph Rowntree Foundation: York, 1992.
274. Warren S. Craft R, *"Designing smart health care technology into the home of the future."* http://www.hctr.be.cua.edu/HCTworkshop/HCT-pos_SW-FutureHome.htm, 1999.
275. Brownsell S. Doughty K, *"Healthcare in the home - the impact of technology on the delivery of services."* Baseline - Journal of the British Association for Service for the Elderly, 1997. **65**: p. 3-17.
276. Garner P, *"Telepressence"* BT Technology Journal, 1997. **15**(3): p. 182.
277. http://telemedtoday.com/articlearchive/articles/telemedicine_articles.htm.
278. Shard P, *"Robot that performs open-heart surgery."* Daily Mail, 23/5/1998.
279. Cochrane P. Heatley D. Pearson I, *"Computers and the aged."* http://www.labs.bt.com/library/cochrane/papers/computer.htm, 1998.
280. http://www.vivatec.co.uk/.
281. IEEE, *"Biotechnology for biomedical engineers."* IEEE Engineering in Medicine and Biology, 1995: p. 199.
282. Sandia National Laboratories, *"Sandia joins national charge into 21st century nanotechnology revolution"* January 21, 2000 News release, http://www.sandia.gov, 2000.
283. *http://www.wired.com/news/technology/0,1282,37217,00.html.*
284. Dixon P, *"The office can really get under your skin."* http://www.globalchange.com/skinchip.htm, 2000.
285. Liao S. Xu Z. Izatt JA. Alcala JR, *"Real-Time frequency domain temperature and oxygen sensor with a single optical fibre."* IEEE Transactions on Biomedical Engineering, 1997. **44**(11): p. 1114-21.
286. http://www.infrared-thermography.com/faq.htm.
287. Gulyaev VY. Markov GA. Koreneva LG. Zakharov VP, *"Dynamical infrared thermography in humans."* IEEE Engineering in Medicine and Biology, 1995: p. 766-70.
288. Anbar M, *"Quantitative dynamic telethermometry in medical diagnosis and management."* CRC Press, 1994.
289. Anbar M, *"Quantitative and dynamic telethermometry: a fresh look at clinical thermology."* IEEE Engineering in Medicine and Biology, 1995: p. 15-16.
290. Winston PH, *"Artificial Intelligence."* 3rd edition. Addison Wesley, 1998.
291. Loeb GE, *"Telecare: enabling the virtual housecall."* http://www.hctr.be.cua.edu/HCTworkshop/HCT-pos_GL-telecare.htm, 1999.
292. Personal communication. Jon Carlier. TeleLarm Care.
293. British Telecom, *"The BT lifestyle monitoring project."* ASAP - Association of Social Alarm Providers National Conference - workshop, 23 September 1998.
294. Goethe JW. Bronzino JD., *"An expert system for monitoring psychiatric treatment."* IEEE Engineering in Medicine and Biology, 1995.
295. Gann R. Goodley S, *"Bluetooth - a bright idea in need of some filling."* Computing, 4 May 2000: p. 40-44.
296. T3 and YAC, *"Now you're talking: a guide to communications today."* T3 and YAC, 2000: p. 11-13.
297. Evans A, *"First Blueetooth device arrives."* PC Plus, 2000: p. 13.
298. Barron A, http://www.nursing-standard.co.uk/week41/online.htm.
299. Williams S, *"The mains attraction."* PC Plus, 1997: p. 39.
300. Navein J. Fisher A. Geiling J. Richards D. Roller J. Hagmann J, *"Portable satellite telemedicine in practice."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 26.
301. Ruggiero C, *"Teleradiology: a review"* Journal of Telemedicine and Telecare, 1998. **4**: p. 25-35.
302. http://www.tensortech.com/products/comm/LyneLynx.html.
303. Bisson S, *"ADSL."* PC Plus, 1998: p. 27.
304. Lloyd C, *"ADSL finally arrives."* PC Plus, 1999: p. 11.
305. Shapcott N. Malagodi M. Pelleschi T. Sanna J. Schmeler M, *"Telerehabilitation used for wheelchair prescription - video and remote pressure measurement."* Preecedings BMES&EMBS Atlanta, 1999.
306. Breitrose C, *"Internet 2 - the sequel."* PC Plus, 1997: p. 21.
307. http://www.srstechnology.co.uk/.
308. Wolf W. Von Maltzahn. Daphtary M. Roa LR, *"Usage patterns of environmental control units by severely disabled individuals in their homes."* IEEE Transactions on Rehabilitation Engineering, 1995. **3**(2): p. 222-27.
309. *http://cslu.cse.ogi.edu/HLTsurvey/ch5node3.html#SECTION51.*

310. http://cslu.cse.ogi.edu/asr/.
311. Boothroyd D, *"Mind over matter."* New Electronics on Campus, 1997: p. 6-8.
312. Gibbings C, *"Security in the information age."* British Telecommunications Engineering, 1996. **15**: p. 78-84.
313. http://burks.bton.ac.uk/burks/foldoc/93/88.htm.
314. Ganley M, *"End to end protection."* New Electronics on Campus, 1997: p. 20-21.
315. Seal C. Gifford M. McCartney D, *"Iris recognition for user validation."* British Telecommunications Engineering, 1997. **16**: p. 113-17.
316. Flom L. Safir A, *"Iris recognition system."* US Patient 4,641,349.3, 1987.
317. Llyod C, *"Your face is your passport."* PC Plus, 1998(June).
318. http://www.etrue.com/TrueFace_Engine.htm.
319. Birmingham City Council, *"An Agenda for Birmingham City Council - health action zones - report to chief officers group."* Birmingham City Council, 10 December 1997.
320. House of Commons Health Committee, *"Long term care: NHS responsibilities for meeting continuing health care needs."* HMSO. London, 1995. **Volume 1 report**.
321. Tierney AJ. Macmillan MS. Worth A. King C, *"Discharge of patients from hospital - current practice and perceptions of hospital and community staff in Scotland."* Health Bulletin, 1994. **52**(6): p. 479-91.
322. Temple J, *"General practice follow up of patients discharge from hospital."* The practitioner, 1998. **232**: p. 148-51.
323. Tierney AJ, *"Discharge of patients from hospital: report of a survey of current practice in acute hospital wards in Scotland and concurrent national surveys of the experiences and views of community nursing staff and general practitioners."* Nursing research unit, Department of nursing studies, University of Edinburgh, Edinburgh, 1993.
324. Mageean RG, *"Study of discharge communications from hospital."* British Medical Journal, 1986. **293**: p. 1283-84.
325. Macmillan MS. Tierney AJ. Atkinson FI. King C. Worth A, *"A national survey of general practitioners' experience and views relating to discharge of elderly people following acute hospital care."* (3rd supplementary report to the report on 'Discharge of Patients from Hospital'). Nursing Research Unit, Department of nursing studies, University of Edinburgh, Edinburgh, 1996.
326. Sommerville I, *"Software engineering."* Addison-Wesley, 4th ed, 1992: p. 222-28.
327. Oxford Reference, *"Dictionary of computing."* Oxford reference, 1991.
328. http://www.threesl.com/sys_analysis.htm.
329. Cooling JE, *"Software design for real-time systems."* Thompson Computer Press.: p. 166-70.
330. Mascot, *"The official handbook of MASCOT."* Version 3.1. Issue 1. Issued by JIMCOM, 1987.
331. Gane C. Sarson T, *"Structured systems analysis: tools and techniques."* IST Inc. New York, 1977.
332. Yourdon E. Constantine L, *"Structured design"* Yourdon Press, New York, 1978.
333. TeleLarm Care, *"Horizon: a new begining."* TeleLarm Care, 1999.
334. NHS executive, *"Information for health: an inforamtion strategy for the moden NHS 1998-2005."* http://www.doh.gov.uk/nhsexipu/strategy/summary/execsum.pdf, 1998.
335. http://www.shef.ac.uk/uni/projects/ctinm/index.html.
336. Department of Health, *"£5.8m for on-line patient records."* http://213.38.88.195/coi/coipress.nsf, 19 June 2000.
337. Department of Health, *"NHS executive information management group."* A strategy for NHS wide networking. Cambridge: Department of Health, 1995.
338. PC Plus, *"New national grid: a new proposal for a British fibre-optic network is unveiled."* PC Plus, 1998: p. 16.
339. Department of Health, *"£60m to speed up modernisation of NHS technology."* http://213.38.88.195/coi/coipress.nsf, 30 June 2000.
340. Department of Health, *"Key NHS national plan moves relating to social care and health."* http://www.community-care.co.uk, 27 July 2000.
341. Tang P. Gann D. Curry R, *"Telecare: new ideas for care and support @ home."* The Policy Press, 2000: p. 29.
342. Sommerville I, *"Software Engineering."* Addison-Wesley, 4th ed, 1992.
343. Cooling JE, *"Software design for real-time systems."* Thompson computer press, 1996: p. 75-78.
344. PCPlus, *"BogoCop optic mouse."* PC Plus, 2000: p. 168.
345. Personal communication Dr Kevin Doughty. Technology in Healthcare.
346. http://www.bongtra.co.kr/gas-sensor/gas-sensor_01.html.
347. Roberts A, *"Health and illness in sheltered housing."* The Centre for Sheltered Housing Studies, 1995.

348. Gann D. Burley R. Curry D. Phippen P. Porteus J. Wells O. Williams M, *"Healthcare and smart housing technologies: report of a DTI international technology services mission to Japan."* Pavilion, 2000.
349. http://www.motionmedia.co.uk.
350. http://www.vspan.com.
351. Halsall F, *"Data communications, computer networks and open systems."* 3rd edition. Addison-Wesley.: p. 202.
352. Welsby K. Adams J. Deslandes J, *"MeterLinkTM: BT's new telemetry service for meter reading."* British Telecommunications Engineering, 1996. **15**(2).
353. Cambridge University Press, *"A glossary of computing terms: an introduction."* 6th ed Cambridge University Press, 1989.
354. Reinsch S. Macrae P. Lachenbrunch PA. Tobis JS, *"Attempts to prevent falls and injury: a prospective community study."* The Gerontologist, 1992. **32**: p. 450-56.
355. Research into Ageing, *"Focus on Healthy Ageing. Exercise."* Research into Ageing. Leaflet Number 4, 1997.
356. http://www.truster.com/.
357. Bilalovic N. Paties C. Mason A, *"Benefits of using telemedicine and first results in Bosnia and Herzegovina."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 91-93.
358. Whitten P. Kingsley C. Grigsby J, *"Results of a meta-analysis of cost-benefit research: is this a question worth asking?"* Journal of Telemdicine and Telecare, 2000. **6**(1): p. 4-6.
359. Håkansson S. Gavelin C, *"What do we really know about the cost-effectiveness of telemedicine?"* Journal of Telemedicnie and Telecare, 2000. **6**(1): p. 133-36.
360. Strode SW Gustke S Allen A, *"Technical and clinical progress in telemedicine."* Journal of American Medical Association, 1999. **281**: p. 1066-68.
361. OFTEL, *"Telecommunications services for people with disabilities: consultative document."* OFTEL Publication, 1998.
362. BBC2, *"Disaster: the millennium time bomb."* BBC2, 13/10/1998.
363. Briggs AH Gray AH, *"Handling uncertainty when performing economic evaluation of healthcare interventions."* Health Technology Assessment, 1999. **3**(2).
364. Drummond MF. O'Brien B. Stoddart GL. Torrance G, *"Methods for the economic evaluation of health care programmes."* 2nd edn. Oxford: Oford University Press, 1997.
365. Beu DE. Raiffa H. Tversky A, *"Decision making."* Cambridge: Cambridge University Press, 1998.
366. Gold MR. Siegel JE. Russell LB. Weinstein MC, *"Cost-effectiveness in health and medicine."* New York: Oxford University Press, 1996.
367. Pauker SG. Kassirer JP, *"The threshold approach to clinical decision making."* N Engl J Med, 1980. **302**(20): p. 1109-17.
368. Gerard K. Mooney G, *"QALY league league tables: handle with care."* Health Economics, 1997. **2**(1): p. 59-64.
369. Drury C, *"Management and cost accounting."* Chapman & Hall, 1994: p. 237.
370. Dodge R, *"Foundations of Business Accounting."* Chapman & Hall, 1993.
371. Dyson JR, *"Accounting for non-accounting students."* (3rd ed). Pitman Publishing, 1994.
372. Atrill P. Harvey D. McLaney E, *"Accounting for Business."* Butterworth Heinemann.: p. 351.
373. AT Foulks Lynch Ltd, *"Paper 1 Accounting Framework."* AT Foulks Lynch Ltd, 1996.
374. Atrill P. Harvey D. McLaney E, *"Accounting for Business."* Butterworth Heinemann.: p. 336-38.
375. SSAP 7 (Provisional), *"Accounting for changes in the purchasing power of money."* 1974.
376. Davies M. Paterson R. Wilson A, *"UK GAAP."* Ernest & Young, 1994: p. 61-68.
377. SSAP 16, *"Current cost accounting."* 1980.
378. Daily mail, *"Interest rates."* Daily mail, 29/4/2000: p. 66.
379. Davies M. Paterson R. Wilson A, *"UK GAAP."* Ernest & Young, 1994: p. 538.
380. Joint evidence to the doctors' and dentists' review body from the Health Departments and the General Medical Services Committee, *"General medical practitioners' workload survey 1992-93: final analysis."* 1994: p. 4.
381. Whitten P. Collins B. Mair F, *"Nurse and patient reactions to a developmental home telecare system."* Journal of Telemedicine and Telecare, 1998. **4**(3): p. 152.
382. Bell JA. May FE Stewart RB, *"Clinical research in the elderly. Ethical and methodological considerations."* Drug Intelligence and Clinical Pahrmacy, 1987: p. 1002-07.
383. Policy Division and Strategic Research Group, *"OPCS 1993 based projects. Not including Frankley/Rubery 1991 census."* Birmingham City Council, 1998.
384. Foster J. Jessopp L. Dale J, *"Concerns and confidence of general practitioners in prviding telephone consultations."* British Medical Journal, 1999. **49**: p. 111-13.

385. Personnel communication Paul Honeyfield. Birmingham Health Authority. Contacts division.
386. Personal communication. John Mayhew. UKHCA - UK Home Care Agency.
387. Department of Health, *"1995 Prescription statistics published."* http://www.open.gov.uk/ (96/257), 29 July 1996.
388. Medical Research Council, *"The health of the UK's elderly people."* Medical Research Council. London, 1994.
389. Age concern - 1994, http://194.152.67.67/stats/age.pop.htm.
390. Department of Health, *"The Governments expenditure plans 1997-98 to 1999-2000."* (Cm 3612), London, Stationery Office, 1997: p. 46.
391. Fisk M, *"Our Future Home: Housing and the inclusion of Older People in 2025."* Help the aged, 1999: p. 23.
392. McDonald AL. Langford IH. Boldero N, *"The future of community nursing in the United Kingdom: district nursing, health visiting and school nursing."* Journal of Advanced nursing, 1997. **26**: p. 257-65.
393. Loane MA. Bloomer SE. Corbett R. Eedy DJ. Gorem HE. Mathews C. Steele K. Wootton R, *"Patient satisfaction with real-time teledermatology in Northern Ireland."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 36-40.
394. Personal Communication. West Midlands Police Headquarters. July 1998.
395. Navein J, *"Telemedicine training."* Journal of Telemedicine and Telecare, 1998. **4**(1): p. 103.
396. Murray I, *"NHS will get £250m to end winter crises."* The Times, 4/11/1998.
397. Anderson JP. Bush JW. Chen M. Dolenc D, *"Policy space areas and properties of benefit-cost/utility analysis."* JAMA, 1986. **255**(6): p. 794-5.
398. Central Statistical Office, *"Social trends 26."* HMSO. London, 1996.
399. Daily Mail, Daily Mail, 27 May 2000: p. 82.
400. Duerinckx AJ. Kenagy JJ. Grant EG, *"Planning and cost analysis of digital radiography services for a network of hospitals (the Veterans Integrated Service Network)."* Journal of Telemedicine and Telecare, 1998. **4**(2): p. 172-78.
401. Law A. Kelton D, *"Simulation modelling and analysis."* 3rd edition. McGraw-Hill Higher Education, 2000.
402. http://www.simulatn.com.au/.
403. http://www.imaginethatinc.com/frame_products.html.
404. http://www.simul8.com/whatissimul8.htm.
405. Personal Communication. Mr Bustin J. 14 April 1999.
406. http://www.imaj.co.uk & Call centre FTE calculator marketing CD.
407. Hogan D, *"Coctail program: Visual Basic on test."* PC Plus, 1999: p. 119-24.
408. Berenson LM. Levine MD, *"Basic business statistics: concepts and applications."* 5th edition. Prentice hall internation editions, 1992: p. 42.
409. Brownsell S, *"The analysis of enhanced first generation telecare systems."* University of Wales, Bangor Dissertation submission, 1997.
410. Tinetti ME. Speechley M. Ginter SF, *"Risk Factors for Falls Among Elderly Persons Living in the Community."* N Engl J Med, 1988. **319**: p. 1701-09.
411. Department of Health, *"The NHS plan."* http://www.doh.gov.uk/nhsplan/npch1.htm, 2000.
412. Johnston B. Wheeler L. Deuser J. Sousa KH, *"Outcomes of the Kaiser Permanente tele-home health research project."* Archieves Family Medicine, 2000. **9**: p. 40-45.
413. http://www.dis.port.ac.uk/ndtm/.
414. Hon. Dr. Antoine Mifsud Bonnici Parliamentary. Secretary for the Care of the Elderly, *"Future actions in the field of telematics and disabilities."* Proceedings of the COST 219 seminar Malta, 1996.
415. Frernch JRP. Raven BH, *"The basis of social power, Group Dynamics: Research and Theory."* University of Michigan Press, 1959.
416. House of Lords Official Report (Hansard), 593, 1998. **201**: p. 68-9.
417. Community-care, *"'Tsar' to help older people."* http://www.community-care.co.uk, 3rd August 2000.
418. http://www.britannica.com/bcom/eb/article/9/0,5716,119079+9,00.html.
419. Brauer GW, *"Telehealth: the delayed revolution in health care."* Medical Progress Through Technology., 1992. **18**: p. 153.
420. Nisbet P. Craig J. Odor P. Aitken S, *"'Smart' wheelchairs for mobility training"* Technology & Disability, 1996. **5**: p. 49-62.
421. Cameran D. Quine S, *"External hip protectors: likely non compliance among high risk elderly people living in the community."* Archives of Gerontology and Geriatrics, 1994: p. 273-81.
422. School of Design. NC State University. Raleigh. North Carolina USA, http://www.design.ncsu.edu/cud/.

423. Friedman RH. Kazis LE. Jette A, *"A telecommunications system for monitoring and counseling patients with hypertension."* American Journal of hypotension, 1996. **9**: p. 285-92.
424. Royal National Institute for the Blind, *"A Question of Risk."* Royal National Institute for the Blind, 1997.
425. Walmsley J. Reynolds J. Shapespeare P. Woolfe R, *"Health Welfare and Practice. Reflecting on roles and relationships."* Sage Publications, 1993: p. 107.
426. Leather P, *"Age File 99: A factfile about older people in England."* Anchor research, 1999: p. 136.
427. McHeath J., 1984.
428. Allied Dunbar, *"Allied Dunbar national fitness survey."* 1992.
429. http://www.devicelink.com/mddi/archive/00/01/012.html.
430. Maclver K, *"Smart way to dress."* The Times Interface, 2/12/1998.
431. Personal communication. Mr Andrew Hall. Managing Director Vivatec.
432. Personal communication. Prof. J Sandu. SNRU. University of Northumbria.
433. Whittaker SJ. Attwater DJ, *"Interactive speech systems for telecommunications applications."* BT Technology Journal, 1996. **14**(2).
434. http://www.abilitynet.co.uk.
435. http://home.ica.net/~fred/anch10-1.htm.
436. Cameraon K. Doughty K, *"Fall detection, prediction and prevention."* Preecedings at "New ways to make health and personal social services more accessible." Institute of medical and social care research, Bangor, 1998.
437. Research into Ageing, *"Healthy ageing news, views and research."* Research into Ageing News, 1998.
438. http://www.digiscents.com/.
439. http://www.eureka.com/whatsnew/robotvac.htm.
440. http://www.honda.co.jp/english/technology/robot/index.html.
441. http://www.cf.ac.uk//engin/research/indusyst/robot.html.
442. http://travellady.com/articles/article-epcot.htm.
443. http://patent.womplex.ibm.com/details?&patent_number=4694639.
444. http://www.globalchange.com/skinchip.htm.

# Appendix A1.1

## Funding Consortium Partners

*TeleLarm Care Limited*: TeleLarm offers a wide range of solutions to housing departments, social services, sheltered housing and control centres that provide peace of mind and enhanced standards of living to the elderly, disabled and those at risk who wish to remain independent and secure in their homes. One of the ways this is achieved is by supplying community alarms and they have been providing communication systems to health and community care sectors for more than 40 years. Further details can be obtained from TeleLarm Care Ltd, Latour House, Chertsey Boulevard, Hanworth Lane, Chertsey, Surrey, KT16 9JR, Tel: 01932 577700.

*Pentyre plc*: Pentyre specialises in the development of software for the most demanding of environments including real-time control, communications systems and control centres. In conjunction with Birmingham City Council Housing department a social alarm control centre system was designed and developed to monitor social alarms used by elderly, disabled or vulnerable people. This system developed by Pentyre is currently being distributed through TeleLarm Care Ltd. Further details can be found at http://www.pentyre.co.uk.

*HET Software Limited*: HET was established in 1993 in the wake of the Care in the Community Act. The core business is computer software, specifically for the care industry and housing sector. HET has developed a number of products in this field, in particular, there are approximately 500 users of its core product, **Care***Manager*. This is a software solution for the organisation of domiciliary and nursing care. Further details can be found at http://www.careware.co.uk.

## Non funding consortium partners

*Birmingham City Council, Housing department (BCC)*: BCC is one of the largest local authorities in England and through the use of community alarms provides support to individuals in their own homes, be they distributed in the community or grouped in a sheltered housing scheme. Through their community alarm control centre they provide assistance to approximately 11,500 elderly, disabled or vulnerable people.

*University of Abertay, Dundee*: David Bradley is Professor of Mechatronic Systems and has a particular interest in the design of complex, intelligent systems with particular reference to mechatronics. He has carried out research in areas such as engineering design, information flow modelling, smart wheelchairs, sensor behaviour and autonomous robots. More recently, he has developed an interest in the applications of systems methodologies to the design, configuration and operation of telemedicine and healthcare systems.

# Appendix A2.1

## Benefits Of Telecare And Telemedicine

The published benefits of telemedicine and telecare have been stated as:

- Empower patients by providing them with information, involving them in the management of their condition, and allowing them to make choices about their treatment[58].
- Reduce the length of hospital stay and therefore the cost of hospitalisation since the patient can be monitored at a distance[135].
- Admission to nursing homes can be delayed or avoided[116].
- Reducing patient journeys for specialist consultations[135].
- Reducing travel costs and time for specialists visiting other hospitals for consulting[135].
- Making better use of healthcare professionals' time, improve patient medicine compliance, and prolong economic activity by the patient and their informal carer[58].
- Reduction in the number of errors in medication[423].
- A reduction in operating costs through centralisation and optimisation of resources (e.g. expertise, laboratories, equipment[135]).
- Savings on hospital accommodation and processing costs as patients are treated remotely[135].
- Savings due to provision of health care in remote clinics or mobile health units versus expansion of urban or regional hospitals (I.e. the difference in construction and running costs of facilities[135]).
- Reduced risk of medical images getting lost[135].
- Improved consultations and second opinions[135].
- Reduction of additional examinations[135].
- Non-urgent home visits to be made by more junior staff safe in the knowledge that they have instant access to backup thus reinstating reassurance visits that are being phased out under budgetary cuts[58].
- Faster diagnosis and treatment[135].
- Shortening of time spent by patients waiting for medical services[357].
- Solutions for administration and logistics, supervision and quality assurance, and education and training for health care professionals and providers[135].
- Access to better health services reduces poverty and increases productivity[135].
- Universal care provision and a much broader reach in rural and remote areas[135].
- Availability of regular or on demand health care in remote areas which helps to slow population migration or attract people back to previously abandoned areas[135].
- Reduce the burden on health and social care professionals by introducing an effective triage system dealing with and prioritising calls for assistance[58].
- Reduction in patient anxiety[116].
- Families can be spared the stress and expense of visiting relatives who are being treated in a distant hospital[135].
- Reduction in ambulance callouts[116].
- An improvement in the flow of information between the GP and specialist, both with referred patients and in emergencies[135].

- An increase in the GP's level of confidence[135].
- Improved image of a country (which is important, for example, in attracting investment[135]).

# Appendix A2.2

## Related Projects

Further details of other related projects identified by Curry and Norris can be found at the project web addresses:

| | |
|---|---|
| Ithaca | http://www.vtt.fi\tte\tre\ithaca |
| Action | http://www.hb.se/action |
| Rise | http://www.atkosoft.com/risepub.htm |

# Appendix A2.3

## Telecare And Telemedicine Developers

A list of some of the well-known telecare and telemedicine suppliers and developers is provided below. In addition a comprehensive list of UK companies involved with telemedicine is maintained by the UK National Database on Telemedicine (NDTM)[32].

| Company | Address | Description |
|---|---|---|
| Acuson | http://www.acuson.com | Manufacturer and service provider of diagnostic medical ultrasound and echocardiography image management systems that generate, display, archive and retrieve ultrasound images. |
| Aerotel | http://www.aerotel.com | Remote diagnostic equipment specialising in ECG and blood pressure monitoring. |
| AMD – American Medical Development | http://www.americanmeddev.com | Remote diagnostic equipment such as video scopes, electronic stethoscopes, vital sign capture devices, microscopes and peripherals such as blood pressure and weight scale. |
| American Telecare | http://www.telemed-care.com/ | Provide equipment and monitoring facilities for remote and hospital based equipment. Virtual consultations with videoconferencing and medical monitoring using various attachments. |
| Antenna | http://www.antenna.se/anteng/index.html | Community alarm manufacturer. |
| British Telecom | http://www.bthealth.com | Various technologies that require telephone lines – videoconferencing/virtual consultations. |
| Cardguard | http://www.cardguard.com/ | Provide equipment for remote cardiology (ECG) and pulmonology monitoring. |
| Instromedeix | http://www.instromedix.com/ | Specialise in cardiac monitoring. ECG, pacemaker and arrhythmia monitoring. |
| International Security Technology | http://www.ist.cc/EN/default.htm | Key product is the WristCare that continuously monitors a users health status and sends an alarm to a control centre when the user is unable to do so. |
| Kodak | http://www.kodak.com/US/en/health/ | Health imaging equipment for use primarily in hospitals but recently for use in home monitoring.( http://www.kodak.com/US/en/health/lifeview/KHIproviderbro.pdf) |
| Motion Media | http://www.motionmedia.co.uk/home.htm | A variety of videophones for remote consultations with medical practitioners. No data is gathered remotely, purely the videophone. |
| Natali | http://www.natali.co.il | Provide a complete diagnosis of medical condition by telephone. Provide equipment and monitoring. |
| Olympus | http://www.telemeduk.com/ | Digital referral system with medical images. Primarily for GP and hospital doctors. |
| Plain software | http://www.plain.co.uk/ | Software used by nurses to provide advice to telephone callers on the symptoms. NHS Direct have used the software acting as an expert system. |
| Shahal | http://www.shahal.co.il/ | Provide community alarm equipment with medical monitoring such as ECG and blood pressure. Also provide smart home technology such as, remote door entry system for emergency services. |
| Sony | http://www.sony.com/medical | Video conferencing and still image capture equipment. Also supply monitors, printers and data storage devices. |
| SRS | http://www.srstechnology.co.uk/ | Develop innovative technology for the benefit of people with disabilities or age related mobility restrictions. Core product is the SRS 100 (Merlin), an 'interactive device controller' which controls various smart home devices in the home such as, door openers, control domestic mains electrical devices, draw curtains etc. |
| tds (Telemedicine) | http://www.tds-telemed.com/new_page | Videoconferencing with hospice patients and nurses. There is also a tds (Dermatology) ltd subsidiary. |

32 http://www.dis.port.ac.uk/ndtm/ukgroup.htm

| | | |
|---|---|---|
| Ltd | s/tds.htm | |
| Technology in healthcare | http://www.tech-healthcare.demon.co.uk/ | Develop sensors and systems for vulnerable people. Products include an automatic fall detection unit and the latest product is the MIDAS system (Modular Intelligent Domiciliary Alarm System) which raises an alarm for help when the user is unable to do so. |
| TeleLarm | TeleLarm Care, Hanworth Lane, Chertsey, Surrey, KT16 9JR. | Community alarm manufacturer and recently developed a fall detection unit. |
| Tunstall Telecom | http://www.tunstallgroup.com | Community alarm manufacturer; recently developed a speech pendant and researching telemedicine equipment through the SAFE21 project. |
| ViTel Net | http://www.vitelnet.com | Develop software programs for a variety of telemedicine appliances. |
| V-SPAN | http://www.vspan.com | Videoconferencing equipment designed especially for medical applications. |
| WelchAllyn | http://www.welchallyn.com | History of providing remote medical diagnostic instruments and moving into transtelephonic monitoring – allowing physicians to accurately observe blood pressure at a distance. |
| 8x8 | http://www.8x8.com | Videoconferencing equipment |

# Appendix A3.1

## Standard Questionnaire

**Block**__________ **FLAT NUMBER** __________

**1. Male/Female**

**2. Live alone/couple**

**3. Do you like having a community alarm and are you satisfied with it?**

☐ Yes, definitely ☐ Mainly yes ☐ No, not really ☐ No

**4. Do you currently have a pendant?**

☐ Yes ☐ No

**5. Number of pull cords tied up/not wearing pendant?**

☐ Not wearing pendant No. inoperable pull cords____ Which rooms_______________

**6. Given the choice would you rather have:**

☐ Just pendant ☐ Pendant 1 pull cord(Rm) ☐ Pendant and all pull cords ☐ Just pull cords

------------------------------------

**7. Which pendant do you prefer?**

☐ Wrist ☐ Broach ☐ Neck cord

**8. Would you like to be able to answer the phone by the pendant and speak into the pendant, for telephone calls and the door entry system?**

☐ Yes ☐ Perhaps ☐ No

**9. Would you prefer the main unit:**

☐ As it is ☐ Built into telephone ☐ As a clock on the wall - ☐ **Anlg** - ☐ **Elec**

**10. In the last year now many times have you used the alarm unit?** _____

**11. In the last year how many times has the alarm unit not been able to help you?**

_____

**12. In these examples would you contact the warden/control centre or contact the people directly yourself?**

☐ Fire ☐ Ambulance ☐ Police ☐ GP ☐ Repairs

**13. Would you allow a sensor to be placed in each room that could trace your movements, so unusual behaviour, such as you being in the living room but not moving, for say 5 hours, raised an alarm?**

☐ Yes, definitely ☐ Yes, probably ☐ Probably not ☐ No ☐ Don't know ☐ If unit was smaller

**14. Would you allow the sensor to be installed in the bathroom**

☐ Yes, definitely ☐ Yes, probably ☐ Probably not ☐ No ☐ Don't know ☐ If unit was smaller

**15. If such an alarm were raised the alarm unit could automatically speak to you with a recorded message. You could respond to this by moving or pressing your pendant and this would cancel the call. Alternatively if you didn't respond the warden/control centre would be called. Would you like a generated speech message before the unit called the warden/cc?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**16. Would you like to have a small medical unit, that your doctor would set up for you, and when you used it, perhaps once a week, it would check your health and inform you?**

☐ Yes ☐ No ☐ Perhaps ☐ If doctor decided

**17. If you were to fall over and were unable to get up would you like this to be automatically detected and the warden or control centre contacted?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**18. Would you be prepared for the health information to be kept so the doctor can use this when you next need their help?**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**19. Keep a record of when you have fallen?**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**20. Keep a record of unusual behaviour?**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**21. Are you concerned about you or others leaving the gas on by mistake?**

☐ Very concerned ☐ Concerned ☐ Not concerned ☐ Indifferent

**22. In a normal week how often do you ring people, including the warden, on the scheme?__**

**23. If this call was free how often do you think you will ring people on the scheme?**

____

**24. When communicating with the warden, control centre or GP, as well as speaking to them through the alarm unit would you like to be able to see them on the television? (also other residents in Hollypiece)**

☐ Yes, all of the time ☐ Yes, most cases ☐ In some cases ☐ Not really ☐ No

**25. Would you like these people to be able to see you on their televisions?**

☐ Yes, definitely ☐ Probably ☐ No ☐ Don't know

**26. During a normal night how many times would you get up __________**

**27. Would it help if when you got out of bed all the rooms that you went into automatically turned the lights on and off for you?**

☐ Yes, definitely ☐ Yes, most cases ☐ Perhaps ☐ No, not really

**28. Have you fallen over in the home during the last year? No. ______**

**29. How many times have you been to the doctors surgery in the last year? _____**

**30. How many times has the doctor come to your home in the last year? ________**

**31. Have you been admitted to hospital in the last year? No. _____**

**32. Do you have any home care support? No. of hours per week? _______**

**33. Do you have any nursing support? No. of hours per week? _________**

**34. Does anyone else provide any support? No. of hours per week?________ person_______**

**35. Do you take any prescription tablets daily? How many? ______,**

**36. How many times a day do you take the prescription drugs? _____,**

**37. Do you sometimes forget to take your medication? How many times a month?**

________

**38. In general would you say your health is?**

☐ Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor

**39. When you activate the alarm how satisfied are you with the time it takes the warden to answer?**

☐ Always satisfied ☐ Norm sat ☐ Occasionally sat ☐ Sometimes dissatisfied ☐ Always diss

**40. When you activate the alarm how satisfied are you with the time it takes the control centre to answer?**

☐ Always satisfied ☐ Norm sat ☐ Occasionally sat ☐ Sometimes dissatisfied ☐ Always diss

**41. How many times a week do you go outside the scheme? _____**

**42. How often do friends visit you? ______**

**43. How often do relatives visit you? ______**

**44. Can you use?**

1 - without help, quite easily.
2 - without help but some difficulty
3 - with some help
4 - with a lot of help
5 - unable
N/A don't have that device

☐ Cooker ☐ Microwave ☐ Washing machine ☐ Vacuum cleaner

☐ Telephone ☐ Radio ☐ TV ☐ Video ☐ Computer

**45. If you were advised to move into residential care or could stay here with technology, automatically detecting unusual behaviour, more community care and adaptations to the home would you prefer?**

☐ To stay here ☐ Move into care

**46. If an exercise class were available here for free would you attend?**

☐ Yes, defiantly ☐ Yes, probably ☐ Might ☐ No

**47. Interviewees age?_______**

# Appendix A3.2

## Additional Questions

**Block__________** **FLAT NUMBER ___________**

**1. Have you any preference for the colour of the main unit?**

____________________

**2. Have you ever had a fire in this flat?**

☐ Yes ☐ No

**3. Have you ever left the gas on by mistake?**

☐ N/A ☐ No No. of times per year_______

**4. Do you think you will fall in the home during the next year?**

☐ Probably ☐ Possibly ☐ Probably not ☐ No ☐ Don't know

**5. If you were to fall over do you think you could call for help?**

☐ Yes, all cases ☐ Yes, most cases ☐ Probably ☐ Probably not ☐ Hardly ever

**6. In the past month, how much of the time have you felt downhearted and sad?**

☐ None ☐ A little ☐ Some ☐ A good bit ☐ Most ☐ All

**7. How valuable is the warden service to you?**

☐ Invaluable ☐ Very good ☐ Good ☐ Satisfactory ☐ Poor ☐ Unnecessary

**8. Do you like having the wardens morning visit?**

☐ Yes, all of the time ☐ Yes, most of the time ☐ No, not really ☐ No

**9. Are there occasions when you're not ready for the wardens morning visit? No./month__**

**10. When the warden does the morning visit, would you prefer**

☐ The physical warden visit
☐ A check by talking with the warden through the alarm unit
☐ No visit, but if you weren't moving by a set time the warden would be automatically called.
☐ Prefer not to have a visit.

**11. In a week how many hours do you spend listening to music/watching the television? ___**

**12. In a week how may hours do you spend reading?** ______

**13. Can you see? (with glasses if worn)**

☐ Easily ☐ Sometimes with difficulty ☐ Often with difficulty ☐ Cannot see

**14.** If difficulty/blind, **Do you use?** ☐ **Braille** ☐ **Minicom**

**15. Do you have a hearing aid?**

☐ No ☐ Yes ☐ Wear all of the time ☐ Most ☐ Some ☐ Occasionally ☐ Never

**16. Can you hear? (with hearing aid if worn)**

☐ No difficulty ☐ Difficulty with some people ☐ Considerable difficulty

**17. How safe do you feel in your home during the day?**

☐ Very ☐ Quite ☐ Not really ☐ Afraid ☐ Very afraid

**18. How safe do you feel in your home at night?**

☐ Very ☐ Quite ☐ Not really ☐ Afraid ☐ Very afraid

**19. Why did you move into the sheltered housing scheme?** ____________________

**20. Can you ever foresee a time when you will move from here?**

☐ Yes ☐ No ☐ If health dictates ☐ To move in with family

**21. In what ways would the flat be easier to live in?** (bathroom - grab walls, ***walk in shower***, Kitchen, adaptation to taps, plugs, work surface height) ☐

**22. Is exercise important to you?**

☐ Yes ☐ Not really ☐ No

**23. Do you go to any exercise classes now?**

☐ No No. per week________________

# Appendix A3.3

## Additional Information

The additional questions were only used in one of the blocks with the purpose of investigating some of the background information. The sample size for these questions was 55.

*Health measures*

Participants were asked how well they thought they could see with glasses if worn. Almost half, 49% indicated they had no difficulty seeing, 25% expressed some difficulty, 24% often had difficulty and 2% indicated they had considerable difficulty. No one used Braille or minicom with 1 person using recorded tapes. The RNIB[424] suggest that of those aged 75 and over 17% are eligible for certification/ registration as blind or partially sighted. Therefore, the 26% of participants indicating they had difficulty would agree with anticipated levels. Telecare developments should therefore ensure that user interfaces are appropriate with suitable contrast and size.

In a similar fashion participants were asked how well they thought they could hear with a hearing aid if worn. Again this is subjective, with some people stating their hearing was very good when raised voices were necessary. Nevertheless, 67% claimed they had no difficulty hearing and 33% indicated they had some difficulty. In total, 6 (11%) possessed a hearing aid, of which 4 said they wear it all of the time, 1 occasionally and 1 never. Verbal communication through the alarm system must therefore be appropriate for users with hearing deficiencies.

Participants were asked if they thought they might fall during the next 12 months. Approximately 33% of older people fall each year[255-258] but 42% were confident that they would not fall, 56% inferred that it was something that could not be ruled out with 1 (2%) suggesting that they probably would fall. This person had previously fallen 6 times during the past 12 months. It is interesting that 42% indicated they would not fall and this may indicate that people were reluctant to acknowledge a fall could occur. The anticipated result would be for all to indicate they may fall as this shows an appreciation of this possibility occurring.

If a fall did occur Table A3.3.1 indicates that the majority of participants believed they should be able to raise an alarm with their present alarm configuration, i.e. pullcords.

Table A3.3.1: *The possibility of raising an alarm after a fall*

| | **Raising an alarm** | |
|---|---|---|
| | **Percentage** | $\eta$ |
| Yes, all cases | 22% | 12 |
| Yes, most cases | 34% | 19 |
| Probably | 31% | 18 |
| Probably not | 9% | 5 |
| Unlikely | 4% | 2 |

Of those indicating they may have difficulty only 1 (14%) had fallen in the past year. Many commented that if a fall occurred they would need to be near to the pullcords, but as previously discussed 43% had at least 1 pullcord deactivated. This may explain why 65% indicated that they would probably be able to activate the alarm. Of those suggesting they would 'probably not' or were 'unlikely' to activate the alarm only 1, had experienced a fall in the last year.

Fig. A3.3.1 indicates that 44% of participants felt sad or depressed during the previous month. Six of the 24 people this accounts for live with someone else, while how people perceive their own health has little significance. Equally the number of times people go outside of their homes into the surrounding area had little significance.

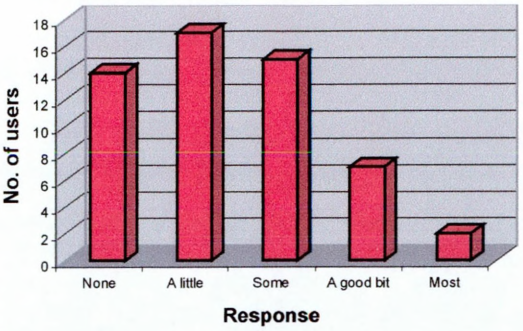



Fig A3.3.1: *An indication of how sad or depressed users felt in the previous month*

*The warden service*

Participants generally valued the warden service as presented in Table A3.3.2

TableA3.3.2: *Satisfaction with the warden service*

| | Warden service | |
|---|---|---|
| | Percentage | $\eta$ |
| Invaluable | 65% | 36 |
| Very good | 20% | 11 |
| Good | 7% | 4 |
| Satisfactory | 6% | 3 |
| Poor | 2% | 1 |
| Unnecessary | - | - |

Clearly the majority value the warden service and Fisk's[391] view that wardens should be phased out in preference of community based services would be unpopular with the participants in this questionnaire. However, over recent years the participants had undergone a 25% reduction in the warden service and some may have given a positive response in an effort to maintain their present service levels. Those less enthusiastic with the warden service were often of this opinion due to a personal social conflict and not because they did not value the service.

As part of the service, each weekday the warden will contact every home in order to verify well being. This is achieved physically by going to everyone's front door 4 days a week and for the remaining day contact is made through the community alarm system to ensure the equipment is functioning correctly. Only 4% indicated that the 'morning visit' was not beneficial with the remaining finding it a comfort. Interestingly those who do not find this visit beneficial valued the warden service as either very good or invaluable.

The morning visit takes place between 09:00 and 10:30 and as such, some people may not be ready. In total, 9% indicated they were often not ready and on average this would occur 2.6 times a month. A lifestyle monitoring system could provide valuable information to the warden. For example, if no response could be gained during the morning visit and intercom, the lifestyle monitoring system could verify if anyone was in the home and hence unnecessary forced entry could be avoided. It could also be used to replace the warden's morning visit. For example, if the normal morning routine had not taken place, i.e. from the bedroom into the bathroom and into the kitchen for breakfast, then only these people would need to be visited. However, although this may be technically possible it would not meet the requirements of users as indicated in Table A3.3.3.

Table A3.3.3: *The choice of warden's 'morning visit'*

| | Choice of 'morning visit' | |
|---|---|---|
| | **Percentage** | $\eta$ |
| Physical warden visit | 87% | 49 |
| Always using the intercom | 6% | 3 |
| Lifestyle monitoring alarm | 7% | 4 |
| No visit | - | - |

It would appear that participants find comfort in the warden's physical morning visit and do not want this to be replaced with technology. A practical point must also be considered; at present when talking through the intercom anyone in the common room can also hear the conversation with the warden and many commented that they disliked this. Hence, personal details are unlikely to be discussed through this method, while during a physical morning visit there is an opportunity for personal details to be discussed and hence in its own right this is a preventative measure. Nevertheless, for community alarm users without the services of a warden the lifestyle monitoring alarm, raising an alert if the morning routine had not been observed, could be advantageous.

*The home*

The reasons why people moved into the sheltered housing scheme often centre on their being unable to manage their previous property as indicated by Table A3.3.4.

Table A3.3.4: *The reasons why people moved into sheltered housing*

| | Reasons for occupancy | |
|---|---|---|
| | **Percentage** | $\eta$ |
| Noise/nuisance | 22% | 12 |
| Own health | 14% | 8 |
| Partners health | 7% | 4 |
| House/garden to big | 24% | 13 |
| Mobility | 4% | 2 |
| Council moved | 18% | 10 |
| Other | 11% | 6 |

The second reason why people moved was due to noise and nuisance at their previous residence. Many of these people were reluctant to move, and it would appear that they feel they have been pushed out of their homes because of the actions of others. The third reason is that the council moved them; many of the residents have been in the tower blocks before they were made into sheltered housing and thus as they have aged they have benefited from the wardens service. Also people in this group have moved to enable the council to offer their previous home, often a larger house, to families when they themselves no longer require the same amount of space. Regarding moving again, 91% cannot envisage another move, although several commented that if they won the lottery they would change their minds. Approximately 7% thought they may move in the future whilst 2% believe they will move in with family when necessary.

Participants where generally satisfied with their accommodation and few had suggestions for improvements. Five commented that lever handle taps to enable them to operate the water taps easier would be helpful, however, the main area for improvement and adaptations was in the bathroom. Several would like to obtain bath lifts or walk in baths, whilst 73% indicated they would like a shower unit to be installed. Many commented they feel unable to have a bath, for fear of being unable to get out of the bath and such a response would be anticipated as 11% of older people have difficulty walking outside or bathing and washing all over. This increases to 41% of those aged 85 and over[425].

It has been suggested that 25% of older people feel unsafe in their own homes during the day whilst this increases to 40% during the night[41]. However, the results from this questionnaire would suggest that many felt safe in their homes as presented in Table A3.3.5

Table A3.3.5: *How safe users felt in their own homes*

| | During the day | | During the night | |
|---|---|---|---|---|
| | Percentage | $\eta$ | Percentage | $\eta$ |
| Very safe | 78% | 43 | 58% | 32 |
| Quite safe | 22% | 12 | 31% | 17 |
| Not really | - | | 9% | 5 |
| Afraid | - | | 2% | 1 |
| Very afraid | - | | - | |

It should be noted that the majority had several security devices on their front doors, with most having at least 2 locks. Nevertheless, with such security users generally felt safe in their own homes during the day. During the night, again there was a general feeling of safety however, comparing the response between the day and night reveals that 29% felt safer during the day with the remainder expressing no preference. The response from users dispersed in the community may be different to those observed here in sheltered housing.

*Activities*

Leather has suggested that men aged 65 and over watch the television for 34 hours a week and women for 37 hours[426]. This questionnaire combined watching the television and listening to music and revealed that these activities accounted for 42 hours per week for men and 40.6 hours for women. Slightly higher than that suggested by Leather and the trend is reversed with men having a higher figure than women. An explanation for this trend reversal is not clear. On average each participant indicated they read for 1.4 hours a day, with 10 suggesting that they read for more than 2 hours a day and 9 indicating they rarely read. Of those who do not read 1 was unable, 5 often have difficulty seeing and 3 can see with ease.

Inactivity is a major risk factor in old age[427]. Healthy older people lose strength (the ability to exert force) at 1 to 2% per year, and power (force * speed) at 3 to 4% per year. Without some form of exercise older people may not be strong enough to perform basic tasks for everyday living and it is also helpful in the prevention of falls and depression[355]. A national survey discovered that 30% of men and 50% of women aged 65-74 do not have sufficient strength in their muscles around the thigh to rise easily from a low chair[428]. The same survey also found that 40% of men and women aged between 65 and 74 do not take part in any moderate or vigorous activity.

When the questionnaire was performed 4 currently attended formal exercise classes. All of these people were actually receiving physiotherapy on average for 1.5 hours a week, therefore no one is currently attending a general exercise class. However, 32 felt exercise was important and this theme was further investigated in the standard questionnaire (sample size 176) where 40 indicated they would attend an exercise class if one were available on the scheme. A further 28 indicated that they may attend. The results from this questionnaire suggest that as many as 39% of participants would attend an exercise class and sheltered housing is uniquely positioned to easily deliver such preventative measures.

*Miscellaneous*

Participants were asked if there had ever been a fire in their home, 4 (7%) acknowledged that there had but all commented that the fire was only 'small'. In addition 7 (13%) commented they had left gas appliances on by mistake during the previous year, at an average of 1.6 times during the year. Two of the 4 who admitted to having a fire had also left a gas appliance on by mistake. However, the sample size is insufficient to draw decisive conclusions.

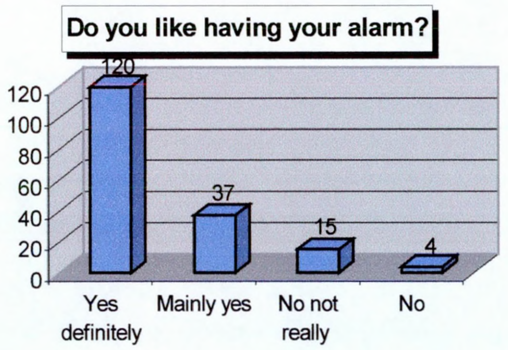
The colour of the alarm unit was not important with only 13 (24%) indicating a preference. A variety of colours were suggested with white (4, 31%) and black (3, 23%) being the most popular.

**Appendix A3.4**

# The Pemberley Road survey Results

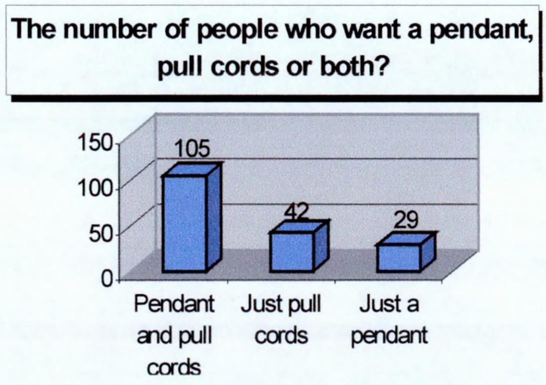
A few weeks ago I visited as many of you as I could to talk about your alarm system. You may remember that I also wanted to know about what you want from it in the future. All the results have now been analysed and given to the Council so they can make a decision about the project here.

In total 176 of you were seen and am grateful for your time, for those I was unable to contact please accept my apologies.




As you can see the majority of you are very happy with the system. However, like me, you believe that more could be done to help you if you had the misfortune of having a problem.

Many of you thought that having a pendant could help, with 76% requesting one. Three different types were available and most ladies choose the type that would fit around your wrist. Most men opted for the brooch type that can clip onto a belt or jumper.




Let's hope you remember to wear them otherwise they won't be able to help you!

Part of the project I am involved in is concerned with the introduction of new features to your alarms and you may remember we went through a number of different possibilities. Your order of preference is:

1. Being able to see who is at the main door to the block on your television.

2. Automatically detecting if you were to fall over and needed help. The alarm system would then contact the warden or Careline centre for you.

3. Automatically detecting if you were unable to get out of your chair or bath, again the warden or Careline centre would be automatically contacted for you.

4. The medical unit that would measure your heart rate, blood pressure and other parameters for you and contact the doctor if there was a problem.

5. Being able to see the warden, your doctor and others on your own television as well as speaking to them.

6. Automatically turning the lights on and off for you at night so you wouldn't need to use the light switch.

This is what you decided and we can therefore concentrate our research efforts on developing what the majority of you want. Only 2 out of the whole 176 people asked were not interested in any of these.

162 of you wanted to stay here for as long as possible, hopefully in the not too distant future we will be able to offer you some of these improvements.

Thank you once again for your time and

**Merry Christmas**

## Appendix A3.5

### Voluntary Boots Questionnaire

1. **Are you a**

   ☐ **Home owner** ☐ **Tenant** ☐ **Other**

2. **How many people live in your home?** __________

3. **Do you have a home security/burglar alarm system?**

   ☐ Yes ☐ No ☐ Maybe in the future

*Assuming there is a need for a community alarm:*

4. **Would you be in favour of lifestyle monitoring, detecting uncharacteristic behaviour?**

   ☐ Yes ☐ Perhaps ☐ No ☐ Don't know

5. **In which rooms would you accept a camera in a Passive Infrared (PIR) Sensor? (not including videoconferencing)**

   ☐ Living room ☐ Kitchen ☐ Hall ☐ Bathroom ☐ Bedroom

6. **Would you want an automatic fall sensor?**

   ☐ Yes ☐ Perhaps ☐ No ☐ Don't know

7. **Would regular health measuring be of interest to you, measuring ECG, blood pressure, breathing characteristics etc?**

   ☐ Yes ☐ Perhaps ☐ If doctor decided ☐ No

8. **Would you be equally happy to have a virtual consultation or a physical consultation with the doctor for routine consultations?**

   ☐ Yes ☐ Perhaps ☐ If doctor decided ☐ No

9. **Would you like to videoconference with other people rather than just using speech on the telephone?**

   ☐ Yes ☐ Perhaps ☐ No ☐ Don't know

10. **How much would you be prepaid to pay for such a service? (all equipment, lifestyle, fall detection etc.)**

a) One off payment for equipment__________
b) Weekly monitoring __________

# Appendix A3.6

## The Wardens Questionnaire

**Name___________________**

**1. Does the alarm system you carry meet your requirements?**

☐ Most of the time ☐ Some of the time ☐ No, not really ☐ No

**2. Improvements______**

**3. In your opinion are the residents happy with the alarm, pull cords/pendants they have?**

☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**4. In your opinion are the pull cords an effective way for the residents to call for help?**

☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**5. In your opinion are the pendants an effective way for residents to call for help?**

☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**6. In a 5 day week and based on 40 users, how many times would the alarm be activated during office hours_________, during non office hours_________**

**7. In a 5 day week and based on 40 users, how many times would the alarm be of no use, i.e. pull cords out of reach, unconscious, during office hours______, during non office hours___**

**8. Would you be in favour of residents having lifestyle monitoring?**

☐ Yes ☐ No ☐ Don't Know

**9. In general would you like to see residents having the medical monitoring?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**10. In general would you like to see residents having an automatic fall sensor?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**11. When talking through the intercom would you like to be able to see residents as well?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**12. Would you be in favour of the door entry system incorporating a video camera, so residents could see and hear who is at the main front door?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**13. Would you like the door entry system to default to Careline so they can open the door to the emergency services and anyone else when you are off duty?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**14. Out of these categories which would you say the majority of residents voted for:**

☐ Just a pendant ☐ Pendant and pull cords ☐ Just pull cords

**15. In these examples would the majority of residents use the alarm or the telephone?**

☐ Fire ☐ Ambulance ☐ Police ☐ GP ☐ Repairs

**16. Regarding lifestyle monitoring, which category do you think the majority of residents voted for:**

☐ Yes, definitely ☐ Yes, probably ☐ Probably not ☐ No ☐ Don't know

**17. Regarding computer generated speech before contacting the warden/control centre, which category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**18. Regarding the medical monitoring unit, which category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ Perhaps ☐ If doctor decided

**19. Regarding an automatic fall sensor, what category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**20. Regarding storing the lifestyle monitoring data, what category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**21. Regarding storing the medical monitoring data, what category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**22. Regarding storing the automatic fall monitoring data what category do you think the majority of residents voted for:**

☐ Yes ☐ No ☐ If GP thought wise ☐ Don't know

**23. When asking residents if they would like to be able to see and speak to their GP and you through the intercom, what category do you think the majority of residents voted for:**

☐ Yes, all of the time ☐ Yes, most cases ☐ In some cases ☐ Not really ☐ No

**24. When asking residents if they would like to let their GP and you see and speak to them through the television, what category do you think the majority of residents voted for:**

☐ Yes, definitely ☐ Probably ☐ No ☐ Don't know

**25. When asking residents 'Are you satisfied with the time it takes Careline to answer a call?', what category do you think the majority of residents voted for:**

☐ Always satisfied ☐ Norm sat ☐ Occasionally sat ☐ Sometimes dissatisfied ☐ Always diss

**26. When asking residents 'If an exercise class were available here for free would you attend?', what category do you think the majority of residents voted for:**

☐ Yes, definitely ☐ Yes, probably ☐ Might ☐ No

# Appendix A3.7

## The Control Centres Questionnaire

**Name**__________________

**1. In your opinion are the pull cords an effective way for the residents to call for help?**

☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**2. In your opinion are the pendants an effective way for residents to call for help?**

☐ Only if worn ☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**3. How would you rate the warden service?**

☐ Invaluable ☐ Very good ☐ Good ☐ Satisfactory ☐ Poor ☐ Unnecessary

**4. How would you rate the ease and quality of communication with the residents at Pemberley Road?**

☐ Excellent ☐ Very good ☐ Good ☐ Satisfactory ☐ Poor

**5. In your experience what percentage of residents would use the alarm rather than use the telephone when contacting the:**

☐ Fire brigade ☐ Ambulance ☐ Police ☐ GP ☐ Repairs

**6. Would you be in favour of lifestyle monitoring, therefore if a person did not move for an unusual length of time this would be recognised. Upon recognition a computer generated message would be heard in the residents home and if they responded to this, i.e. woke up and cancelled the alarm you would not be contacted. Alternatively, if they could not respond i.e. were unable to move from the chair/bath then you would be contacted.**

☐ Yes ☐ No ☐ Don't know

**7. In general would you like to see residents having medical monitoring. Residents would use a simple medical unit, that could measure blood pressure, pulse, heart rate, temperature and breathing characteristics. When used, say weekly, it would compare the measurements with GP defined parameters and raise an alarm if there was a problem. The parameters set would mean that if outside of these, the GP should be contacted?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**8. In general would you like to see residents having an automatic fall sensor, therefore when someone falls and are unable to get up on their own, an alarm would be raised?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**9. Would you be in favour of the Pemberley Road main door entry system having a video camera. The picture could then be available to you on your computer screen, so you could let in the emergency services and visitors when wardens are off duty?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know ☐ Only the emergency services

**10. When talking through the intercom would you like to be able to see residents as well?**

☐ Yes ☐ No ☐ Only certain residents ☐ Don't know

**11. When asking the residents 'Are you happy with the alarm, pull cords/pendants you have?' which category do you think the majority voted for:?**

☐ Yes ☐ Most of the time ☐ No, not really ☐ No

**12. When asking the residents 'Which system would you prefer?' which do you think the majority voted for:?**

☐ Just a pendant ☐ Pendant and pull cords ☐ Just pull cords

**13. When asking the residents 'Do you want lifestyle monitoring?' which do you think the majority voted for:?**

☐ Yes, definitely ☐ Yes, probably ☐ Probably not ☐ No ☐ Don't know

**14. When asking the residents 'Do you want a medical monitoring unit?' which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Perhaps ☐ If doctor decided

**15. When asking the residents 'Do you want an automatic fall sensor? which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**16. When asking the residents 'Can we keep a record and store the lifestyle monitoring information?' which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**17. When asking the residents 'Can we store the medical monitoring measurements?' which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**18. When asking the residents 'Can we keep a record of when you fall?' which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Perhaps ☐ Don't know

**19. When asking the residents 'Would you like to be able to speak to and see, through your television, the control centre operator, GP and warden?' which category do you think the majority voted for:?**

☐ Yes, all of the time ☐ Yes, most cases ☐ In some cases ☐ Not really ☐ No

**20. When asking the residents 'Would you like to be able to see who's at the main door on your television and speak to them, before letting them in? which category do you think the majority voted for:?**

☐ Yes ☐ No ☐ Don't know

**21. When asking the residents 'Would you like to be able to let the GP, control centre operator or warden see you (i.e. operator could see older person) on their screen as well as you seeing them on your television?' which category do you think the majority voted for:?**

☐ Yes, definitely ☐ Probably ☐ No ☐ Don't know

**22. When asking the residents 'How satisfied are you with the time it takes Careline to answer your call?' which category do you think the majority voted for:?**

☐ Always satisfied ☐ Norm sat ☐ Occasionally sat ☐ Sometimes dissatisfied ☐ Always diss

**23. When asking the residents 'If an exercise class were available here for free, would you attend?' which category do you think the majority voted for:?**

☐ Yes, definitely ☐ Yes, probably ☐ Might ☐ No

# Appendix A.4.1

## The Government Information Strategy

The Government's information strategy is reproduced below[334].

- *'the **short-term** (October 1998 – March 2000), which will see introduction of initial, highest priority, deliverables including:*

  *- ensuring the NHS copes with the millennium (Year 2000) problem.*

  *- developing initial costed Local Implementation Strategies and (agreeing them with Regional Offices).*

  *- completion of essential infrastructure.*

  *- connecting all computerised GP practices to NHSnet.*

  *- offering NHS Direct services to the whole population.*

  *- completing the national NHS email project.*

  *- establishing local Health Informatics Services.*

  *- completion of the cancer information strategy.*

  *-beacon EHR (Electronic Health Records) sites complete plans.*

- *the **medium-term** (April 2000 – March 2002), where clinical systems will begin to be more widely implemented. The following are key targets:*

  *- 35% of all acute hospitals to have implemented a Level 3 EPR*[33]*.*

  *- substantial progress in implementing integrated primary care and community EPR's in 25% of Health Authorities.*

  *- use of NHSnet for appointment booking, referrals, radiology and laboratory requests/results in all parts of the country.*

  *- community prescribing with electronic links to GPs and the Prescription Pricing Authority.*

  *- telemedicine and telecare options considered routinely in all Health Improvement. Programmes.*

  *- a National Electronic Library for Health accessible through local intranets in all NHS organisations.*

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[33] This level of EPR will require each acute hospital to have an integrated patient master index, patient adminstration and departmental systems, plus electronic clinical orders, results reporting, prescribing and multi-professional care pathways.

*- information strategies as appropriate to underpin completed National Service Frameworks.*

*- Beacon EHR sites have an initial first generation EHR in operation.*

- *the **longer-term** (April 2002 – March 2005) which sees the wider availability of Electronic Health Records shared across care sectors and achievement of the following targets:*

  *- full implementation at primary care level of first generation person-based Electronic Health Records.*

  *- all acute hospitals with Level 3 EPRs.*

  *- the electronic transfer of patient records between GPs.*

  *- 24 hour emergency care access to patient records.'*

# Appendix A5.1

## $2^{nd}$ Generation Data Flow Diagrams

The structure of the $2^{nd}$ generation system is defined in Fig A5.1.1. It begins with a telecare system being installed in a users home and once successfully completed monitoring can commence. If the home based system considers that there is an emergency situation then this can be verified through the IHAS with the warden, control centre or health zone being contacted if assistance is required. These external entities can also be contacted directly by the user if they so wish. Other calls from the users home to the control centre are to:

- Access the EPR: either because the user wishes to view their details or carers, home helps, nurses or the GP enter the actions they have performed when at the users home.
- Equipment calls and warden logs: these ensure that equipment is working correctly and can be used for accountability purposes.
- Warden scheme default: for users living on warden schemes the warden is the first point of contact, however if they are unable to respond the control centre is contacted by default.

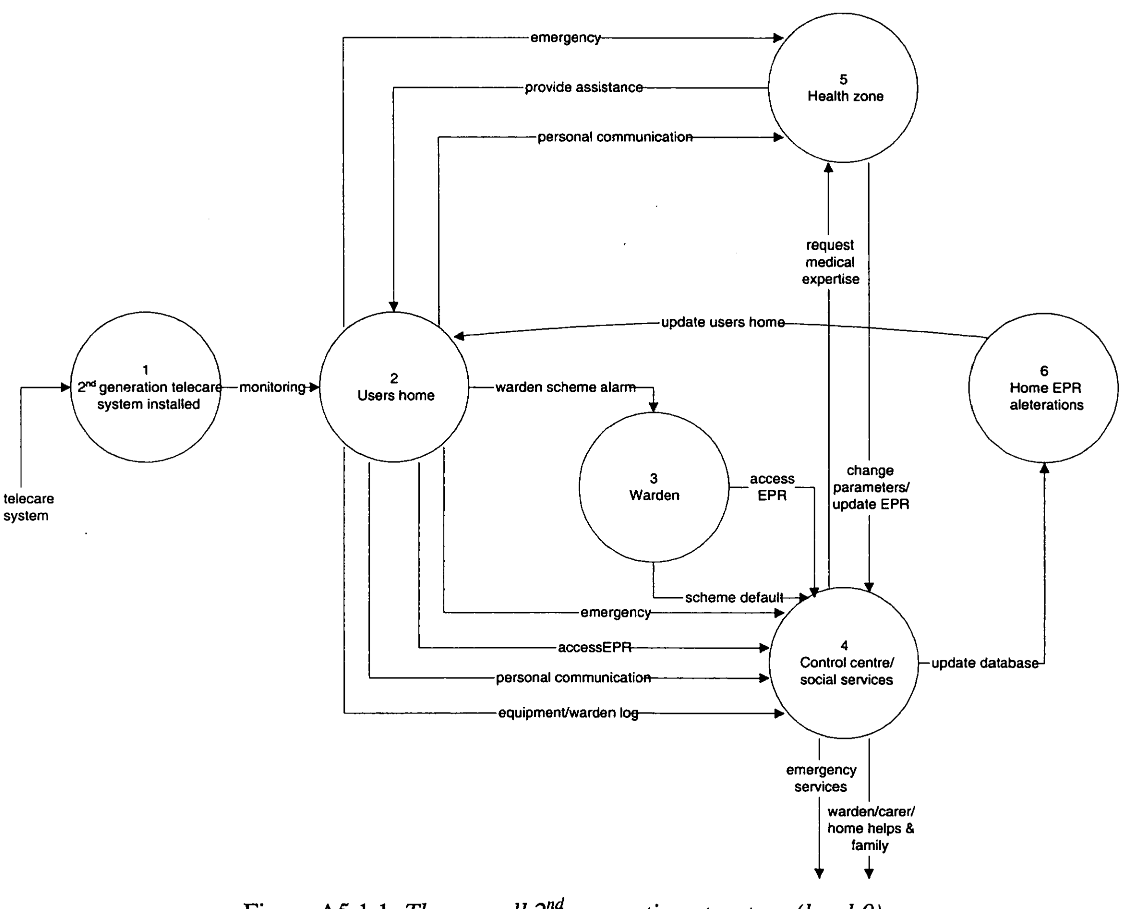



Figure A5.1.1: *The overall $2^{nd}$ generation structure (level 0)*

A significant enhancement is the improved information available in the system as every professional interaction is entered into the users EPR. In the current system identified in Chapter 4, when the warden provided assistance this information remained with the warden and was lost to other professionals.

However, Fig A5.1.1 reveals that this information is now entered into the users EPR and may therefore assist others.

If a users EPR is amended and the change impacts upon the users home equipment then the home must be updated with the relevant changes. Such a change may be a new GP surgery phone number, or a change in the drug regime for the drug dispenser. These changes are facilitated through process 6. Fig A5.1.1 indicates that process 6 is only accessible through the control centre and this is due to EPR's being stored here. The health zone access EPR's by connecting to the control centre, therefore ensuring that there is only once instance of each users details.

Each process defined in Fig A5.1.1 is developed in more detail below.

*Process 1: '2nd generation telecare system installed'*

Fig A5.1.2 indicates that the process of acquiring a 2nd generation telecare system is almost identical to the present system identified in Chapter 4. It would be anticipated that more users would acquire the 2nd generation telecare system through hospital discharge but the process would not change. The only deviation is with the assessment, the purpose of the assessment in the present system is to decide whether the potential user should receive a community alarm or not. In the 2nd generation system this fundamental decision must be made, but if a user is to benefit from a telecare system, the level and any particular modules that would be beneficial, such as water detection or a drug dispenser, must be identified.

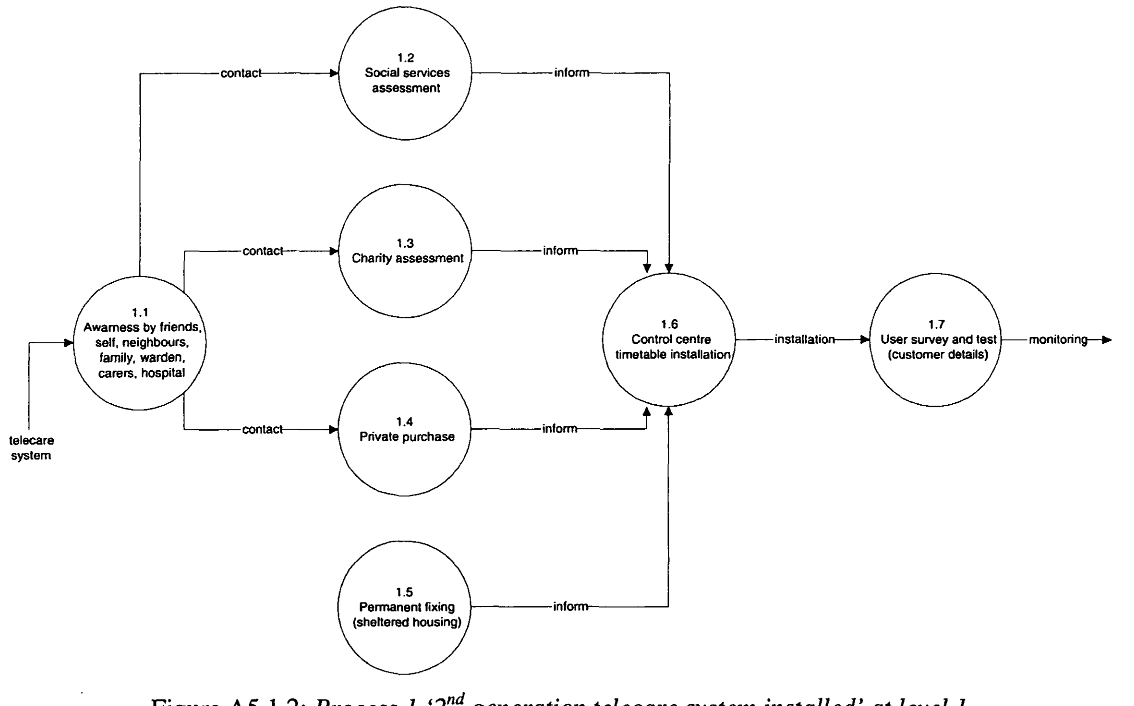



Figure A5.1.2: *Process 1 '2nd generation telecare system installed' at level 1*

In the present system any long-term illnesses or medication information was obtained during a user survey and the survey is still performed in the 2nd generation system. However, the data is entered directly into the EPR as the information is gathered in the users home, therefore simplifying the process. The amount of data gathered is also reduced as the 2nd generation system generates considerable amounts of data itself and therefore is not reliant on user information that may be inaccurate or become dated. When the system has been successfully installed monitoring can commence.

*Process 2: 'Users home'*

Process 2 is developed further in Fig A5.1.3. The 'provide assistance' input originates from the health zone and entails advice and assistance. Part of the assistance could be in the form of a virtual consultation and process 2.1 must identify when a videoconferencing call is received from the GP or virtual neighbourhood and facilitate this. Videoconferencing can also be an output from the home when the user wishes to communicate with others on the virtual neighbourhood. When the EPR at the control centre is amended and changes impact upon the home, process 2.1 must recognise and implement the changes. Appropriate security must be in place to ensure that the control centre gave authority for the changes.

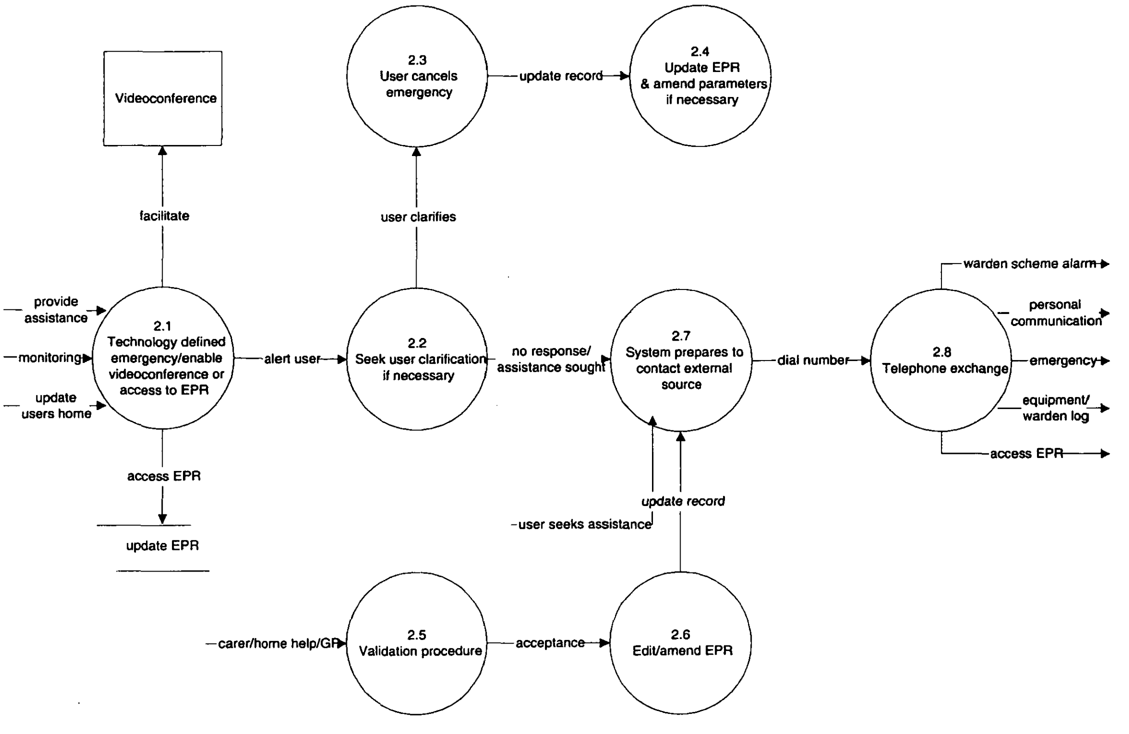



Figure A5.1.3: *Process 2 'Users home' at level 1*

Whichever level of system a user has installed in their home, it will continuously monitor parameters for situations that require external assistance. If process 2.1 considers a situation requires further investigation then conformation can be sought from the user in process 2.2. If no assistance is required then this should be recorded in the EPR in process 2.4 and arrangements made to reduce the possibility of the same 'false' alarm occurring again.

As previously indicated when carers and home helps perform their duties in the users home a record should be kept of the actual tasks they completed and the time they arrive and depart. The EPR at the control centre can then be updated and the safety of staff monitored. In a similar fashion GP's can edit the EPR to change parameters during a home visit. However, in order to access the EPR the professional involved should be validated in process 2.5. This ensures that the professional concerned has access to the information and also identifies which sections of data can be viewed and edited. The requirements of the GP is notably different when compared to a carer and thus information that does not assist a professional should be kept confidential. Process 2.6 allows amendments and data to be added.

Process 2.7 enables contact to be made with external entities and is accessed either by the home based system defining an emergency, a request to access the control centre EPR, or the user initiates an alarm call with this being achieved in one of two ways:

1. Pendant or pullcord activation: The user activates an emergency alarm and the home based system had not recognised the user required assistance.
2. Information request: The user does not require urgent attention but requests information, for example a request for information on service charges or an enquiry on the whereabouts of a carer.

Process 2.7 will decide who to contact and act accordingly for example, if the medical monitoring module indicates that the GP should be informed process 2.7 will identify the telephone number of the surgery and organise the data in a suitable format for the surgery to understand. The alternative point of contact is the control centre who requires the nature of the call to be identified in the header of the call, thus ensuring the prioritising of calls. Process 2.8 will connect and send the appropriate information.

*Process 3: 'Warden'*

The 2$^{nd}$ generation telecare system does not alter the way in which the warden works. However, it is suggested that when assistance has been provided or an alarm responded to, the reason for the alarm and any action taken be entered into the users EPR. As such processes 2.5 to 2.8 identified in Fig A5.1.3 also occur for the warden who will access the EPR and provide information after it has been confirmed they have authority to access the record.

*Process 4: 'Control centre/social services'*

Process 4 is developed in Fig A5.1.4, where it can be seen that process 4.1 will monitor incoming calls and respond accordingly. Any calls that require an operator will be continually reviewed so that those calls with the greatest priority are answered first. The different call types which process 4.1 must identify are:

*Equipment log*: Every time a users EPR is modified in the home, or at defined times if this does not occur, the control centre will be contacted and the user EPR updated with the most accurate information. If a users EPR is not updated within the defined time process 4.1 identifies the user and generates a fault report from which the engineers can arrange access and maintain the equipment.

*Warden log*: In a similar fashion to the present system when wardens log on and off duty this is again recorded for accountability purposes in process 4.4.

*Request to access EPR*: The GP or hospital can access the EPR and having viewed the information or amended any fields the changes made are stored. This is performed by process 4.1 and if the changes affect the home, for example changes in the drug regime then the EPR stored at the home can be changed in process 6.

The types of call identified above all occur without operator involvement, while those identified below will necessitate the assistance of the operator.

*Emergency action*: The fire, security and medical monitoring module can result in an immediate call for assistance from the emergency services. Due to the current legislative arrangements such calls cannot go directly to these services without the operator ensuring that their presence is required. This check is made in process 4.5 and the appropriate service is contacted in process 4.6. Details of the action taken are relayed to the user and the call is closed down. This entails entering what action was taken and any further details that may be appropriate. Once the call is closed the operator can answer any further calls that may be waiting a response.

*Advice and assistance*: Process 4.1 will maintain a list of the next call to answer and the operator can only respond to the call with the highest priority. There are a variety of types of call, user telephone call, incontinence etc. but whatever the type of call the processes are the same. The operator will firstly identify the reason for the call in process 4.7 and then decide on the appropriate action to take. If no assistance is required from other services then the call can be answered and closed. While where additional services are required such as, the GP, out-of-hours centre, or responder, then these can be contacted in process 4.9 and the call closed in process 4.8.

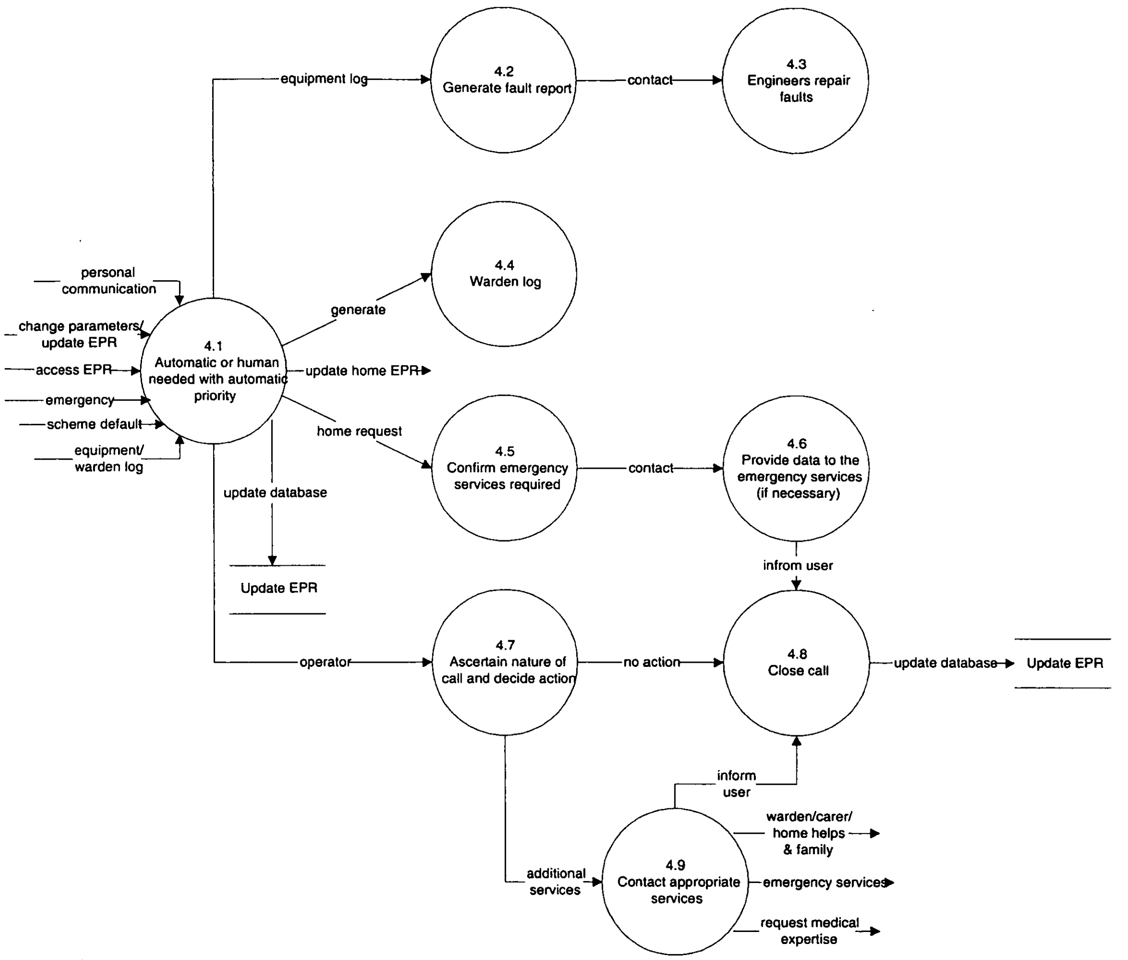



Figure A5.1.4: *Process 4 'Control centre/social services' at level 1*

*Process 5: 'Health zone'*

The health zone consists of the GP surgery and hospital. The GP surgery process is developed in Fig A5.1.5 and when contacted the system must recognise if the call originates from the medical monitoring module or the user. If the call contains data then this must be analysed by the GP, however if the GP fails to analyse the data prior to leaving the surgery then process 5.2 must gather together any calls that require immediate medical attention and contact the control centre. Non critical calls are stored and the GP can respond to these when they are next available; the user should be informed of the current position.

When the GP analyses the data from the medical monitoring module it is recognised that not all of the users medical history will be available on the EPR. The GP may have there own computerised or paper based information system that can be used to provide additional information. Process 5.2 indicates that having analysed the data the GP can:

1. Decide that no action needs to be taken. The user should be informed.
2. Alter the medical monitoring parameters in the users home. The user should be informed of the action taken.
3. Request a consultation, either virtual or physical.
4. Admit the user to hospital.

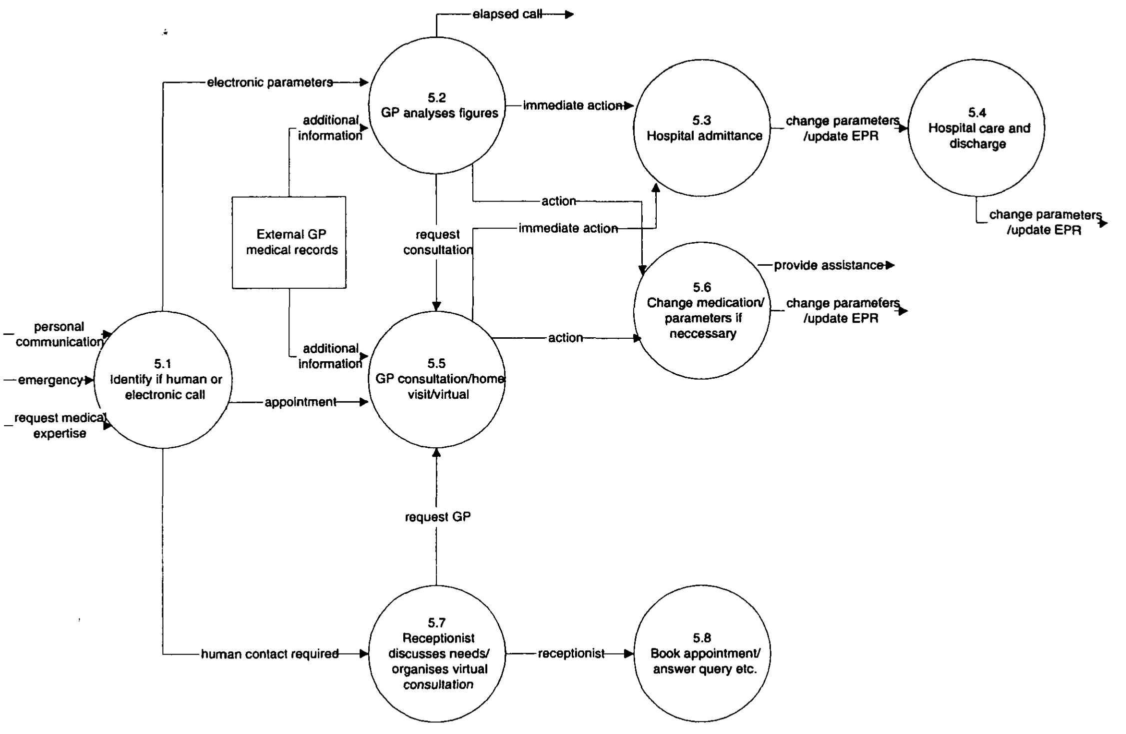



Figure A5.1.5: *Process 5 'Health zone' at level 1*

Process 5.5 suggests the use of virtual consultations and these can be achieved as a direct result of the users medical monitoring module, or an organised appointment replacing a home visit or previously surgery based consultation. To enable the efficient use of the GP's time these consultations are organised by the receptionist in processes 5.7 and 5.8.

In addition to the medical monitoring module as an input to Process 5.1 the user may contact the surgery directly. The purpose of this is to arrange a consultation or to seek advice on medication for example. The user may perform this through the video conferencing equipment or by a standard telephone. The receptionist will respond to such calls and should do so in the same communication format if possible.

Process 5.3 indicates hospital admittance and for every user admitted to hospital the EPR can be analysed and the appropriate personal and medical information easily obtained. Appropriate security procedures should be in place and the EPR should be updated so as to indicate that the user has been admitted. Any care arrangements can then be cancelled while the user is in hospital. When the user is discharged in process 5.4 the care arrangements can be reinstated along with any changes in the care plan that may have been arranged. The discharge summary can also be entered into the EPR, while the action undertaken by the hospital during the stay will be entered into the EPR and immediately available to the GP.

Arrangements for nurse virtual consultations are performed outside of the GP surgery and arranged independently by the nurse. Details of the consultation however are entered into the EPR so a record can be kept and available to the GP and hospital.

*Process 6: 'Home EPR alterations'*

Changes to the drug regime, control centre or surgery telephone numbers etc. requires the users home EPR to be modified. Fig A5.1.6 indicates the process required and begins with conformation that the caller has the authority to access the EPR and modify fields. If authority is not given then process 6.1 should terminate the call informing the person who tried to modify the EPR that they were unsuccessful.

Having successfully gained access to the EPR the appropriate fields can be updated along with any modules that require changes. The affect of the changes and the individual who made them can be stored on the EPR and the call terminated. Conformation of the successful update should be provided to the caller.

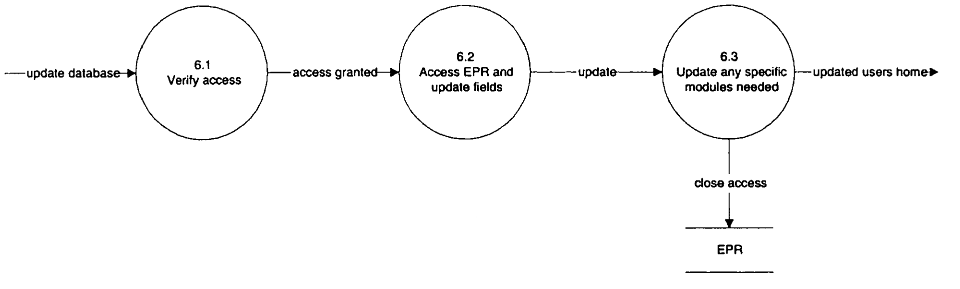



Figure A5.1.6: *Process 5 'Home EPR alterations' at level 1*

# Appendix A5.2

## 3rd Generation Functional Requirements

**Function**

- Support independent living.
- Provide 24-hour medical monitoring where required.
- Enable early diagnosis of medical problems.
- Enable early diagnosis of physical problems.
- Enhance and interact with the 2nd generation equipment.
- Provide greater relevant information for those who require it.
- Provide diagnosis support.

**Major System Elements**

Components of 2nd generation system.
Lifestyle monitoring.
Security.
Weight detection.
Drug dispenser.
Medical band.
Distance support.
Intelligent Home Alarm System (IHAS).
User control.
Virtual GP/neighbourhood.
GP surgery.
Pharmacist.
EPR.
Control centre.
Hospital Health Services.

**Module** **Components of 2nd generation system.**

Process

Unless specifically discussed below all of the modules suggested in the 2nd generation system are available in the 3rd generation system and work in the same way. Improvements in accuracy, size or speed are expected to take place but the basic mode of operation is the same as that previously identified.

**Module** **Lifestyle monitoring.**

Process

In addition to the functions performed by this module in the 2nd generation system, performance is improved and greater amounts of data are obtained. The, 3rd generation system will allow two or more users to be monitored individually without each user having to wear a device that differentiates between various users. Instead of general movement being detected, the actual movement of each user is now monitored. This enables a greater degree of accuracy and also enables the distance walked to be calculated and analysed. The information should be entered in the EPR. If the user leaves their home then this should be noted and any analysis of trends on that day ignored. This is because the user may walk more if for example they are putting their shopping away, or less due to being tired after going for a walk, the information is not accurate and should therefore be ignored. If the distance walked shows a continued decline then the GP should be informed.

A users gait (distance of step when walking[192]) should be measured in at least one room in the house. For each user in the home the gait reading should be stored in the EPR so that the average gait for that day is recorded and a list of recent days compiled. If a user changes to a three pole gait, i.e. is using a walking stick, then this must be recognised and readings recorded and analysed when the user is walking with or without the walking aid.

If the home contains stairs then the number of times the user climbs the stairs should be recorded in the EPR, and any significant change investigated. Measuring the time it takes to climb the stairs is not considered as users may be doing exercises on the stairs, stop because the telephone rings, or go slowly because they are cleaning. All these would greatly affect the accuracy of such monitoring and is not therefore considered.

In order to reduce the number of false alarms when it would have been expected a user had gone to bed, but they are watching a rescheduled favourite television programme; the module should have access to the real-time television listings and recognise that an alarm should not be generated in such circumstances. The module must recognise that the television is turned on and that the user is in the room where the television is located.

The module should quantify the actual amount of time users spend sleeping. It must differentiate between a user in bed reading, resting or sleeping. The EPR should maintain a list of the amount of time users spend sleeping and deviations can be investigated as can changes in the times users go to sleep.

Inputs User activity. Time (system clock).

Outputs EPR. IHAS. Control centre. GP surgery for changes in the gait measurement.

Major error Unable to measure gait. Unable to distinguish between visitors and different users in the same room. Unable to access the EPR or communicate with the IHAS.

Exception The module must be given a period of time to resolve itself. If after this time the fault still exists the user should be informed through the IHAS. The user should only be informed if it is recognised that the user is not asleep in bed, that guests are not present and that at least one able user is in the home (i.e. if the user is severely disabled the system should only be informed when another adult is present). If the fault continues to exist a fault report should be generated, the control centre contacted and the user informed.

Current status Acoustic signature and video camera's could both be possibilities, however developments would be necessary to meet all of the requirements. Gait analysis has been achieved by wearing a device above the knee[193], but acceptance would be questionable. Force plates on the floor and camera systems[192] can be used but cost could be inhibiting on a large scale.

**Module** **Security.**

In the 2nd generation system access to the EPR from the users home was only allowed for the user, carer, home help, nurse and GP. Access should now be increased to any professional interacting with the user in their home. Appropriate security must be in place to ensure authorised access is granted and only the information relevant to the professional concerned can be viewed and edited.

If no one is in the home and the front/back door is used to gain access then verification of that person should be sought. If it is a user or they have authority to be in the home then this should be recognised by the lifestyle monitoring module and no action taken. However, if the person is not recognised then the security module must seek conformation that they have authority to be in the home. Having used iris recognition, smart card or a pin number for example, these details should be validated and if the person is not recognised then the control centre should be contacted so the operator can assist the person or contact the police.

Where cameras are used either on the front door or within the home then a picture of the intruder should be taken and provided to the police.

Where someone without authorisation has tried to view a users EPR then the control centre should be informed. If the problem persists they may require assistance from the police to investigate the matter.

Inputs Movement in the home. Use of security equipment, iris recognition etc.

Outputs Control centre.

Major error Unable to communicate with IHAS. Unable to detect movement and recognise users or intruders. Unable to verify visitors with iris recognition etc. Unable to provide the control centre with a picture of the intruder.

Exception The exception response is the same as that identified for the lifestyle monitoring module.

Current status The 2nd generation security module explained that the equipment needed to meet these requirements exists. Nevertheless, the individual elements would need to be brought together.

| | |
|---|---|
| **Module** | **Weight detection.** |
| Process | At approximately the same time each day a users weight should be measured and recorded in the EPR. If the user is not in a position to be weighed at the normal time, then no reading should be taken for that date. If the weight, as defined by a GP, changes significantly within a short time scale then the user should be informed through the IHAS that the GP will be contacted. The IHAS should only inform the user if guests are not present and the user is not asleep in bed. Cancellation of the call should be provided. |
| Inputs | User. Time (system clock). |
| Outputs | EPR. IHAS. Ultimately the GP. |
| Major error | Unable to successfully recognise a user and measure their weight. Unable to communicate with the IHAS and ultimately the GP. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | Weight detection through pressure sensors or force plates is available and could be used to meet the requirements of this module. Another possibility would be to measure weight when the user is sitting on the toilet seat and is currently being investigated in Japan[429]. |

| | |
|---|---|
| **Module** | **Drug dispenser.** |
| | Reminders are necessary if the user forgets to take their medication and should only occur when it is recognised that the actual user is in the home and guests are not present. If however the time medication is taken is of a critical nature, then a reminder should be given irrespective of the presence of guests.<br><br>The EPR should indicate if a repeat prescription is or may be required and by determining how many tablets or how much syrup was initially installed and the amount dispensed, an automatic alert can be sent to the GP prior to medication running out. Tablets and syrups should be stored in a standard sized cartridge provided by the pharmacist which store data on what tablet/syrup is in the cartridge, when to dispense, if the time of dispensing is critical, in what quantities to dispense, how many tablets/amount were originally stored in the cartridge and might a repeat prescription be required. When the cartridge is installed into the drug dispenser the EPR can be updated. |
| Inputs | User taking medication. Recognition of an installed cartridge. EPR. |
| Outputs | Dispensing of medication. EPR. Reminder to take medication. |
| Major error | Unable to dispense medication. Unable to communicate with IHAS and EPR. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | It would appear that no device currently exists that meets these requirements, however with the present state of technology an effective device could be produced. |

| | |
|---|---|
| **Module** | **Medical Band.** |
| Process | It is envisaged that the stand-alone medical monitoring unit will be developed to measure additional parameters with improved accuracy. An alternative option will be a medical band perhaps worn on the wrist or over the chest like a vest, which allows continuous monitoring 24 hours a day. In the EPR the GP will define the minimum users should wear the band and therefore users will be reminded through the IHAS if they fall below the requirements. Reminders taking place when the user is in the home without guests being present.<br><br>Where there are two or more users of the stand-alone equipment in the home only one device is required but it must distinguish between users. Users of the medical band require their own device, as monitoring may be required 24 hours a day for each user.<br><br>If a user is outside of defined parameters the IHAS should be informed. A call can then be automatically made to the GP or out-of-hours medical centre (if the alert is raised after surgery hours), assuming the user does not cancel the call. At approximately the same time each day the medical band should download the data it has gathered, showing the average, highest and lowest readings for |

each parameter. This information should be stored in the EPR. If however, the medical band detects a situation that may require immediate medical attention then the IHAS should be immediately informed. Where immediate medical attention is required the surgery or out-of-hours medical centre are contacted depending on the time of day. The module should also detect when the user may be suffering from minor illness and therefore enable friends and family to be contacted to provide support.

When outside of the home the medical band should only raise an alarm if immediate medical attention may be required, communicating through the distance support module.

Whenever the parameters being measured in the EPR are amended by the GP the IHAS should inform the medical band of the new parameters.

| | |
|---|---|
| Inputs | User. EPR amendments. |
| Outputs | IHAS or distance support. EPR. GP or control centre. |
| Major error | Unable to monitor medical parameters. Unable to communicate with the IHAS, distance support or EPR modules. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | No system is currently available although the intelligent vest[430] has been discussed and a medical band produced by IST[217] is being marketed in the UK by Vivatec[280]. IST suggests that it monitors the general physical activity of the wearer together with pulse rate and temperature[217] but there are no results from a large scale field trial[431] so it is unclear how successful this device actually is. Communication between the medical band and the distance support module can be achieved through Bluetooth[295] etc. |

**Module** **Distance support.**

Process: In addition to providing a secure and safe home environment consideration must also be given when users are outside of this environment. The distance support module will communicate with the medical band and contact the control centre when assistance is needed away from the home. This module will also allow the user to activate a call for assistance themselves and once activated the control centre will be contacted. The detection of falls is not required as the medical band may detect these, while passers by could provide assistance. A cancellation button is not provided to ensure that muggers cannot cancel a call for help.

Once activated full-duplex speech should be provided and the location of the user indicated on the control centre operators screen. Mobile wardens, carers, police or ambulance can then be contacted and assistance provided.

The module should continuously test itself so that it is known if there is a malfunction. If there is then the IHAS should be informed when the equipment is in the home. The IHAS can then communicate with the user to alleviate the problem defaulting to the control centre if the problem cannot be resolved.

| | |
|---|---|
| Inputs | User activation. Medical band. |
| Outputs | Control centre. IHAS if there is a malfunction. |
| Major error | Unable to activate a user call for assistance or communicate with the medical band. Unable to contact the control centre when required and facilitate full-duplex communication. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | SAFE 21, Social Alarms For Europe in the 21$^{st}$ century[223], the Universities of Northumbria, Dundee and Bristol[432] are developing a mobile phone that will contact a control centre when an emergency button is pressed, using Global Positioning System (GPS) to provide the position of the caller. Communicating with the medical band is not foreseen as a problem but the physical size of the equipment may be. |

| | |
|---|---|
| **Module** | **Intelligent Home Alarm System (IHAS).** |
| Process | In addition to the functions of the IHAS in the 2nd generation system, this generation has an additional safety element. If the user activates a 'communication' button (to ensure conversation with the IHAS and not other people in the home) then speech can be used to inform the IHAS of activities i.e. Mrs A may say "I'm going to Mr X's, I should be back by 11." The IHAS should interpret this and repeat the instruction back to Mrs A in a meaningful way for verification, i.e. "Hope you have a nice time at Mr X's, I'll anticipate your return at 11pm." The IHAS should estimate if 11 refers to am or pm according to the time of day the instruction was given. The IHAS should also ensure that it has the telephone number of Mr X, asking the user for it if it necessary. If there are two or more Mr X's then conformation should be sought that the IHAS is referring to the correct Mr X. Through use of the lifestyle monitoring module the IHAS must recognise when the user leaves and if they do not ignore the instruction. Automatic speech recognition should be in the users native tongue.<br><br>If the user does not return some time after the stated time (11pm in this example) then the EPR should be accessed for the telephone number of Mr X and contact made. Using automatic speech recognition Mr X can then inform the IHAS that Mrs A has left, never arrived, or is still there. If Mrs A has left then the IHAS should give further time for Mrs A to return, if she fails to return then the control centre should be informed. If Mrs A never arrived then the IHAS should inform the control centre immediately with the time Mrs A left and details of the intended destination. If Mrs A is still at Mr X's home then additional time should be given before contacting Mr X again.<br><br>When the IHAS contacts Mr X the EPR should indicate the preferred language for Mr X, however if this is not present then the IHAS should use the language used by Mrs A. If this is not English then English should be used repeating each sentence spoken.<br><br>Some users may find this feature a comfort, while others may find it intrusive, however the user decides whether to use this feature.<br><br>For those people who suffer from burglaries and attacks where the telephone line is cut then the use of the mobile phone network should be available. Therefore, if any emergency is detected and a call cannot be made because a dial tone cannot be gained then the IHAS can switch to the mobile phone network.<br><br>The IHAS also provides the capability to contact some services directly as opposed to defaulting to the control centre. For example, calls requiring immediate medical attention that occur outside of surgery hours are directed to the out-of-hours medical centre. Responders and family can also be contacted directly as opposed to being routed throughout the control centre if the IHAS considers contact would be beneficial, for example when the medical band indicates the user may be suffering from the flue the IHAS can contact the family and inform them through speech synthesis. It is envisaged that calls to the emergency services will still require routing through the control centre due to the legislative position rather than any technical deficiency. |
| Inputs | Communication with every home based module. Incoming voice/virtual communication including videoconferencing and automatic speech recognition of a users whereabouts (Mr X in the example above). Cancellation of a possible emergency call. |
| Outputs | Contact GP, control centre, family or friend, etc. Recorded/generated speech messages to users/visual communication for a user with hearing difficulties. |
| Major error | Unable to cancel an emergency call. Unable to communicate with the user, other modules, or external organisations such as the control centre and GP surgery. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | Discrete or single word speech recognition through the telephone system has proved successful in trails. Continuous, natural speech is currently not possible through the telephone system[433]. For |

large vocabularies the accuracy of automatic speech recognition is unlikely to be above 87% at present[434]. As such, this may not be sufficient for speech communication with the IHAS. The accuracy for users with speech disorders is likely to reduce accuracy further as speech is often weak, slow or imprecise[435].

The use of speech synthesis with telephone messages is available and has proved to be successful[108].

| | |
|---|---|
| **Module** | **User control.** |
| Process | Because of the lifestyle monitoring module the 2nd generation system did not require pullcords or the user to wear a pendant, however due to the time it took the lifestyle monitoring module to identify a situation, the pullcord or pendant activation was still required to obtain assistance quickly. This 3rd generation system removes the requirement for the pullcord and pendant as the user can choose to activate a call for assistance through speech. By using a command word, the IHAS can be used to recognise that the user wishes to activate an alarm. Conformation can be sought and if necessary the control centre, GP etc. contacted.<br><br>The command word should be a word or phrase that is unlikely to be used in general conversation such as 'wake up telecare system'. Through speech the user can then request the assistance of the control centre.<br><br>For users with speech disorders, the automatic speech recognition system may not be successful and the pullcords or pendant may still be required. |
| Inputs | User activation of command word. |
| Outputs | IHAS. |
| Major error | Unable to detect or recognise the command word. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | Requires automatic speech recognition and was discussed under the IHAS module. |

| | |
|---|---|
| **Module** | **Virtual GP/neighbourhood.** |
| Process | The concept introduced in the 2nd generation system is not altered in terms of its functions but operation is improved in the 3rd generation system in two ways.<br><br>Video conferencing on a 1-to-1 basis is replaced with video conferencing capable of accepting multiple users at the same time. Anyone can introduce people to the group by dialling their telephone number. If a user is videoconferencing and someone else contacts them their details should be displayed on the screen. The user can then break off their current call and communicate with the new caller if they so wish.<br><br>The ease and quality of communication is also improved so that the user does not have to use a microphone positioned near to their mouth. Instead speech is detected anywhere in the room and any background noise removed.<br><br>An additional piece of data is also gathered, the number of times the video camera is used. If a user consistently uses the virtual neighbourhood and interacts with the same people, then if over time the number of calls too and received from these people declines then this should be stored on the EPR. A gradual decline may show signs of depression. If the telephone usage is not reduced over the same time period then this may indicate a lack of confidence in appearance. When a carer or the next assessment is performed then the reason for this can be investigated.<br><br>Through the virtual neighbourhood users should have access to physiotherapy and exercise schemes. |

For users near to the end of a physiotherapy course where it may be questionable whether or not they receive treatment, or users with similar conditions not requiring physical contact, physiotherapy can be given remotely. Clearly there will be many occasions where physical contact is required on a 1-to-1 basis and remote physiotherapy could not be used.

Small exercise groups through videoconferencing also allow users to maintain their physical well being. For both physiotherapy and exercise schemes the EPR can record that a session took place and for physiotherapy a report made on any progress.

| | |
|---|---|
| Inputs | A call received/made by the IHAS. A call received whilst conferencing with others. Activation of the users video camera. |
| Outputs | Making a videoconferencing call. Physiotherapist records treatment in the users EPR. |
| Major error | Unable to contact users on the virtual neighbourhood ând display their image. Unable to detect speech and siphon out background noise. Unable to communicate with IHAS. Unable to capture and display an image of the user. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | Technically it is possible to achieve the requirements of this module if there is a suitably fast transmission speed into the users home. |

| | |
|---|---|
| **Module** | **GP surgery.** |
| Process | When the GP receives an electronic call from a users IHAS the medical information provided should be analysed and an expert system suggest the cause and suitable treatment. The GP can then view the information and decide on the appropriate treatment or request a consultation. When the GP prescribes a treatment if this differs to the expert system then the GP must explain the reason for the difference in the users EPR. The expert system will then verify that the medication prescribed does not have adverse reactions with any other drugs the user may already receive. If there are potential difficulties then the GP can be informed and the process repeated. |
| Inputs | User parameters outside of defined levels. EPR. Expert system. |
| Outputs | Inform GP and ultimately the user of any action taken. |
| Major error | Unable to access or analyse the EPR. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | An expert system for monitoring psychiatric treatment has been created. It identifies deviations from established practice standards (covering the evaluation, diagnosis and treatment of psychiatric disorders) and issues information alerts about these events[294]. It does not appear that an expert system that is up to date for general practice has been created. |

| | |
|---|---|
| **Module** | **Pharmacist.** |
| Process | When a prescription has been issued by the GP a central pharmacist database will be informed with the prescription and details of the user. For physical consultations a paper prescription can also be issued, for virtual consultations a paper prescription can be collected from the surgery if necessary although the majority of pharmacists should have access to the central pharmacist database and therefore the paper prescription is not required. |

When the user tries to obtain their medication the pharmacist can validate the user through the security feature of the EPR, i.e. perhaps by using the iris or thumb print recognition. If someone else is seeking to obtain the medication on the users behalf then they should also use the recognition equipment so a record can be kept of the individual who obtained the medication. Upon the medication being given the users EPR should be updated with the time and date of this action. If it is discovered that the user did not receive the medication, perhaps because the cartridge was not installed in the drug dispenser, then the details of the person who received the medication can be kept. Whenever this person tries to receive medication from any pharmacist again the recognition equipment will be able to identify them and indicate that this individual took medication that a user never received. Action can then be taken to resolve the issue.

| | |
|---|---|
| | For users with mobility problems it may be advantageous for the medication to be delivered directly to the users home. |
| Inputs | GP prescription. Recognition of recipient of medication and comparison to ensure they have not previously taken medication that users never received. |
| Outputs | Medication. EPR. Detain recipient if previously a user did not receive their medication. |
| Major error | Unable to access the database of prescriptions. Unable to detect an individual who should not be given medication. Unable to update the EPR that medication has been given. Unable to detect that a user has not received medication after it has been dispensed by the pharmacist. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | No such system exists, technically the functions could be delivered but communication between the relevant agencies is likely to be a stumbling block. In Japan some postmen deliver and receive payment for medication[348]. |

| | |
|---|---|
| **Module** | **EPR.** |
| Process | The additional parameters introduced in the 3rd generation system should be stored in the same fashion as the EPR for the 2nd generation system, while it should also operate as previously identified. |
| Inputs | Amendments from all relevant home based modules. Amendments from the GP, social services, hospital and carers/home helps and all other professionals interacting with the user in their home. |
| Outputs | Secure accurate information for the IHAS. Social services, GP, out-of-hours medical centre, hospital and other professionals interacting with the user. |
| Major error | Unable to update/view any field. Unable to protect what each professional (carer, GP etc.) is allowed to view/update. |
| Exception | The exception response is the same as that identified for the lifestyle monitoring module. |
| Current status | Enhancements to the database would be trivial if the database was originally set up to anticipate additional fields and viewpoints. |

**Module** **Control centre.**

Process

If a user does not return home after the time indicated by the IHAS then the control centre will be contacted and the operator should contact a family member, responder or warden. The action taken should be recorded and if the user cannot be found a defined time latter then the operator should be informed again and the police contacted. The priority of the queuing system at the control centre should be:

1. Fire.
2. Gas.
3. Security.
4. Distance support.
5. Falls.
6. Lifestyle monitoring.
7. User activated emergency call.
8. Incontinence.
9. User telephone call.
10. User information enquiry.
11. Carer/home help failed to log on at the expected time.
12. User not returned home.
13. GP enquiry for EPR.
14. Hospital access to EPR.
15. Warden/carer log.
16. Failure to access the users home EPR*.

* The control centre is contacted when someone has tried to access the home EPR but does not have authority to do so. It may be necessary to investigate who tried to gain access.

The control centre operator and caller should be assisted with language support so that non-English speech is translated. Therefore, if a user spoke Indian, this module would translate the Indian into English for the operator and repeat the process for the caller, so they hear the operator in their own language.

As part of a contingency plan if one control centre is busy, perhaps due to a local fire or technical problem, a percentage of the calls should be re-routed to other control centres if they have spare capacity.

When the computer system at the control centre is not being utilised fully an expert system should interrogate the medical component of each clients EPR and analyse the medication people are on. If situations arise where medication has been repeated an unwise number of times without consultation or medicines have side effects which could be minimised with new drugs a list (with a maximum defined, so that doctors are not overwhelmed) should be compiled for each GP. If the GP does not access the record within a few days then the control centre should be informed to take further action.

The expert system must also regularly analyse each users EPR and estimate the probability of a fall. The distance walked in the home, gait measurements, number of times a user climbs the stairs, and the detection of falls can be added to other parameters such as the ADL score, gender, cognition, medical history, and vision[436] to indicate which users may experience a fall. Intervention can then be made with education and exercise or hip protectors.

Inputs — EPR. Manual enquiries, emergency calls from the home. Warden/carer or other professional logging.

Outputs — Inform warden, carer/home help, family, key holder, emergency services or GP. Generate a fault report for engineers.

Major error — Unable to access EPR. Unable to receive/make telephone calls. Unable to analyse EPR's. Unable to analyse records with the expert system.

Exception — The module must be given a period of time to resolve itself, if after this time the fault still exists then the operators should be informed and a parallel (backup) system automatically activated, defaulting to a separate control centre if the problem is significant and persists.

Current status — Call handling is available but the expert systems are not. Birmingham City Council has experimented with a language translation system but has not completed the project[240]. It is unlikely that successful systems will be available until voice recognition becomes more accurate.

**Module** — **Hospital Health Services.**

Process — Automatically suspend services when a user is admitted to hospital and inform the control centre carer schedule prior to the anticipated discharge. In essence this module does not change, health care is provided when the community cannot provide the necessary support and attention, and continues in the hospital until the user can 'safely' re-enter the community.

Inputs — User. EPR.

Outputs — Contact family/friends. Halt/resume care package. Update the EPR with discharge summary and anticipated discharge date.

Major error — Unable to access the EPR.

Exception — The exception response is the same as that identified for the lifestyle monitoring module.

Current status — Available.

# Appendix A5.3

## 3rd Generation Data Flow Diagrams

The fundamental change to the telecare system was introduced in the 2nd generation system, this 3rd generation system enhances the abilities of the system but the communication within the system does not significantly alter. Fig A5.3.1 indicates that the process begins with the installation of the telecare system and once successfully completed monitoring of the user(s) commences. This monitoring continues until the users home identifies a situation where assistance may be required in process 2. Verification that assistance is actually required is sought in the majority of cases and the warden, control centre, health zone or responder are contacted to provide assistance.

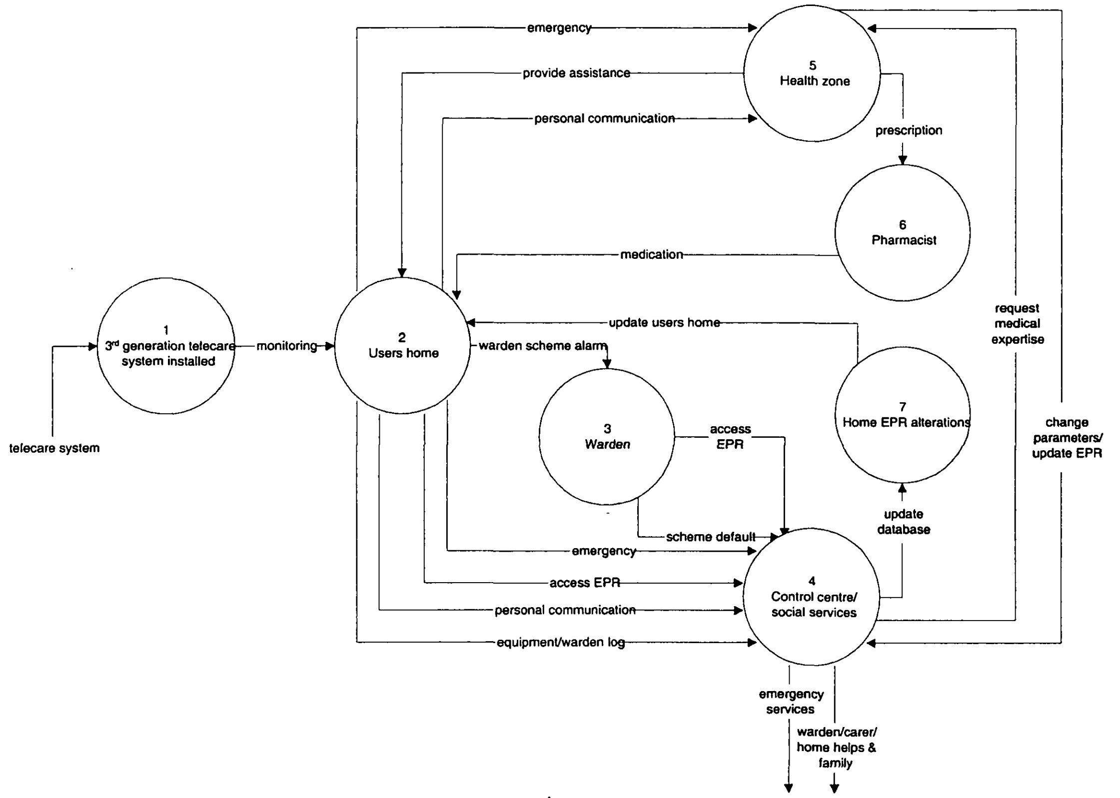



Figure A5.3.1: *The overall 3rd generation structure (level 0)*

The warden records their interactions with users in process 3, while the control centre in process 4 provides support to the user and facilitates assistance from other services typically the emergency services and the health service.

The health zone in process 5 does not significantly change its operation from the 2nd generation system, although a new output from this process is the electronic prescription. This allows virtual consultations to be performed without requiring the user to visit the surgery to obtain the prescription. Any medication can then be provided either by the user or someone on their behalf visiting the surgery, or by the medication being sent to their home directly. Process 7 indicates that the users home EPR is updated to reflect changes in the drug regime, or other modules. In order for the health zone to access the EPR this is again enabled through the control centre.

*Process 1: '3rd generation telecare system installed'*

The process does not significantly alter from that defined in Appendix A5.1. The process still includes defining which modules each user requires and then installing them. Although the equipment is different the actual process does not change.

*Process 2: 'Users home'*

In comparison to the 2nd generation system represented in Fig A5.1.3 the 3rd generation system works in the same way. Irrespective of what is actually monitored the processes are the same. The only differences being that videoconferencing now includes physiotherapy and exercise schemes, and that process 2.7 can contact a responder or family member directly without being routed through the control centre.

*Process 3: 'Warden'*

This process is the same as the 2nd generation system; when the warden provides assistance the actions are recorded in the users EPR.

*Process 4: 'Control centre/social services'*

Only one change is apparent when compared to the 2nd generation system. Through the use of an expert system the control centre will regularly analyse each users EPR and for example, ensure that medication has not been repeated an unwise number of times. If this occurs the GP is informed with and a suitable course of action. The GP can then respond and provide the support required.

The control centre is also contacted when someone has tried to access the home EPR but does not have authority to do so. It may be necessary to investigate who tried to gain access.

*Process 5: 'Health zone'*

The process identified in Fig A5.1.5 does not alter significantly in the 3rd generation system. The 2nd generation system included external GP records that aided in consultation but these are now included in the EPR and available to the GP and hospital. Another enhancement is a list of users where the control centre's expert system suggests that the users details should be reviewed. The GP can then respond accordingly and change medication or request a consultation if necessary.

In the 2nd generation system as a consequence of a virtual consultation it was necessary for the user, or someone on their behalf, to obtain any prescriptions from the surgery and then obtain medication from the pharmacist. In this 3rd generation system the GP can prescribe medication electronically to a central pharmacist database who can then provide the medication.

*Process 6: 'Pharmacist'*

When a doctor prescribes medication both an electronic and paper prescription is provided. Fig A5.3.2 indicates the processes when an electronic prescription is provided. The pharmacist database is updated in process 6.1 with the medication required for that particular user. The users personal security details are also provided for example iris or thumb print.

Process 6.1 will also indicate which prescriptions are required to be delivered directly to the users home. The nearest or approved pharmacist in contacted and the medication dispatched to the user in process 6.2. The arrival of the medication is recorded and process 6.5 indicates that this is logged. Checks can then be made to ensure that users actually received the medication. For example, the date when the medication was provided in process 6.3 can be compared with the users EPR indicating when the cartridge was installed into the drug dispenser.

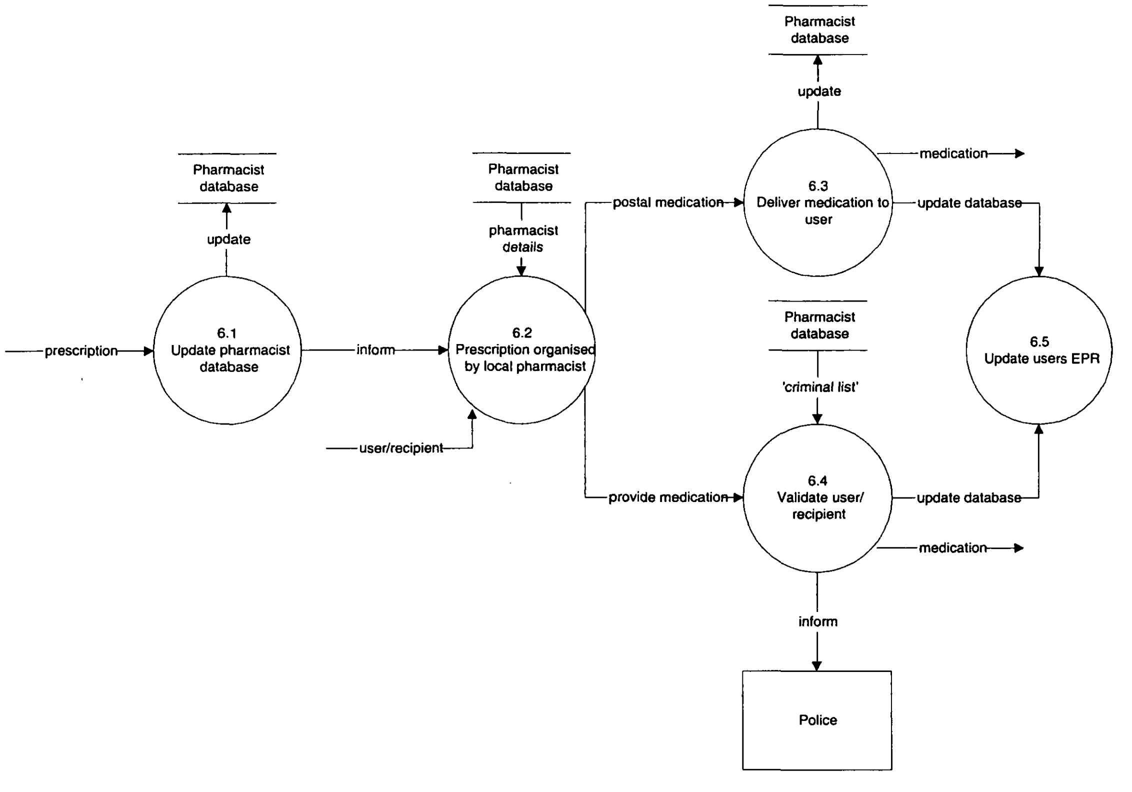



Figure A5.3.2: *Process 6 'Pharmacist' at level 1*

Process 6.2 indicates an alternative method of securing medication where the user, or someone on their behalf, physically obtains it from the pharmacist. For pharmacies without access to the pharmacist database the paper prescription will be required but for those with access, the security details of the recipient of the medication can be validated in process 6.4 and medication provided if appropriate. The users EPR is then updated, indicating when the medication was provided.

Due to the improved communication of the overall system it is possible to track medication and ensure that users receive the medication prescribed. If it becomes apparent that individuals are obtaining medication that users never receive, then because the security details (iris or thumb print) are obtained prior to the pharmacist giving the medication, the identity of these individuals is known. If an individual tries to obtain medication falsely again then they will be recognised by process 6.4 and the matter can be investigated or the police contacted if necessary.

*Process 7: 'Home EPR alterations'*

The only change when compared to the 2nd generation system identified in Fig A5.1.6, is that unsuccessful attempts to access the home EPR result in the control centre being informed. If necessary they can investigate who is trying to gain access without authority.

# Appendix A5.4

## 4th Generation Functional Requirements

| | | |
|---|---|---|
| **Function** | ▪ Support independent living.<br>▪ Support implanted medical sensors.<br>▪ Perform remote ADL assessment.<br>▪ Enable early diagnosis of physical and possible mental problems.<br>▪ Enhance and interact with the 2nd and 3rd generation equipment.<br>▪ Provide robotic assistance for tasks of daily living. | |
| **Major System Elements** | Components of 2nd and 3rd generation system.<br>Water detection.<br>Incontinence detection.<br>Robotic assistance.<br>Virtual GP/neighbourhood. | Implanted medical monitoring.<br>Intelligent Home Alarm System (IHAS).<br>User control.<br>Control centre. |

| | |
|---|---|
| **Module** | **Components of 2nd and 3rd generation system.** |
| Process | Unless specifically discussed below all of the modules suggested in the 2nd and 3rd generation systems are available in the 4th generation system and work in the same way. Improvements in accuracy, size or speed are expected to take place but the basic mode of operation is the same as that previously identified. |

| | |
|---|---|
| **Module** | **Water detection.** |
| Process | When a user has a bath, shower or uses the sink in the bathroom this activity should be recognised and stored in the EPR. In combination with the lifestyle monitoring module it should be recognised if a user is having a shower or bath or merely cleaning. Any noticeable change in washing etc. can therefore be recognised. It may be that getting into the bath is proving problematic and adaptations are needed. The module should also ensure that flooding does not occur.<br><br>The use of the toilet this should also be recorded in the users EPR. |
| Inputs | Detection of water and source, i.e. sink, shower, and bath. Use of toilet. |
| Outputs | EPR. IHAS and ultimately the control centre. |
| Major error | Unable to detect user. Unable to communicate with IHAS and lifestyle monitoring modules. Unable to detect water flow. |
| Exception | The module must be given a period of time to resolve itself. If after this time the fault still exists the user should be informed through the IHAS. The user should only be informed if it is recognised that the user is not asleep in bed, that guests are not present and that at least one able user is in the home (i.e. if the user is severely disabled the system should only be informed when another adult is present). If the fault continues to exist a fault report should be generated, the control centre contacted and the users informed. |
| Current status | A valve inside, or sensor attached, to the plumbing would be achievable or acoustic signature may be a possibility, as long as it could be distinguished whether the bath, shower or sink was being used. |

| | |
|---|---|
| **Module** | **Incontinence detection[34].** |
| Process | Through a non-intrusive method the detection on incontinence should be obtained. This module should recognise the onset of incontinence in the bedroom and main living room. If it becomes apparent that a user is beginning to be incontinent then they can be advised of appropriate exercise schemes that may be beneficial. They may also qualify for an assessment of their care package. |

[34] Older women who experience incontinence are two times more likely to enter nursing care, and for men the likelihood is trebled. Incontinence affects 5% of the adult population in the UK and it is estimated that associated health care costs are £1.4 billion per annum[437].

Once detected the system should update the users EPR and the control centre module indicate that a user should be consulted. Computer generated speech for such a personal matter may be intrusive and therefore a carer or occupational therapist may be better placed to respond in this instance.

Where two or more users live together and do not suffer from incontinence the module should be installed. The onset of incontinence can then be identified and assistance provided. When at least one user in the home uses incontinence pads the module should not be used (and withdrawn if appropriate) as the module will be unable to detect if another user in the home is beginning to be incontinent.

| | |
|---|---|
| Inputs | Presence of incontinence. |
| Outputs | EPR. |
| Major error | Unable to detect and quantify the presence of incontinence. Unable to communicate with the IHAS. |
| Exception | The exception response is the same as that identified for the water detection module. |
| Current status | A technology to meet this specific need does not appear to have been developed. However, research has enabled computer systems to smell[438] and may be a possibility. |

**Module** **Robotic assistance.**

Process: This module contains several different robots that each perform tasks to assist the user, namely:

1) Vacuum the home. Once activated the robot should vacuum the whole home, including any stairs that may be present. When completed the user should be informed through the IHAS. The robot should then return to its storing position where its batteries can be recharged.

   If during the cleaning process the battery source is low then the robot should return to its store and recharge its batteries. If mains supply is not available to re-charge the batteries then the user should be informed through the IHAS. When the vacuum cleaner needs emptying the user should be informed through the IHAS and information provided on how this is achieved. If the user is in receipt of a care package then this message is not necessary and the carer can be informed when they arrive. (The security module of the 3rd generation system will detect the arrival of the carer.)

2) Physical aid. The purpose of this aid is to remove items that have been accidentally dropped on the floor. Once the item has been gathered it should then be returned to the user without damaging it, and then return to its store and recharge its batteries as indicated for the first robotic aid.

   In order that the robot locates the correct objects it will be necessary for the user to issue verbal instructions in the users natural language. The robot must ensure that in the process of manoeuvring around the home that it does not damage furniture or cause the user(s) to stumble. When returning the object it must be effective for wheelchair and more able bodied users.

3) Cloths assistant. This robot should assist the user in dressing. Its functions include assisting with putting socks and shoes on, and providing assistance with buttons on shirts or blouses. In a similar fashion the robot must return to its store and recharge its batteries when not in use.

Whenever any of the robots are used this should be recorded in the users EPR.

| | |
|---|---|
| Inputs | User activation. |
| Outputs | Assistance from the robotic aid. Record of the event in the users EPR. |
| Major error | Unable to be activated. Unable to return to store or recharge batteries. Unable follow instructions. Unable to assist the user. |
| Exception | The exception response is the same as that identified for the water detection module. |
| Current | Commercial robotic vacuum cleaners are becoming apparent in the USA at a cost of $1,000 |

status (approximately, £600), however currently they are only able to operate on flat surfaces[439]. Robots to perform the other tasks identified do not appear to be currently available or researched. Various organisations are conducting research into walking robots that can manoeuvre themselves around the home[440, 441] or robotic lawnmowers in the garden[442, 443]. Having successfully developed these robots the knowledge could be applied to the applications defined above.

**Module** **Virtual GP/neighbourhood.**

Process It is anticipated that all users will have access to a suitably fast communications network and therefore be able to videoconference with other users. All users will also have access therefore to video consultations.

In addition to the previous functions the user should have access to a scanner so that they can obtain assistance when they receive post they cannot understand. They can then obtain assistance from members of the virtual neighbourhood, warden, family member or responder. If assistance cannot be obtained from these sources the control centre should be contacted and a time organised for assistance with a member of staff from social services. Particularly relevant when applying for state aid.

Inputs User. A call received/made by the IHAS. A call received whilst conferencing with others. Activation of the users video camera.

Outputs Scanned image. Making a videoconferencing call. Physiotherapist records treatment in the users EPR.

Major error Unable to scan the letter or form which is causing concern. Unable to contact users on the virtual neighbourhood. Unable to detect speech and siphon out background noise. Unable to communicate with IHAS. Unable to capture image of user.

Exception The exception response is the same as that identified for the water detection module.

Current status Scanning equipment is already commercially available although consideration to usability may be required to ensure that users can operate the equipment successfully.

**Module** **Implanted medical monitoring.**

Process As a replacement for the medical band, sensors are to be placed under the skin to measure the users vital signs. These implanted sensors have the same function as the medical band but allow 24-hour monitoring without the user having to wear a bracelet or vest.

One of the sensors should measure the body temperature and therefore the temperature analysis module introduced in the 2nd generation system is not required as the body temperature is more reliable in detecting the onset of hypothermia.

In addition for diabetics[35] a sensor should continuously monitor the users blood glucose levels and release insulin when necessary.

The 2nd and 3rd generation medical modules are available as an alternative to implanted sensors for those users where such monitoring is not necessary or the user declines implanted sensors.

Inputs Medical sensors. Changes in parameters.

Outputs IHAS or distance support modules. Ultimately the GP surgery or out-of-hours medical centre.

Major error Unable to monitor the users vital signs. Unable to communicate with the IHAS or distance support modules. Sensors rejected by the body as muscles and tissue grow over the sensor and crush it. Sensors provide irritation to the body or make the user unwell.

Exception The exception response is the same as that identified for the water detection module.

Current status Several million 'injectable computers' consisting of a chip, power generator, transmitter and receiver were created in 1998 by companies such as Datamars in Switzerland[444]. It has been suggested that

35 It has been suggested that in the UK 1 in 8 people over the age of 65 have diabetes[347].

implanted sensors will be in widespread use by 2010[141].

| | |
|---|---|
| **Module** | **Intelligent Home Alarm System (IHAS).** |
| Process | The only added function to the 4th generation system is that having recognised that there is a fire the fire brigade is contacted directly. |
| Inputs | As defined in the 3rd generation system. |
| Outputs | As defined in the 3rd generation system. |
| Major error | As defined in the 3rd generation system. |
| Exception | As defined in the 3rd generation system. |
| Current status | As defined in the 3rd generation system. |

| | |
|---|---|
| **Module** | **User control.** |
| Process | The 3rd generation system removed the requirement for a pendant or pullcord, using automatic speech recognition as an alternative. However, for users with speech disorders such a possibility may have been ineffective. Based on the suggestion of Boothroyd[311] that mind control will be available by 2010, mind control is expected to be an alternative in the 4th generation system. Due to the likely costs it is envisaged that this functionality will be reserved to users who cannot use automatic speech recognition. |
| Inputs | Users thought. |
| Outputs | All actions the system is capable of. For example, contacting the control centre or GP, cancelling a call to the GP. |
| Major error | Unable to detect the users wishes. Performing actions that the user did not intend. |
| Exception | The exception response is the same as that identified for the water detection module. |
| Current status | Controlling a switch by the mind is already possible and it has been suggested by Boothroyd that such systems will be common place by 2010[311]. |

| | |
|---|---|
| **Module** | **Control centre.** |
| Process | In addition to the functions performed by the control centre expert system in the 3rd generation system it must also perform ADL assessments. The data required for remote assessments can be acquired on a daily basis and whenever a users EPR is updated at the control centre the assessment can be performed. Where the expert system suggests intervention would be beneficial, social services should be informed and a re-assessment performed. If the suggested intervention is not implemented then the reason for this should be entered into the users EPR. |

The ADL assessment[182] is defined below with possible methods that could be used to automatically assess users.

- *Bathing* – Occurrence, frequency, type (bath or shower) and recognition of user is compiled by the water detection and lifestyle monitoring modules.
- *Continence* – The presence of incontinence is detected in the home by the incontinence detection module of the 4th generation system and the sensor in the incontinence pads of the 2nd generation system.
- *Cooking* – The time spent in the kitchen and time spent in front of the cooker, fridge etc. can be complied by the lifestyle monitoring module. Such a method does not guarantee that a meal has been eaten, but it is not possible to detect this in the present system either. The implanted sensors or an intelligent toilet may be able to detect what food was eaten and its nutritional value.
- *Dressing* – The time taken once the user has got out of bed in the morning and gone to the cupboard etc. can be detected from the lifestyle monitoring module. Until field trials have been undertaken it is not possible to judge how reliable this approach may be. For users with the cloths assistant robotic assistant how often the user needs this can be monitored and analysed over time.

- *Eating* – Addressed under cooking.
- *Grooming* – A reduction over time in videoconferencing while the use of the normal telephone remains the same or increases may indicate unhappiness with appearance and a lack of grooming. The lifestyle monitoring module may also be able to indicate how often a user spends in front of a mirror. However, using a different mirror may lead to misleading results. Nevertheless, the reason why a different mirror was being used may be beneficial, for example indicating that the user was experiencing difficulty raising from a bedside chair.
- *Mobility* – Gait analysis and distance walked provided by the lifestyle monitoring module.
- *Stairs* – Analysed by the lifestyle monitoring module.
- *Toilet* – Usage can be monitored by the lifestyle monitoring and water detection modules. If a commode is used then the system cannot gather accurate information.
- *Washing* – How often users wash and whether they use the sink, shower or bath can be obtained from a combination of the water detection and lifestyle monitoring modules.
- *Use of wheelchair* - A wheelchair incorporating such features as measuring the number and severity of 'bumps' and able to communicate with the IHAS could achieve the desired result.

The possible onset of distress or dementia should also be detected and indicated to social services. Examples would include:

- Leaving gas appliances on.
- After going to bed returning to ensure that the front door was closed.
- An increase in the number of times a user climbs the stairs and goes into the same room. Possibly checking that their purse is still in the chest of drawers.

The overall priority of calls being queued on the control centre system should be:

1. Gas.
2. Security.
3. Distance support.
4. Falls.
5. Lifestyle monitoring.
6. User activated emergency call.
7. Incontinence.
8. User telephone call.
9. User information enquiry.
10. User not returned home.
11. User request for advice with a letter or form.
12. Carer/home help failed to log on at the expected time.
13. GP enquiry for EPR.
14. Hospital access to EPR.
15. Warden/carer log.
16. Failure to access the users home EPR.

| | |
|---|---|
| Inputs | EPR. Manual enquiries, emergency calls from the home. Warden/carer or other professional logging. |
| Outputs | Inform warden, carer/home help, family, key holder, emergency services, GP. Fault report for engineers. Social services for re-assessment. |
| Major error | Unable to access EPR. Unable to receive/make telephone calls. Unable to analyse a users EPR with the expert system. |
| Exception | The module must be given a period of time to resolve itself, if after this time the fault still exists then inform the operators and automatically run a parallel (backup) system – defaulting to a separate control centre if the problem is significant and persists. |
| Current status | The call handling could be performed with current technology however, it would appear that the expert system does not exist in a suitable format. |

# Appendix A5.5

## 4th Generation Data Flow Diagrams

Two new processes are introduced in the 4th generation system as indicated in Fig A5.5.1. These are:

- Process 8, fire brigade.
- Process 9, emergency services.

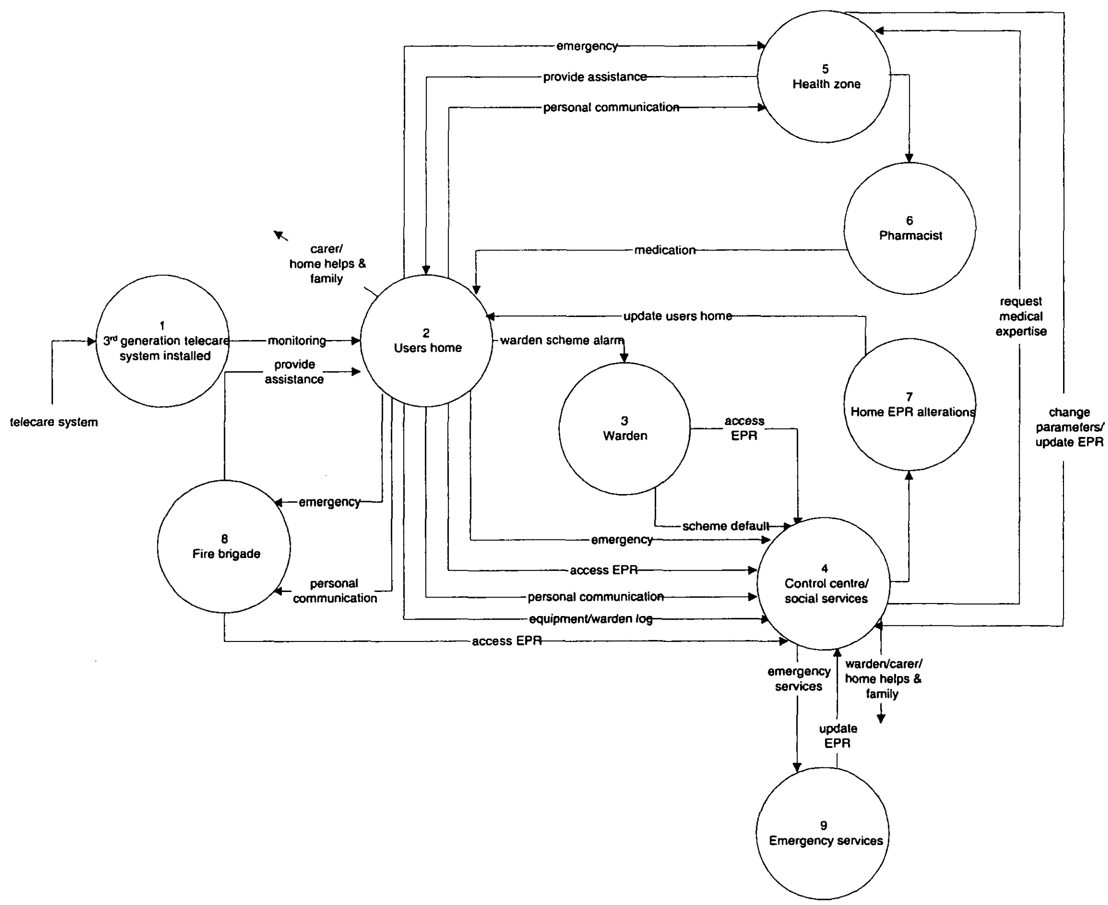



Figure A5.5.1: *The overall 4th generation structure (level 0)*

In order to reduce the time from detecting a fire to contacting the fire brigade, the fire brigade is contacted directly as opposed to being routed through the control centre, as evident in the previous generations. They can then provide the necessary assistance and record their actions in the users EPR. If a user generates a number of false alarms then the fire brigade can access the users EPR and disable this function; resulting in the control centre validating the need for assistance.

Process 9, indicates that when the emergency services (police, fire, ambulance) interact with a user their actions are recorded in the EPR. The information can then be used in any assessment of the users care package. All professionals that interact with the user therefore provide information into the system, the only people who do not have access to the EPR and consequently no ability to provide input, are the users friends and family. However, there is an opportunity for these to contribute in any assessment of the users care package.

*Process 1: '4th generation telecare system installed'*

The process does not alter from that defined in Appendix A5.3.

*Process 2: 'Users home'*

The process is the same as that defined in Appendix A5.3, however process 2.7, made the decision on whom to contact and in addition to contacting the GP surgery, out-of-hours medical centre, control centre or responder, it can now include contacting the fire brigade directly.

*Process 3: 'Warden'*

This process is the same as the 3rd generation system defined in Appendix A5.3

*Process 4: 'Control centre/social services'*

In the Appendix A5.1, process 4.1 'automatic or human needed with automatic priority' enabled the computer system to define whether the operator was needed or the system could respond itself. As part of this process in the 4th generation system an expert system will analyse each users EPR and perform an automatic ADL assessment. This section is highlighted in Fig A5.5.2.

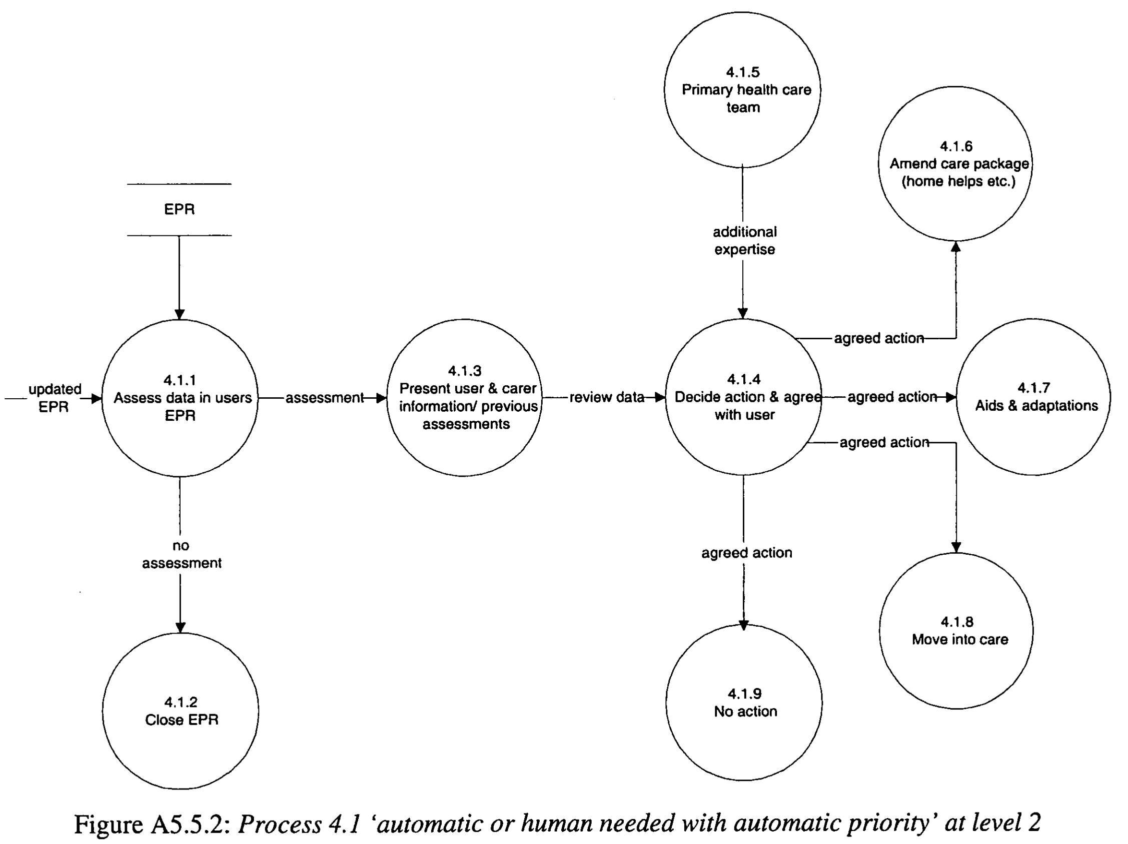



Figure A5.5.2: *Process 4.1 'automatic or human needed with automatic priority' at level 2*

The process begins when the control centre updates a users EPR with new data from the users home. As soon as the system has spare capacity the EPR can be accessed and the ADL assessment performed. If no intervention is necessary then the EPR can be closed and other functions performed by the control centre system. If however, there is a deviation in the ADL assessment where intervention may be beneficial then the relevant data should be organised and presented to social services who can interact with the user, family and responder, and agree a package of support. Process 4.1.3 indicates whenever social services are contacted they must perform an assessment, this may be physically or virtually but an assessment must take place.

When deciding the appropriate action medical advice can be taken from the primary care team in process 4.1.5. The outcomes from the assessment should be recorded in the users EPR and would consist of:
Process 4.1.6: Amend care package – increase or decrease the level of support provided by carers, home helps and nurses.
Process 4.1.7: Aid & adaptations – provide assistance for everyday living, examples would include larger taps, handrails or stair lifts.
Process 4.1.8: Move into care – arrange provision in supported housing, residential or nursing care, although sheltered housing may also be an option.
Process 4.1.9: No action – the users EPR should be updated so that the automatic ADL assessment does not recommend unnecessary intervention again.

*Process 5: 'Health zone'*
The process identified in Appendix 5.2 does not alter significantly in the 4$^{th}$ generation system.

*Process 6: 'Pharmacist'*

All pharmacists should now have access to the pharmacist database, but the process does not change when compared to the 3$^{rd}$ generation system described in Appendix A5.2.

*Process 7: 'Home EPR alterations'*

When compared to the 3$^{rd}$ generation system the fire brigade can access a users EPR through the control centre and disable the routing of fire calls to themselves. However, how this is achieved is the same as that identified in Appendix 5.2 for the health zone, i.e. through the control centre with appropriate security checks.

*Process 8: 'Fire brigade'*

The fire brigade responds in the same way whether they receive a call from the control centre, directly from the user, or the fire detection module in the users home. Having responded to the fire call the 4$^{th}$ generation system requires the fire brigade to record the action taken. For example, if it is found that the cause for the fire was forgetting to distinguish a cigarette then this should be recorded in the users EPR.

*Process 9: 'Emergency services'*

Whenever any of the emergency services provide assistance to a user the actions taken should be recorded in the users EPR. This may provide useful information when performing an assessment. This is performed through the control centre with appropriate security checks.

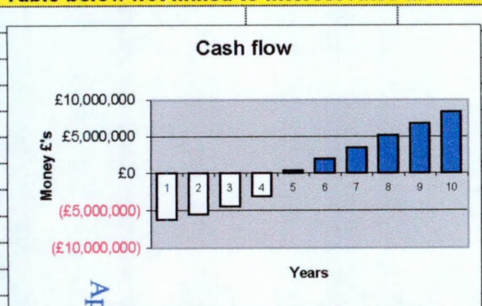
## Appendix A6.1

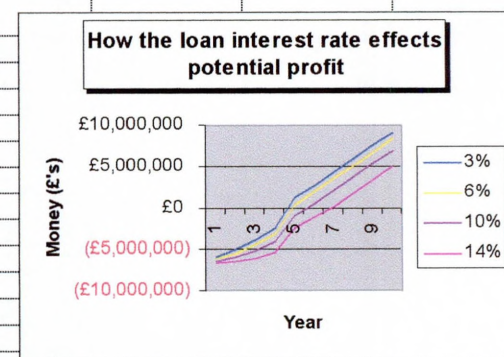
## Cost Analysis Worksheet

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Cost Analysis** | | | | | | | | | | | |
| 13 | ***Overall Financial Position*** | | | | | | | | | | | |
| 14 | | | | | | | | | | | | |
| 15 | Variables | | | | | | | | | | | |
| 16 | Number of community alarm users: | 11,618 | | | | | | | | | | |
| 17 | Number of community alarm installations: | 10,625 | | | | | | | | | | |
| 18 | Number of GP installations: | 574 | | | | | | | | | | |
| 19 | Number of nurse installations: | 28 | | | | | | | | | | |
| 20 | Number of warden schemes: | 141 | | | | | | | | | | |
| 21 | Hardware control centre cost: | £49,957 | | | | | | | | | | |
| 22 | Percentage of users to have nurse visits: | 2% | | | | | | | | | | |
| 23 | | | | | | | | | | | | |
| 24 | Variables | Present | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
| 25 | % reduction in surgery consultations | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0.0% | 0.0% |
| 26 | % reduction in home visits | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0.0% | 0.0% |
| 27 | Virtual surgery consultations (GP) | | 10.0% | 12.5% | 15.0% | 17.5% | 20.0% | 22.5% | 25.0% | 27.5% | 30.0% | 32.5% |
| 28 | Home visit consultations (GP) | | 15.0% | 17.5% | 20.0% | 22.5% | 25.0% | 27.5% | 30.0% | 32.5% | 35.0% | 37.5% |
| 29 | % reduction in nurse visits | | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 30 | Percentage of nurse visits to become virtual | | 7.5% | 10.0% | 12.5% | 13.0% | 13.0% | 13.0% | 13.0% | 13.0% | 13.0% | 13.0% |
| 31 | Percentage of admissions to hospital | 32.4% | 32.2% | 32.0% | 32.0% | 32.0% | 32.0% | 32.0% | 32.0% | 32.0% | 32.0% | 32.0% |
| 32 | Average duration of hospital stay | 9.5 | 9 | 8.75 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| 33 | Additional care visits due to early release | | 0.8 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| 34 | Additional nurse visits due to early release | | 0.4 | 0.6 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| 35 | Bed blocking | 20% | 18% | 16% | 14% | 12% | 10% | 10% | 10% | 10% | 10% | 10% |
| 36 | Number of people in residential care | 3.50% | 3.375% | 3.250% | 3.125% | 3.000% | 3.000% | 3.000% | 3.000% | 3.000% | 3.000% | 3.000% |
| 37 | Reduction in ambulance calls | | 8% | 9% | 10% | 11% | 12% | 12.5% | 12.5% | 12.5% | 12.5% | 12.5% |
| 38 | Reduction in police security calls | | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20.0% | 20.0% |

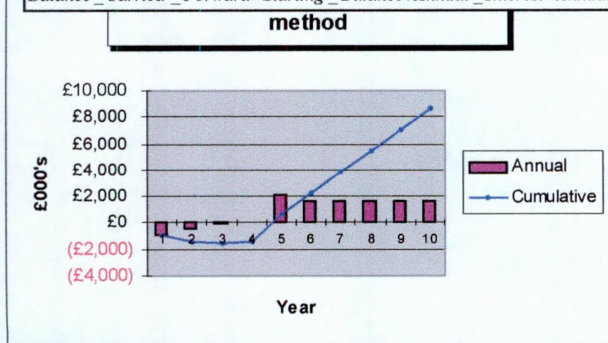
| | A | B | C | D | E | F | G | H | I | J | L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | ***Variables*** | *Current System* | *Proposed System* | | | | | | | | |
| 42 | | | | | | | | | | | |
| 43 | Life span of home based equipment (years) | 5 | 10 | | | | | | | | |
| 44 | Life span of warden scheme server | identical | | | | | | | | | |
| 45 | Life span on control centre | identical | | | | | | | | | |
| 46 | Life span of GP/nurse equipment | | 10 | | | | | | | | |
| 47 | | | | | | | | | | | |
| 48 | **Capital costs** | | | | | | | | | | |
| 49 | Initial outlay in home equipment costs | £1,909,025 | £7,487,150 | | | | | | | | |
| 50 | Warden scheme equipment | £352,500 | £493,500 | | | | | | | | |
| 51 | Control centre equipment | | £49,957 | | | | | | | | |
| 52 | GP equipment | | £321,440 | | | | | | | | |
| 53 | Nurse equipment | | £15,671 | | | | | | | | |
| 54 | **Total** | **£2,261,525** | **£8,367,718** | | | | | | | | |
| 55 | | | | | | | | | | | |
| 56 | **Installation and training** | | | | | | | | | | |
| 57 | Generate medical parameter home records | | £97,072 | | | | | | | | |
| 58 | Home equipment | £208,474 | £261,599 | | | | | | | | |
| 59 | GP/nurse equipment | | £14,821 | | | | | | | | |
| 60 | Staff training @20% | £70,500 | £176,114 | | | | | | | | |
| 61 | **Total** | **£278,974** | **£549,606** | | | | | | | | |
| 62 | | | | | | | | | | | |
| 63 | **Equipment maintenance (Per annum)** | | | | | | | | | | |
| 64 | Home units | £99,408 | £16,593 | | | | | | | | |
| 65 | GP units | | £896 | | | | | | | | |
| 66 | Nurse units | | £44 | | | | | | | | |
| 67 | Batteries and pendants | £127,296 | £143,868 | | | | | | | | |
| 68 | **Total** | **£226,704** | **£161,401** | | | | | | | | |
| 69 | | | | | | | | | | | |
| 70 | **Operating costs** | **Present** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** | **Year 7** | **Year 8** | **Year 10** |
| 71 | Property forced entry | £22,587 | £17,711 | £17,711 | £17,711 | £17,711 | £17,711 | £17,711 | £17,711 | £17,711 | £17,711 |
| 72 | Unsuccessful carer visits | £3,150 | £306 | £306 | £306 | £306 | £306 | £306 | £306 | £306 | £306 |
| 73 | Telephone costs (inc. cc/GP/nurse) | £13,529 | £35,831 | £32,053 | £32,669 | £33,234 | £33,785 | £34,336 | £34,886 | £35,437 | £36,539 |
| 74 | Surgery consultations | £413,409 | £526,211 | £327,307 | £330,312 | £333,316 | £336,321 | £339,325 | £342,330 | £345,334 | £351,344 |
| 75 | Home visit consultations | £383,035 | £330,114 | £326,048 | £321,981 | £317,915 | £313,848 | £309,782 | £305,715 | £301,649 | £293,516 |
| 76 | Nurse visits | £245,092 | £146,916 | £144,827 | £142,738 | £142,321 | £142,321 | £142,321 | £142,321 | £142,321 | £142,321 |
| 77 | Hospital bed costs | £5,097,724 | £4,858,445 | £4,723,311 | £4,618,156 | £4,614,605 | £4,611,054 | £4,611,054 | £4,611,054 | £4,611,054 | £4,611,054 |
| 78 | Residential care | £5,603,361 | £5,392,219 | £5,192,507 | £4,992,796 | £4,793,084 | £4,793,084 | £4,793,084 | £4,793,084 | £4,793,084 | £4,793,084 |
| 79 | **Total** | **£11,781,887** | **£11,307,755** | **£10,764,071** | **£10,456,669** | **£10,252,491** | **£10,248,429** | **£10,247,919** | **£10,247,408** | **£10,246,897** | **£10,245,875** |

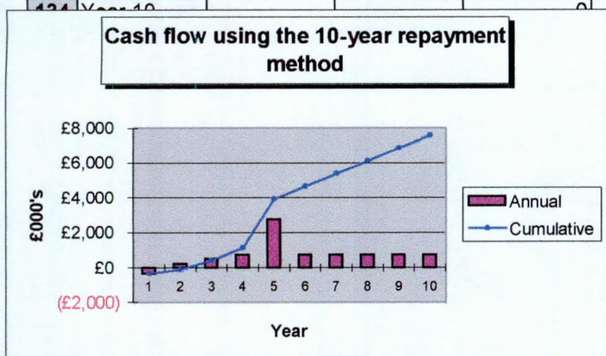
| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 95 | Expenditure | Present | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
| 96 | Present expenditure | | £12,008,591 | £12,008,591 | £12,008,591 | £12,008,591 | £14,046,402 | £12,008,591 | £12,008,591 | £12,008,591 | £12,008,591 | £12,008,591 |
| 97 | Equipment maintenance | £226,704 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 | £161,401 |
| 98 | Operating costs | £11,781,887 | £11,307,755 | £10,764,071 | £10,456,669 | £10,252,491 | £10,248,429 | £10,247,919 | £10,247,408 | £10,246,897 | £10,246,386 | £10,245,875 |
| 99 | **Total expenditure** | **£12,008,591** | **£11,469,156** | **£10,925,472** | **£10,618,071** | **£10,413,893** | **£10,409,831** | **£10,409,320** | **£10,408,809** | **£10,408,298** | **£10,407,787** | **£10,407,276** |
| 100 | Profit compared to present | | £539,435 | £1,083,119 | £1,390,520 | £1,594,698 | £3,636,572 | £1,599,271 | £1,599,782 | £1,600,293 | £1,600,804 | £1,601,314 |
| 101 | Compound profit | | £539,435 | £1,622,554 | £3,013,074 | £4,607,772 | £8,244,344 | £9,843,615 | £11,443,396 | £13,043,689 | £14,644,493 | £16,245,807 |
| 102 | | | | | | | | | | | | |
| 104 | | | | | | | | | | | | |
| 105 | | | Loan outstanding at start of year | Interest at 6% | Total amount owed before repayment | Proceeds from project | Loan outstanding at year end | **Interest rates** | | | | |
| 106 | | | | | | | | Balance | 8% | 10% | 12% | 15% |
| 107 | **Assume the loan is** | | | | | | | | | | | |
| 108 | **repaid out of the proceeds of the project** | Year 1 | £6,376,825 | £382,610 | £6,759,435 | £539,435 | £6,220,000 | (£6,220,000) | (£6,347,536) | (£6,475,073) | (£6,602,609) | (£6,793,914) |
| 109 | | Year 2 | £6,220,000 | £373,200 | £6,593,200 | £1,083,119 | £5,510,081 | (£5,510,081) | (£5,772,221) | (£6,039,462) | (£6,311,804) | (£6,729,883) |
| 110 | | Year 3 | £5,510,081 | £330,605 | £5,840,686 | £1,390,520 | £4,450,166 | (£4,450,166) | (£4,843,478) | (£5,252,888) | (£5,678,700) | (£6,348,845) |
| 111 | Assume no loan for | Year 4 | £4,450,166 | £267,010 | £4,717,176 | £1,594,698 | £3,122,478 | (£3,122,478) | (£3,636,258) | (£4,183,478) | (£4,765,446) | (£5,706,473) |
| 112 | present system or in year | Year 5 | £3,122,478 | £187,349 | £3,309,826 | £3,636,572 | (£326,745) | £326,745 | (£290,587) | (£965,254) | (£1,700,728) | (£2,925,873) |
| 113 | 5 when need replacement equipment in the home | Year 6 | (£326,745) | (£19,605) | (£346,350) | £1,599,271 | (£1,945,621) | £1,945,621 | £1,285,437 | £537,491 | (£305,544) | (£1,765,483) |
| 114 | | Year 7 | (£1,945,621) | (£116,737) | (£2,062,358) | £1,599,782 | (£3,662,140) | £3,662,140 | £2,988,054 | £2,191,022 | £1,257,572 | (£430,523) |
| 115 | | Year 8 | (£3,662,140) | (£219,728) | (£3,881,868) | £1,600,293 | (£5,482,161) | £5,482,161 | £4,827,391 | £4,010,417 | £3,008,774 | £1,105,191 |
| 116 | | Year 9 | (£5,482,161) | (£328,930) | (£5,811,091) | £1,600,804 | (£7,411,894) | £7,411,894 | £6,814,385 | £6,012,262 | £4,970,630 | £2,871,773 |
| 117 | Assume when loan repaid | Year 10 | (£7,411,894) | (£444,714) | (£7,856,608) | £1,601,314 | (£9,457,923) | £9,457,923 | £8,960,851 | £8,214,803 | £7,168,420 | £4,903,853 |
| 118 | any savings are subjected to that interest rate profit | | | | | | | **Interest rate** | | | | |
| 119 | **Table below not linked to interest rates above as assume 0% interest when in profit** | | | | | | | **6.00%** | | | | |
| 120 | | | | **Assume 0% interest on profit** | | | | | | | | |
| 121 | | | | | **3%** | **6%** | **10%** | **14%** | | | | |
| 122 | | | | Year 1 | (£6,028,695) | (£6,220,000) | (£6,475,073) | (£6,730,146) | | | | |
| 123 | | | | Year 2 | (£5,126,437) | (£5,510,081) | (£6,039,462) | (£6,589,248) | | | | |
| 124 | | | | Year 3 | (£3,889,710) | (£4,450,166) | (£5,252,888) | (£6,121,222) | | | | |
| 125 | | | | Year 4 | (£2,411,703) | (£3,122,478) | (£4,183,478) | (£5,383,495) | | | | |
| 126 | | | | Year 5 | £1,152,517 | £326,745 | (£965,254) | (£2,500,613) | | | | |
| 127 | | | | Year 6 | £2,751,788 | £1,926,016 | £537,491 | (£1,251,428) | | | | |
| 128 | | | | Year 7 | £4,351,570 | £3,525,798 | £2,137,273 | £173,154 | | | | |
| 129 | | | | Year 8 | £5,951,863 | £5,126,091 | £3,737,566 | £1,773,447 | | | | |
| 130 | | | | Year 9 | £7,552,666 | £6,726,894 | £5,338,369 | £3,374,251 | | | | |
| | | | | Year 10 | £9,153,981 | £8,328,209 | £6,969,684 | £4,975,565 | | | | |



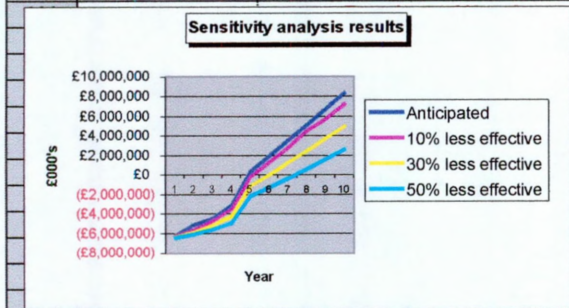



$$Balance\_Carried\_Forward = Starting\_Balance + Annual\_Interest - Annual\_Re\,payment$$

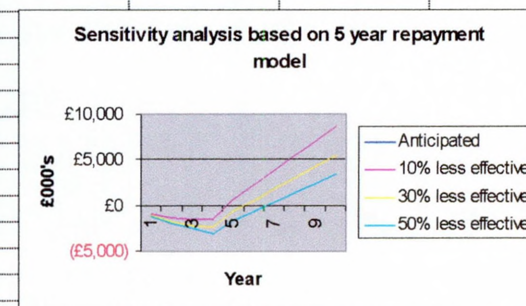


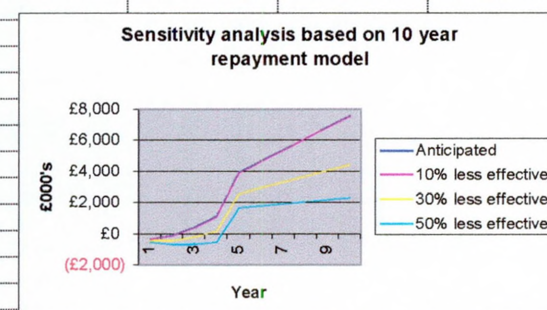




| | P | Q | R | S | T | U | V | W | X | Y | Z | AA | AB | AC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 118 | | | Repayment Models | | | | | | | | | | | |
| | | | | | | | Interest rate = | 6% | | | | | | |
| | | | | | | | 5 year Re_payment = | £1,513,835 | | | | | | |
| | | | | | | | 10 year Re_payment = | £866,406 | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | ncome) | | cumulative | | | | | | | |
| | | | | | avings | cash flow | cash flow | divide 1000 for graph | | | | | | |
| | | | | | £539,435 | (£974,400) | (£974,400) | (£974) | (£974) | | | | | |
| | | | | | £1,083,119 | (£430,716) | (£1,405,116) | (£431) | (£1,405) | | | | | |
| | | | | | £1,390,520 | (£123,315) | (£1,528,431) | (£123) | (£1,528) | | | | | |
| | | | | | £1,594,698 | £80,863 | (£1,447,568) | £81 | (£1,448) | | | | | |
| | | | | | £3,636,572 | £2,122,737 | £675,169 | £2,123 | £675 | | | | | |
| | | | | | £1,599,271 | £1,599,271 | £2,274,440 | £1,599 | £2,274 | | | | | |
| | | | | | £1,599,782 | £1,599,782 | £3,874,221 | £1,600 | £3,874 | | | | | |
| | | | | | £1,600,293 | £1,600,293 | £5,474,514 | £1,600 | £5,475 | | | | | |
| 133 | Year 9 | | | 0 | £1,600,804 | £1,600,804 | £7,075,318 | £1,601 | £7,075 | | | | | |
| 134 | Year 10 | | | 0 | £1,601,314 | £1,601,314 | £8,676,632 | £1,601 | £8,677 | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | ncome) | | cumulative | | | | | | | |
| | | | | | avings | cash flow | cash flow | divide 1000 for graph | | | | | | |
| | | | | | £539,435 | (£326,971) | (£326,971) | (£327) | (£327) | | | | | |
| | | | | | £1,083,119 | £216,713 | (£110,258) | £217 | (£110) | | | | | |
| | | | | | £1,390,520 | £524,114 | £413,856 | £524 | £414 | | | | | |
| | | | | | £1,594,698 | £728,292 | £1,142,148 | £728 | £1,142 | | | | | |
| | | | | | £3,636,572 | £2,770,166 | £3,912,314 | £2,770 | £3,912 | | | | | |
| | | | | | £1,599,271 | £732,865 | £4,645,179 | £733 | £4,645 | | | | | |
| | | | | | £1,599,782 | £733,376 | £5,378,554 | £733 | £5,379 | | | | | |
| | | | | | £1,600,293 | £733,887 | £6,112,441 | £734 | £6,112 | | | | | |
| | | | | | £1,600,804 | £734,398 | £6,846,839 | £734 | £6,847 | | | | | |
| | | | | | £1,601,314 | £734,908 | £7,581,747 | £735 | £7,582 | | | | | |
| 148 | | £3 | | | | | | | | | | | | |
| 149 | | | | | | | | | | | | | | |




| | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | y from proceeds of project as profits occur | | | | | | | |
| | | | | 30% | 50% | | | | | | |
| | | | | (£6,341,257) | (£6,422,096) | | | | | | |
| | | | | (£5,849,885) | (£6,076,421) | | | | | | |
| | | | | (£5,112,025) | (£5,553,264) | | | | | | |
| | | | | (£4,185,628) | (£4,894,394) | | | | | | |
| | | | | (£1,161,774) | (£2,154,119) | | | | | | |
| | | | | £6,211 | (£1,286,729) | | | | | | |
| | | | | £1,244,413 | (£366,783) | | | | | | |
| | | | | £2,483,126 | £608,869 | | | | | | |
| | | | | £3,722,350 | £1,607,040 | | | | | | |
| | | | | £4,962,085 | £2,605,721 | | | | | | |
| 175 | | | | | | | | | | | |
| 176 | | | | | | | | | | | |
| 177 | | | | | | | | | | | |
| 178 | not linked to table | using 5 yr repayment - cumulative only | | | | | | | | | |
| 179 | | (£974) | (£995) | (£1,096) | (£1,176) | | | | | | |
| 180 | | (£1,405) | (£1,426) | (£1,738) | (£1,959) | | | | | | |
| 181 | | (£1,528) | (£1,549) | (£2,163) | (£2,585) | | | | | | |
| 182 | | (£1,448) | (£1,468) | (£2,443) | (£3,107) | | | | | | |
| 183 | | £675 | £655 | (£682) | (£1,587) | | | | | | |
| 184 | | £2,274 | £2,254 | £556 | (£590) | | | | | | |
| 185 | | £3,874 | £3,854 | £1,794 | £407 | | | | | | |
| 186 | | £5,475 | £5,454 | £3,032 | £1,404 | | | | | | |
| 187 | | £7,075 | £7,055 | £4,272 | £2,403 | | | | | | |
| 188 | | £8,677 | £8,656 | £5,511 | £3,401 | | | | | | |
| 189 | | | | | | | | | | | |
| 190 | | | | | | | | | | | |
| 191 | not linked to table | using 10 yr repayment - cumulative only | | | | | | | | | |
| 192 | | (£327) | (£347) | (£448) | (£529) | | | | | | |
| 193 | | (£110) | (£131) | (£443) | (£664) | | | | | | |
| 194 | | £414 | £393 | (£220) | (£643) | | | | | | |
| 194 | | £1,142 | £1,122 | £146 | (£517) | | | | | | |
| 196 | | £3,912 | £3,892 | £2,555 | £1,650 | | | | | | |
| 197 | | £4,645 | £4,625 | £2,926 | £1,780 | | | | | | |
| 198 | | £5,379 | £5,358 | £3,298 | £1,911 | | | | | | |
| 199 | | £6,112 | £6,092 | £3,670 | £2,042 | | | | | | |
| 200 | | £6,847 | £6,826 | £4,043 | £2,174 | | | | | | |
| 201 | | £7,582 | £7,561 | £4,416 | £2,306 | | | | | | |



# Appendix A6.2

## Home Worksheet

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Home enviromnent** | Figures in this colour have references | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | *Current System* | *Proposed System* | |
| 5 | Variables | | | |
| 6 | Initial outlay in equipment costs [1] | £175 | £700 | |
| 7 | Life span of equipment (years) [2] | 5 | 10 | |
| 8 | Transport cost to home [3] | £9.62 | £9.62 | |
| 9 | Installation cost per minute [229] [4] | £0.25 | £0.25 | |
| 10 | Installation and training time required [5] | 40 | 60 | |
| 11 | Unit faults per year [6] | 5% | 3.5% | |
| 12 | Cost of replacement unit [7] | £175 | £30 | |
| 13 | Time spent to repair equipment [8] | 10 | 20 | |
| 14 | % of pendant failures [9] | 18% | 16% | |
| 15 | Cost of replacement pendant [10] | £50 | £50 | |
| 16 | Time required to replace pendant [11] | 5 | 5 | |
| 17 | Percentage of users with batteries [12] | | 90.0% | |
| 18 | Replace batteries (years) [13] | | 5 | |
| 19 | Time required to change batteries [14] | | 10 | |
| 20 | Average number of batteries required [15] | | 5 | |
| 21 | Individual battery cost [377] [16] | | £4 | |
| 22 | *Component costs (£)* | | | |
| 23 | **Initial equipment cost [17]** | **£35.00** | **£70.00** | |
| 24 | **Installation [18]** | **£3.92** | **£2.46** | |
| 25 | **Maintenance & unit replacements [19]** | **£9.36** | **£1.56** | |
| 26 | **Battery replacement [20]** | **£10.96** | **£15.52** | |
| 27 | **Total** | **£59.24** | **£89.55** | |
| 28 | | | | |

# Appendix A6.3

## Control Centre Worksheet

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Community alarm control centre** | Figures in this colour have references | | |
| 2 | | | | |
| 3 | | | | |
| 4 | *Variables* | Current System | Future System | |
| 5 | | | | |
| 6 | Total number of people living alone in the community [1] | 2,280 | 2,280 | |
| 7 | Total number of clients [2] | 11,618 | 11,618 | |
| 8 | Total number of people in sheltered housing [3] | 8,938 | 8,938 | |
| 9 | Number of warden schemes [229] [4] | 141 | 141 | |
| 10 | Warden scheme server and warden control [5] | £2,500 | £3,500 | |
| 11 | Calls requesting an ambulance [6] | 1416 | 1303 | |
| 12 | % of calls that can be reduced for the ambulance service [7] | | 8% | |
| 13 | Calls requesting the fire brigade [8] | 96 | 96 | |
| 14 | Total number of calls regarding a fire [9] | | 120 | |
| 15 | % of calls that are increased regarding fire [10] | | 25% | |
| 16 | Calls requesting the police [11] | 852 | 650 | |
| 17 | % of calls that can be reduced for the police [12] | | 20% | |
| 18 | Calls requesting a doctor [13] | 672 | 404 | |
| 19 | % of calls that can be reduced to the doctor [14] | | 40% | |
| 20 | Client on floor [15] | 876 | 876 | |
| 21 | No answer calls [377] [16] | 5,916 | 5,206 | |
| 22 | Number of occasions where forced entry is needed [17] | 123 | 97 | |
| 23 | Cost of gaining entry to a property [18] | £200 | £200 | |
| 24 | Pulled in error calls [19] | 23,832 | 357 | |
| 25 | Calls to social services and information resources [20] | 3,384 | 0 | |
| 26 | Number of calls requesting a responder [21] | 3,444 | 3,444 | |
| 27 | Alarm program/test [22] | 11,808 | 0 | |
| 28 | Number of carer visits (week) [23] | 2,154 | 2,154 | |
| 29 | Number of hours in between test calls [24] | | 168 | |
| 30 | Test calls (year) [25] | 77,688 | 260,503 | |
| 31 | Warden log [26] | 123,108 | 123,108 | |
| 32 | Carer request [27] | 2,184 | 2,184 | |
| 33 | Neighbourhood Housing Office/Housing Association [28] | 228 | 228 | |
| 34 | Repairs [29] | 3,144 | 3,144 | |
| 35 | Wanted warden [30] | 6,828 | 6,828 | |
| 36 | Continuous activation [31] | 48 | 33.6 | |
| 37 | Number of carer visits where a client is in hospital (week) [32] | 2 | 0.2 | |
| 38 | Number of nurse visits where a client is in hospital (week) [33] | 2 | 0.2 | |
| 39 | Alarm install [34] | 336 | 336 | |
| 40 | Alarm repair [35] | 636 | 626 | |
| 41 | Non defined [36] | 5316 | 5316 | |
| 42 | Cost of a carer visit [37] | £10.00 | £10.00 | |
| 43 | Cost of a individual nurse visit [38] | £20.28 | £19.45 | |
| 44 | Changing the home record physically in the home (years) [39] | | 3 | |
| 45 | Number of calls required to update home records (year) [40] | | 874 | |
| 46 | Number of phone calls regarding change of batteries [41] | 2,091 | 3,950 | |
| 47 | Average length of time for communication (min) [42] | 3.50 | 3.50 | |
| 48 | Average length of time for electronic call (min) [43] | 0.08 | 0.08 | |

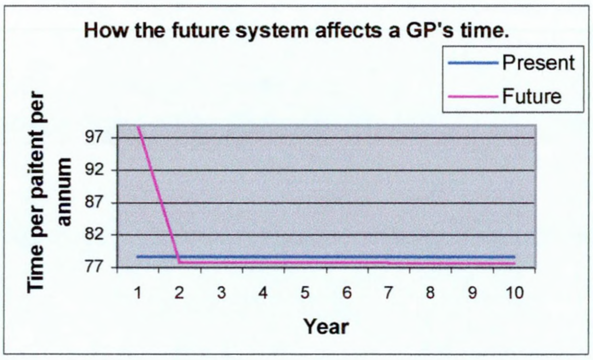
| | A | B | C | D |
|---|---|---|---|---|
| 49 | Phone line charge per minute [44] | £0.015 | £0.015 | |
| 50 | Phone line charge for access to control centre/home/GP [45] | £0.042 | £0.042 | |
| 51 | Number of calls concerning being timed out of a room [46] | | 58 | |
| 52 | Number of calls concerning problematic gas levels [47] | | 33 | |
| 53 | Number of calls concerning security problems [48] | | 8,143 | |
| 54 | Number of calls answered by control centre staff [49] | 6 | 3 | |
| 55 | Number of calls made by operators on clients behalf [50] | 3 | 2 | |
| 56 | Total number of operator calls (in and out) per client [51] | 9 | 6 | |
| 57 | No of calls dealt with by the control centre system (per user) [52] | 17 | 42 | |
| 58 | **Component costs (£)** | | | |
| 59 | **Costs incurred due to forced entry [53]** | **£2.13** | **£1.67** | |
| 60 | **Unsuccessful carer/nurse visits [54]** | **£0.27** | **£0.03** | |
| 61 | **Additional cost for storing the home record [55]** | | **£0.43** | |
| 62 | **Cost of manual calls [56]** | **£0.43** | **£0.26** | |
| 63 | **Cost of electronic system calls [57]** | **£0.73** | **£1.75** | |
| 64 | **Warden scheme equipment [58]** | **£30.34** | **£42.48** | |
| 65 | **Total** | **£33.90** | **£46.61** | |
| 66 | | | | |
| 67 | **Total number of calls handled [59]** | 307,279 | 547,675 | |
| 68 | **Phone time for each client per year (mins) [60]** | 32.85 | 22.75 | |
| 69 | | | | |

# Appendix A6.4

## Health Zone Worksheet

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Health Zone** | Figures in this colour have references | | |
| 2 | | | | |
| 3 | | | | |
| 4 | **GP surgery and primary care system** | | | |
| 5 | | *Current System* | *Proposed System* | |
| 6 | ***Variables*** | | | |
| 7 | Average time for a surgery consultation (mins) [1] | 8.4 | 8.4 | |
| 8 | Average time for a home visit (mins) [2] | 13.2 | 13.2 | |
| 9 | Average travel time for a home visit (mins) [3] | 12 | 12 | |
| 10 | No. of times medical measurements are outside agreed parameters [229][4] | | 1 | |
| 11 | Additional phone time required prior to virtual consultation [5] | | 2 | |
| 12 | Additional calls for patients not taking medication [6] | | 0.03% | |
| 13 | Average time needed for patients not taking medicine [7] | | 8 | |
| 14 | Set up clients medical monitoring parameters [8] | | 10 | |
| 15 | Number of surgery consultations [9] | 5.07 | 5.07 | |
| 16 | Number of home consultations [10] | 1.43 | 1.43 | |
| 17 | Average additional time required for a virtual consultation [11] | | 2.4 | |
| 18 | % of surgery consultations to become virtual [12] | | 10% | |
| 19 | % of home visit calls to become virtual [13] | | 15% | |
| 20 | % of unsuccessful virtual consultations (surgery based) [14] | | 0.5% | |
| 21 | % of unsuccessful virtual consultations (home based) [15] | | 1.0% | |
| 22 | Phone line time required for a virtual consultation (prev surgery) [377] [16] | | 12.8 | |
| 23 | Phone line time required for a virtual consultation (prev home visit) [17] | | 17.6 | |
| 24 | GP travel cost for a home visit [18] | £12.03 | £12.03 | |
| 25 | GP's charge per minute [19] | £0.84 | £0.84 | |
| 26 | % of consultations requiring parameters in the home to be edited [20] | | 15% | |
| 27 | Number of GP's [21] | | 574 | |
| 28 | Cost for each GP/nurse being able to video conference [22] | | £560.00 | |
| 29 | Number of nurse visits (week) [23] | 232 | 232 | |
| 30 | % of nurse visits that can be achieved remotely [24] | | 7.5% | |
| 31 | Average nurse travel time to client (mins) [25] | 15 | 15 | |
| 32 | Average duration of nurse visit (mins) [26] | 12.5 | 12.5 | |
| 33 | Number of nurse visits per day per nurse [27] | 7.96 | 8.30 | |
| 34 | Nurse charge per day inc. overheads [28] | £161.54 | £161.54 | |
| 35 | **Component costs (£)** | | | |
| 36 | **Additional cost for setting parameters [29]** | | **(£0.84)** | |
| 37 | **Additional cost for surgery consultations (access home record) [30]** | | **(£0.38)** | |
| 38 | **Additional costs for virtual surgery consultations [31]** | | **(£0.16)** | |
| 39 | **Additional calls to GP regarding out of parameters [32]** | | **£1.09** | |
| 40 | **Changing parameters in the home [33]** | | **(£0.05)** | |
| 41 | **Saving due to early detection and cheaper prescriptions [34]** | | **£11.16** | |
| 42 | **Saving of a home visit becoming a virtual one [35]** | | **£2.48** | |
| 43 | **Not taking drugs saving because of warning to GP [36]** | | **£0.08** | |
| 44 | **Additional cost for GP equipment [37]** | | **(£2.77)** | |
| 45 | **Equipment cost for nurses [38]** | | **(£0.13)** | |
| 46 | **Telephone costs for virtual nurse calls [39]** | | **(£0.17)** | |
| 47 | **Saving from a virtual nurse visit (year) [40]** | | **£4.32** | |
| 48 | Total | | **£14.61** | |

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 50 | GP time per client per year [41] | Current | *Future* | | |
| 51 | | *System* | *System* | | |
| 52 | set up parameters time | 0 | 10.0 | | |
| 53 | surgery | 42.6 | 43.8 | | |
| 54 | home visit | 36.0 | 34.0 | | |
| 55 | outside parameters | 0 | 10.8 | | |
| 56 | change medical parameters in the home record | 0 | 0 | | |
| 57 | | Surgery | Home visit | Total | Saving |
| 58 | Present system | 42.6 | 36.0 | 78.6 | |
| 59 | | | | | |
| 60 | Year 1 | 43.8 | 34.0 | 98.7 | (£20.03) |
| 61 | Year 2 | 44.1 | 33.7 | 77.8 | 0.8 |
| 62 | Year 3 | 44.4 | 33.4 | 77.8 | 0.8 |
| 63 | Year 4 | 44.8 | 33.0 | 77.8 | 0.8 |
| 64 | Year 5 | 45.1 | 32.7 | 77.8 | 0.9 |
| 65 | Year 6 | 45.4 | 32.4 | 77.7 | 0.9 |
| 66 | Year 7 | 45.7 | 32.0 | 77.7 | 0.9 |
| 67 | Year 8 | 46.0 | 31.7 | 77.7 | 0.9 |
| 68 | Year 9 | 46.3 | 31.4 | 77.7 | 1.0 |
| 69 | Year 10 | 46.6 | 31.0 | 77.6 | 1.0 |
| 70 | | | | | |



| | F | G | H | I |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | **Hospital environment/residential care** | | | |
| 5 | | *Current System* | *Proposed System* | |
| 6 | **Variables** | | | |
| 7 | Cost of hospital bed per night [1] | £141.56 | £141.56 | |
| 8 | No. of hospital days if medication is not taken in the home [2] | 2 | 2 | |
| 9 | Average length of time in hospital (days) [3] | 9.5 | 9 | |
| 10 | % of clients admitted to hospital [229] [4] | 32.4% | 32.2% | |
| 11 | Reduction in the number of admissions [5] | | 0.2% | |
| 12 | Number of admissions for people 65 and over [6] | 47,984 | 47,392 | |
| 13 | Number of admissions for people 75 and over [7] | 15,988 | 15,791 | |
| 14 | % of falls that result in 3 days in hospital because of hypothermia [8] | | 0.01% | |
| 15 | % of people admitted to residential homes [9] | 3.5% | 3.375% | |
| 16 | % of people admitted to residential homes in a year (turnover) [10] | 42.5% | 42.5% | |
| 17 | Number of weeks people are delayed entry to residential care [11] | | 8 | |
| 18 | Cost of residential homes (week) [12] | £265 | £265 | |
| 19 | Additional cost for assisting people in the community (week) [13] | | £128 | |
| 20 | % of patients waiting to be discharged [14] | 20% | 18% | *Saving* |
| 21 | **Component costs (£)** | | | |
| 22 | **Hospital days saved [15]** | **£436** | **£410** | **£25.48** |
| 23 | **Waiting to be discharged from hospital [377][16]** | **£3.06** | **£2.73** | **£0.32** |
| 24 | **Hypothermia saving from reduced time on the floor [17]** | | | **£0.0032** |
| 25 | **Additional community care due to hospital discharge [18]** | | **(£2.42)** | **(£2.42)** |
| 26 | **Additional nurse care due to hospital release [19]** | | **(£2.78)** | **(£2.78)** |
| 27 | **Saving due to less people in residential care [20]** | **£482** | **£465.08** | **£17.23** |
| 28 | **Additional cost for people staying in the community [21]** | | **(£4.33)** | **(£4.33)** |
| 29 | **Saving due to latter arrival at residential care [22]** | | **£37** | **£36.89** |
| 30 | **Total** | | | **£70.40** |
| 31 | | | | |

# Appendix A6.5

## Emergency Services Worksheet

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | **Emergency services** | | Figures in this colour have references | | |
| 2 | | | | | |
| 3 | *Ambulance* | | | | |
| 4 | | *Current System* | *Proposed System* | | |
| 5 | *Difference* | | | | |
| 6 | Number of clients [1] | 148,100 | 148,100 | | |
| 7 | Number of calls [2] | 150,000 | 138,000 | | |
| 8 | Cost per call out [3] | £77.50 | £77.50 | *Saving* | |
| 9 | **Total cost per individual** | **£78.49** | **£72.21** | £6.28 | |
| 10 | | | | | |

| | G | H | I | J | K |
|---|---|---|---|---|---|
| 1 | Total saving: £10.50 | | | | |
| 2 | | | | | |
| 3 | *Fire* | | | | |
| 4 | | *Current System* | *Proposed System* | | |
| 5 | *Difference* | | | | |
| 6 | Number of clients [1] | 148,100 | 148,100 | | |
| 7 | Number of calls [2] | 5,034 | 5,034 | | |
| 8 | Cost per call out [3] | £469 | £469 | | |
| 9 | Cost saving per minute due to fire [229][4] | | £55 | | |
| 10 | Saving in time due to alarm [5] | | 2 | | |
| 11 | Saving in damage costs [6] | | £553,740 | *Saving* | |
| 12 | **Total cost per individual** | **£15.94** | **£12.20** | £3.74 | |
| 13 | | | | | |

| | M | N | O | P | Q |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | *Police* | | | | |
| 4 | | *Current System* | *Proposed System* | | |
| 5 | *Difference* | | | | |
| 6 | Number of clients [1] | 148,100 | 148,100 | | |
| 7 | Unnecessary forced entry [2] | 40 | 0 | | |
| 8 | Cost per call out [3] | £469 | £469 | | |
| 9 | Security calls [3] | 4,369 | 3,496 | | |
| 10 | Cost of call out [229] [4] | £77.5 | £77.5 | *Saving* | |
| 11 | **Total cost per individual** | **£2.31** | **£1.83** | £0.48 | |
| 12 | | | | | |

# Appendix A8.1

## User Documentation For The Telecare Utility Program

### A8.1.1 Ensuring The Correct Data

Before using the utility program the control centre database needs to be in a suitable format i.e. all of the information should be in a table called 'Histlog' with the fields identified in Table A8.1.

Table A8.1: *Required fields for the utility programme*

| Field | Type | Description |
|---|---|---|
| RECEIVED | Date/Time | The time a call was received at the control centre and became apparent on the operators screen |
| RESPONSE | Date/Time | The time the call was responded to, i.e. when the operator answered the call |
| CLEARED | Date/Time | The time the call ended and was closed down |
| POLICE | Number | Whether or not during the call the police were contacted 0 = false <>0 = true |
| AMBULANCE | Number | Whether or not during the call the ambulance service were contacted 0 = false <>0 = true |
| FIRE | Number | Whether or not during the call the fire brigade were contacted 0 = false <>0 = true |
| DOCTOR | Number | Whether or not during the call the doctor was contacted 0 = false <>0 = true |
| RESPONDER | Number | Whether or not during the call a responder was contacted 0 = false <>0 = true |
| UNIT_CATEGORY | Text | 1 = Scheme<br>2 = Dispersed<br>3 = Housing Association<br>4 = Linked bungalows<br><br>1,3 and 4 are considered as originating from sheltered housing, while 2 is considered as originating from a dispersed/community alarm. |
| CALL_TYPE | Text | The type of call:<br>C = Client call<br>P = Pulled in Error<br>M = Mains<br>W = Warden<br>T = Test<br>M = maintenance<br>B = Battery<br>S = Smoke alarm<br>E = Low temperature<br>I = Intruder<br>A = Inactivity |
| COMMENTS_CODE | Text | If the call is a client call (i.e. CALL_TYPE = "C") , the control centre system forces the operator to enter a closing down comment describing the call:<br>1 = carer<br>2 = Installation by<br>3 = NHO/Housing Association contacted<br>4 = No response – closed down<br>5 = Non call<br>6 = Repairs reported<br>7 = Service work order<br>8 = Support service contacted<br>9 = Tenant on floor<br>10 = Testing/programming by<br>11 = Wanted warden<br>12 = Warden off duty<br>13 = Warden on duty<br>14 = Weather damage/activation<br>15 = Extra comments<br>16 = Yearly PR visit by<br>67 = Yearly PR visit by |

However, the control centre 'Histlog' table does not contain either of response or cleared, therefore these fields must be added to the table before the utility program can transfer the data into the format acceptable for the telecare simulation package. These fields are in a table called 'History' and therefore need to be added into the 'Histlog' table the SQL statement below can be executed:

*'UPDATE History INNER JOIN Histlog ON History.HISTORY_ID = Histlog.HISTORY_ID SET Histlog.response = History.response;'*

Here the unique History_ID for each call received at the control centre is used to transfer the response field from the 'History' table into the 'Histlog' table. The same process can be used for cleared, where 'response' is changed to 'cleared' in the above SQL statement.

### A8.1.2 Getting Started

This program is best viewed at a resolution of 800*600.

To install the utility program, insert the CD into the drive and open the 'Telecare_utility' folder found in the 'Telecare_progs' folder. Clicking on the set-up icon will begin the installation process with further instructions being provided on screen.

To remove the program and all of its components use the Add/Remove programs from the control panel.

When the program has been successfully installed it can be selected from the taskbar, with the screen highlighted in Fig A8.1.1 appearing.

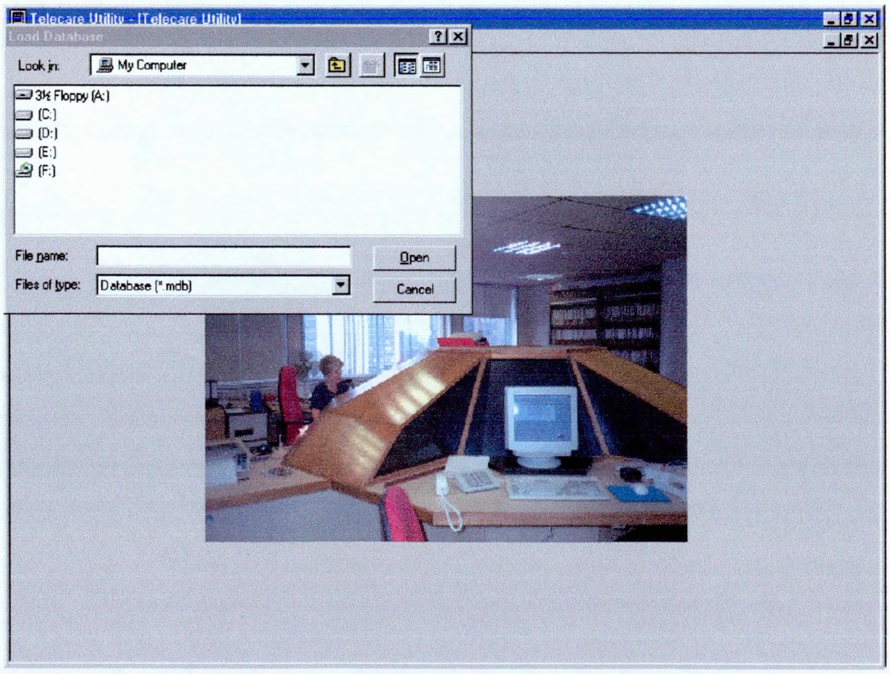



Figure A8.1.1: *The telecare utility opening screen*

The control centre database which is to be transferred into a suitable format for the telecare simulation package can be selected. Alternatively, the 'Select database' button can be used. If the database chosen does not contain the necessary fields in the 'Histlog' table then the data transfer cannot be performed and the users should be informed. When an acceptable database has been chosen it will be analysed for the COMMENTS_CODE's and CALL_TYPE's defined in Table A8.1. A progress bar at the bottom of the screen will indicate the state of progress and when the database has been fully analysed a screen similar to that in Fig A8.1.2 will be evident.

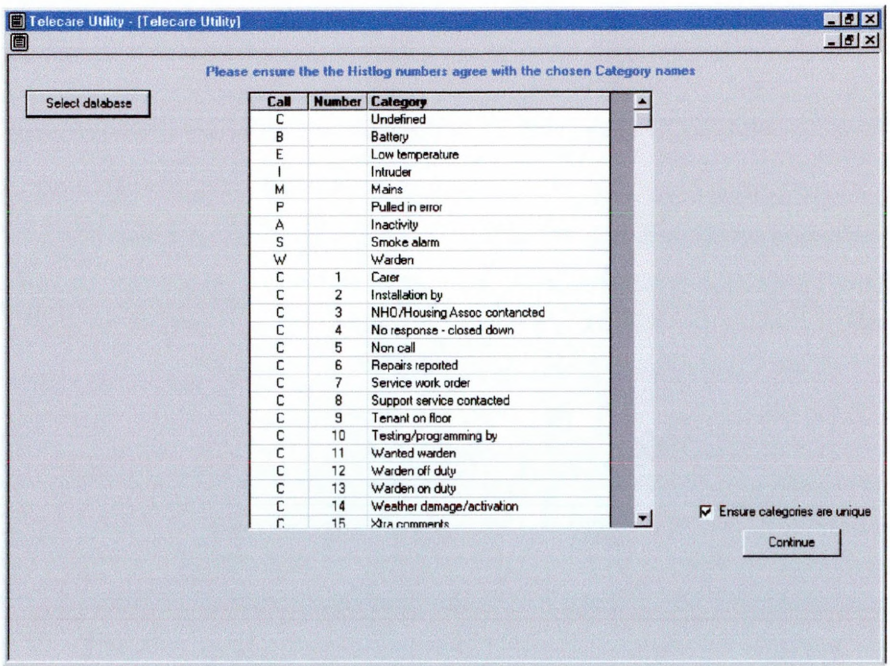



Figure A.8.1.2: *Identification of the categories evident at the control centre*

If this is the first time this database has been selected, then all of the 'Category' entries of Fig A8.1.2 will be empty. The 'Category' entry refers to what the COMMENTS_CODE's and CALL_TYPE's actually mean, for example, a call type of P will often mean Pulled in Error, however this may not always be the case so clarification is needed.

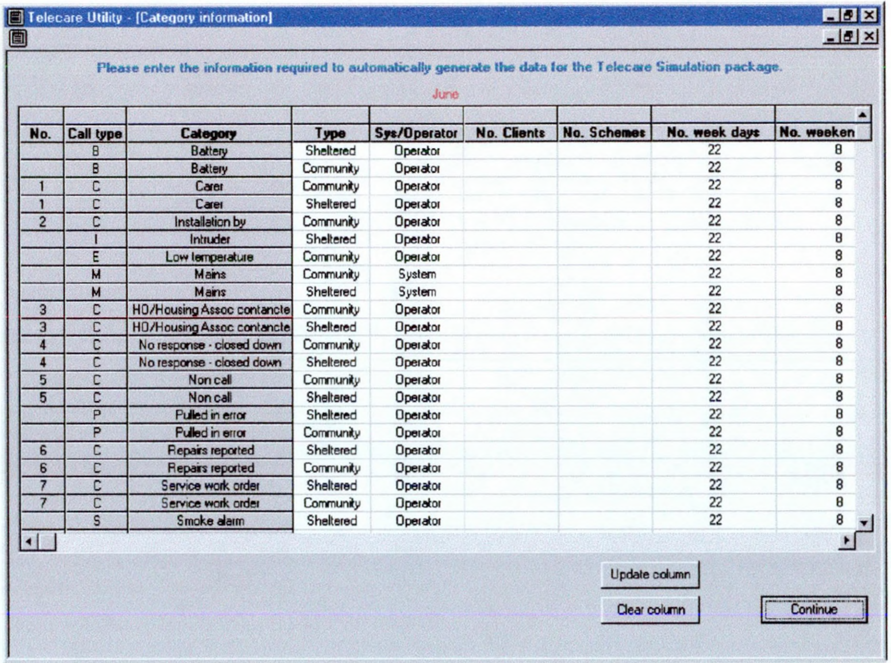
While analysing the selected database a table called 'U_Category' is created. This table contains the fields COMMENTS_CODE, CALL_TYPE and CATEGORY and will store the information from Fig A8.1.2. If the COMMENTS_CODE, CALL_TYPE and CATEGORY names are the same then this table can be inserted from a previously created database so that the actual category names do not have to be re-entered.

When the appropriate category names for the COMMENTS_CODE's and CALL_TYPE's have been entered 'Continue' can be pressed. However, every category must have a category name so if any have been left blank the user will be prompted for the required information. An option 'Ensure categories are unique' is provided to ensure that the same category name cannot be entered for different COMMENTS_CODE's or CALL_TYPE's. If however, this option is not required, the 'Ensure categories are unique' option can be deselected and no verification of the category names will be performed.

Having successfully entered the required information the database selected will be analysed; the current state of progress being indicated by the progress bar at the bottom of the screen.

### A8.1.3 Additional Information

Having selected the database to use, and successfully entered the category names, additional information is required before the data can be manipulated. A screen similar to Fig A8.1.3 will be evident where this additional information can be entered.




| No. | Call type | Category | Type | Sys/Operator | No. Clients | No. Schemes | No. week days | No. weeken |
|---|---|---|---|---|---|---|---|---|
| | B | Battery | Sheltered | Operator | | | 22 | 8 |
| | B | Battery | Community | Operator | | | 22 | 8 |
| 1 | C | Carer | Community | Operator | | | 22 | 8 |
| 1 | C | Carer | Sheltered | Operator | | | 22 | 8 |
| 2 | C | Installation by | Community | Operator | | | 22 | 8 |
| | I | Intruder | Sheltered | Operator | | | 22 | 8 |
| | E | Low temperature | Community | Operator | | | 22 | 8 |
| | M | Mains | Community | System | | | 22 | 8 |
| | M | Mains | Sheltered | System | | | 22 | 8 |
| 3 | C | HO/Housing Assoc contancte | Community | Operator | | | 22 | 8 |
| 3 | C | HO/Housing Assoc contancte | Sheltered | Operator | | | 22 | 8 |
| 4 | C | No response - closed down | Community | Operator | | | 22 | 8 |
| 4 | C | No response - closed down | Sheltered | Operator | | | 22 | 8 |
| 5 | C | Non call | Community | Operator | | | 22 | 8 |
| 5 | C | Non call | Sheltered | Operator | | | 22 | 8 |
| | P | Pulled in error | Sheltered | Operator | | | 22 | 8 |
| | P | Pulled in error | Community | Operator | | | 22 | 8 |
| 6 | C | Repairs reported | Sheltered | Operator | | | 22 | 8 |
| 6 | C | Repairs reported | Community | Operator | | | 22 | 8 |
| 7 | C | Service work order | Sheltered | Operator | | | 22 | 8 |
| 7 | C | Service work order | Community | Operator | | | 22 | 8 |
| | S | Smoke alarm | Sheltered | Operator | | | 22 | 8 |

Figure A8.1.3: *Entering additional information*

For the month indicated, June in the example of Fig A8.1.3, the call types evident during this month are indicated in the first 3 columns. The 4th column shows where the call originated from, i.e. Sheltered Housing or from a dispersed alarm in the community. The 5th column headed, 'Sys/Operator' indicates whether the call is answered by the system, or requires operator involvement. Based on the call type of the call an estimation of whether the call is a system or operator call is made but the user should verify this.

The remaining columns require additional information as indicated in Table A8.1.2.

Table A8.1.2: *Additional user information*

| Column | Description (for the specified call, indicated by the first 4 columns) |
|---|---|
| No. clients | The number of users who could have contributed to the category in question. I.e. if the call is indicated as 'Community', the number of users who have a community alarm and live dispersed throughout the community. |
| No. schemes | If the call is indicated as 'Sheltered', then the number of sheltered housing schemes to where a service is provided. If the category is from the community then this information is not relevant and therefore the program will not allow data to be entered. |
| No. week days | The number of weekdays over which the data in the control centre database was gathered. An estimation is made based on the number of days data is present. |
| No. weekend days | The number of weekend days over which the data in the control centre database was gathered. An estimation is made based on the number of days data is present. |
| The duration of an outgoing call (in seconds) | |
| Responder | To a responder. |
| Doctor | To the doctor. |
| Ambulance | To the ambulance service. |
| Police | To the police. |
| Fire | To the fire brigade. |

If a column has the same data for all categories of a call, for example the duration of a call to the ambulance is 50 seconds, then this information can be entered once in the appropriate column and the 'Update column' button used to update the whole column. When the necessary information has been entered and the 'Continue' button activated any information that has not been provided will be identified and requested.

If the database selected for manipulation contains data for other months then this process is repeated until all of the months have the additional information required. At which point the user can specify the file location of the created database and the control centre database will be analysed and a new database created for the telecare simulation program. The analysis may take some time, but information regarding the current state of progress is indicated at the bottom of the screen.

# Appendix A8.2

## User Documentation For The Telecare Simulation Program

### A8.2.1 Getting Started

This program is best viewed at a resolution of 800*600.

To install the utility program, insert the CD into the drive and open the 'Telecare_simulation' folder found in the 'Telecare_progs' folder. Clicking on the set-up icon will begin the installation process with further instructions being provided on screen.

To remove the program and all of its components use the Add/Remove programs from the control panel.

When the program has been successfully installed it can be chosen from the taskbar, with the screen highlighted in Fig A8.2.1 appearing.

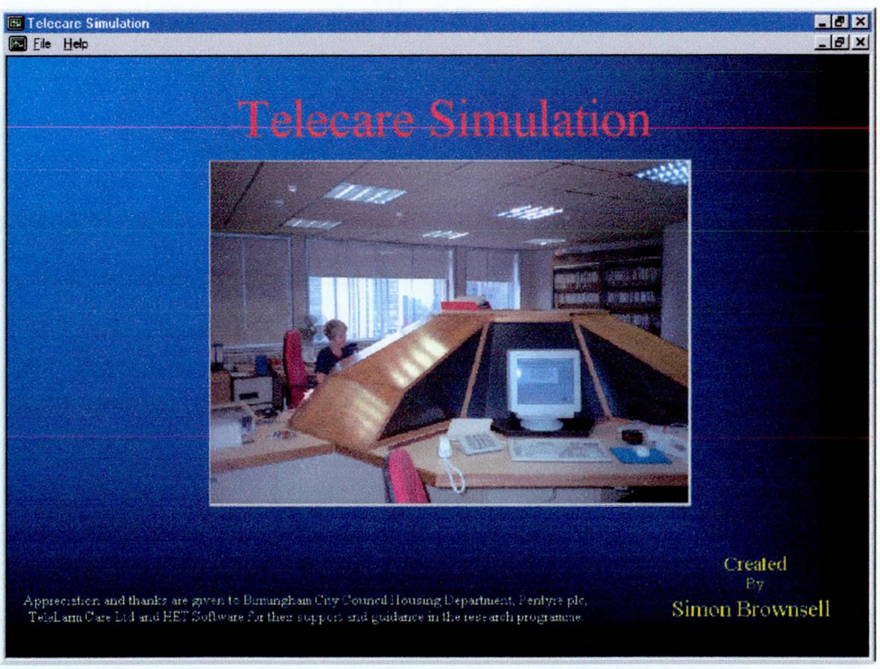



Figure A8.2.1: *The telecare simulation program opening screen*

From this screen all areas of the program can be accessed. This welcome screen allows access to:

- 'Opening a database': a core database which holding the call profiles of categories.
- 'Creating a core database': create a database which the telecare simulation uses.
- 'Loading a profile': load the results of a previous simulation run.

In addition a list of the last three databases and profiles is available in order to quickly load recently used files.

In order to run the simulation and generate results a database is required that stores the call profiles that are to be used in the model. If a core database is not available or been created then this must be created by selecting 'New Core database'. Alternatively, the telecare utility program can be used to create the Core database.

### A8.2.2 Creating a New Core database

When choosing to create a new core database a file name and location for the database is required. Once accepted the database structure will be created and the screen evident in Fig A8.2.2 will be apparent.

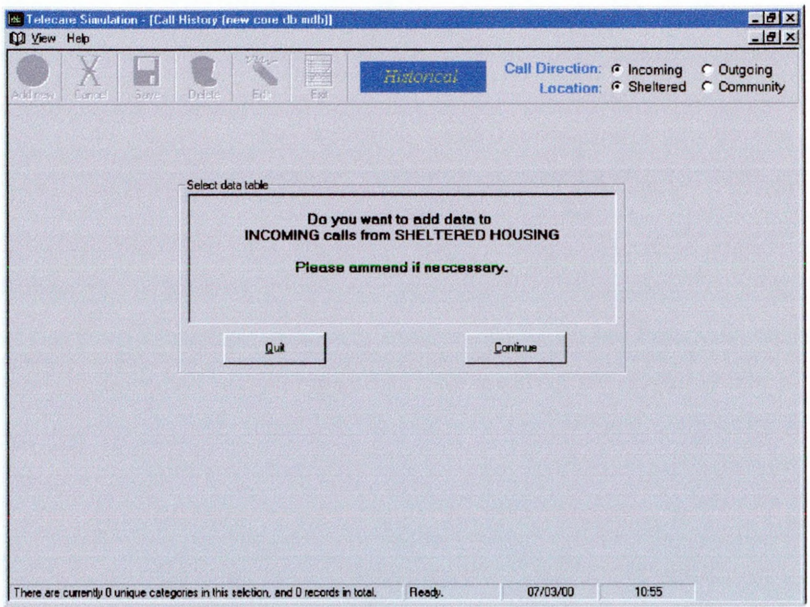



Figure A8.2.2: *Creating a new core database*

At this point the call profiles of categories to be included in the model can be entered and the choice is given as to what type of data to enter. Both the call direction and location can be changed by using the options in the top right corner of this screen in Fig A8.2.2. When the desired option has been chosen, by clicking on the 'Continue' button the screen in Fig A8.2.3 will appear.

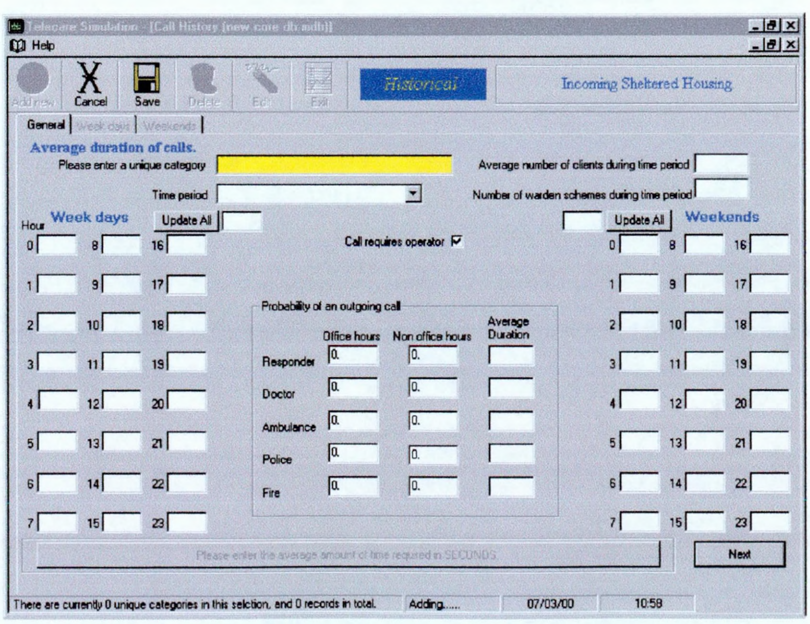



Figure A8.2.3: *Entering unique category information*

*Entering category information*

Having indicated the call direction (incoming or outgoing) and origin (sheltered housing or dispersed) further information is required to define a unique category. First a unique category name must be entered, for example 'Pulled in Error'. If the core database already contains a category with the same name, call direction and origin, then a list of the present categories will be presented on the screen and a suitable category name must be re-entered.

The time period indicates when the call data entered was gathered. The time period can be for a specific calendar month or the culmination of data of 3, 6, 9 or 12 months of call data. A choice can be made from the 'Time period' drop down menu.

Over the time period indicated the number of clients or users is required in order to accurately estimate future possibilities. If data is being entered for sheltered housing schemes, then the actual number of schemes is also required.

If the call requires the operator's involvement then the 'Call requires operator' should be checked. However, if the call is a system call and does not require the operator then this should be unchecked and the occurrence of calls entered by clicking on 'next'.

*Operator involved calls*

For calls requiring operator involvement the average duration of the call should be entered on an hourly basis. Therefore, if calls take longer at night than during the day this can be reflected in the model, alternatively if the average duration is the same throughout the day by entering a time in the update box and pressing the 'Update all' button, all 24 hours will be updated with the same duration. The time being entered should be in seconds and the average duration is required for both weekdays and weekends.

If the category of call being entered generates outgoing calls to a responder, doctor, ambulance, police or fire brigade then the probability that an individual call generates a call to each of these entities should be entered. For example, entering 0.5 represents a 50% chance of an outgoing call. The appropriate average duration of the outgoing call should also be entered.

*The number of week day calls*

Having entered the appropriate information relating to the duration of calls, when these calls occur is required using the template in Fig A8.2.4. The number of calls occurring for a particular hour should be entered on the column on the left, for example, if 100 calls were entered over the time period 09:00 to 10:00 then 100 is entered in 'Hour 9'. How these 100 calls are dispersed within the hour should be entered on the right of Fig A8.2.4

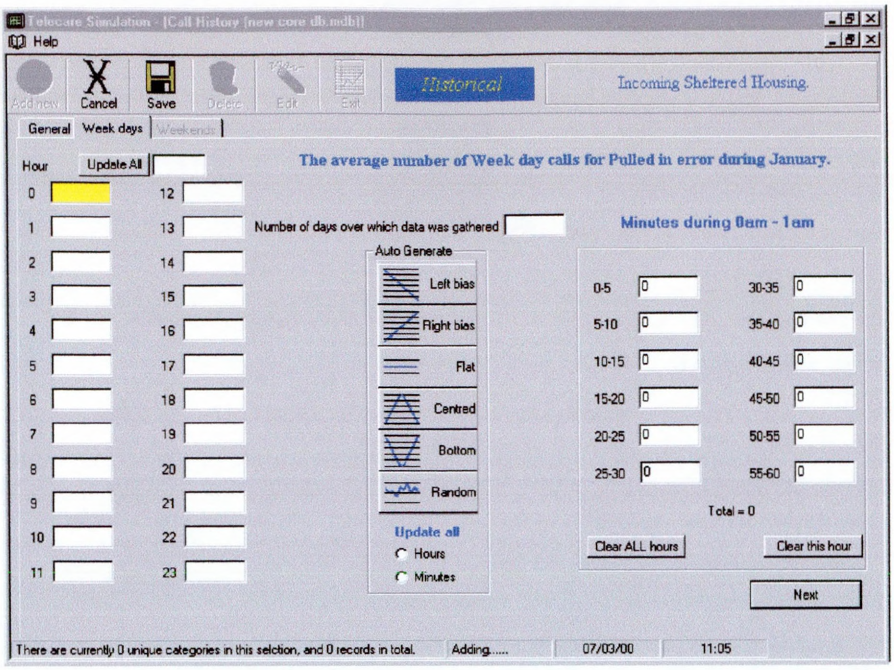



Figure A8.2.4: *Call occurrence for a weekday*

If the actual dispersion within the hour is known then this information can be entered directly, alternatively the 'Auto generate' section in the middle of the screen can be used to distribute the calls appropriately. For example, if 100 was entered in 'Hour 9' and the distribution of calls was biased to the left, i.e. more calls are evident at the beginning of the hour than the end, then by selecting the left bias button, while 'Hour 9' is highlighted, will automatically populate the 5 minute time slots. The options available are indicated in Table A8.2.1.

Table A8.2.1: *Automatic distributions*

| Auto generate | Description | Example using 100 calls as the total for the hour |
|---|---|---|
| Left | The data is secured to the left, i.e. more calls are received at the beginning and decline throughout the time period | 15,14,13,12,10,9,8,6,5,4,3,1 |
| Right | The data is secured to the right, i.e. few calls are received at the beginning and gradually increase throughout the time period | 1,3,4,5,6,8,9,10,12,13,14,15 |
| Flat | An equal number of calls are distributed throughout | 2,2,2,2,2,2,2,2,2,2,2,2, |
| Centred | Follows a normal distribution. More calls are received in the middle than the beginning and end | 2,5,7,10,12,14,14,12,10,7,5,2 |
| Bottom | Follows an inverse normal distribution. More calls are received at the beginning and end than the middle | 14,12,10,7,5,2,2,5,7,10,12,14 |
| Random | The calls are randomly distributed. | 10,6,5,13,11,5,9,9,7,9,7,9 |

The auto generate section in the middle of the screen can be used in several ways.

1. By entering the number of calls in an hour slot with the background yellow (i.e. this hour is selected), then by using the auto generate the 5 minute time slot for the selected hour will be generated accordingly to the distribution chosen.
2. By entering a number, say 48, in the update all box and selecting hours in the auto generate section, will enable the 48 entered to be distributed across all of the 24 hours, for example by choosing flat, all 24 hours will have 2 automatically entered.

3. By selecting minutes in auto generate and choosing an appropriate distribution, the 5-minute slots for all 24 hours will be automatically generated based on the numbers entered in each hour on the left of the screen.

Having entered the number of calls received for each hour and the corresponding 5-minute distributions, the number of days over which the data was gathered should be entered. Therefore, if the number of calls represent 4 weeks then 4 weeks of 5 days (only entering week days at this stage) represents 20 days. Once completed the same process is repeated for weekends.

Once the necessary information has been entered the data will be saved to the core database and another month for this category can be added or alternatively if this is not required, the main core database screen will be displayed as indicated in Fig A8.2.5.

### A8.2.3 Working with the core database

The main core database screen is indicated in Fig A8.2.5. In the top right corner of this screen are the current selection options for call direction and location, while below these is a list of the categories entered under the indicated call direction and location. Based on the category selected from the drop down menu the call data and graph show the number of calls received for week and weekdays. The graph can be enlarged by double clicking on it or by choosing 'Enlarge graph' from the 'Graph' drop down menu. For comparison purposes it is possible to have a number of these graph windows open at the same time.

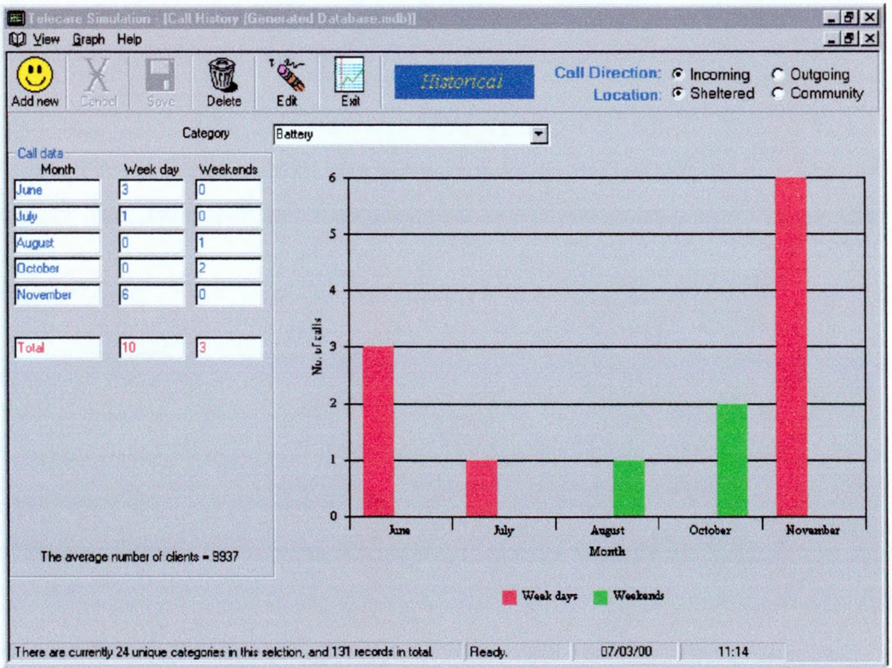



Figure A8.2.5: *The core database main screen*

Fig 8.2.5 indicates various options that are described below:

*Historical/Predicted*


The database groups data into historical and predicted call types. The type currently being viewed is displayed at the centre of the screen.

For ease of use it is suggested that historical data represents calls where the data is generated from actual records. Therefore, having integrated a control centres call history, this data would be entered as historical data. When new, hypothetical, call types are included then it is suggested that these be entered as predicted calls. The type of calls being viewed can be changed by clicking on the 'View' drop down menu.

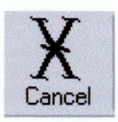
*Adding new data*


To enter new data into the core database the 'Add new' button can be used. A choice can then be made as to whether you wish to enter a new time period to an existing category or a new category all together.

Having chosen to enter a new time period to an existing category the selection criteria can be changed from incoming to outgoing calls etc. and a list is then provided of the categories currently entered. Once the required category has been selected data can be entered for a new time period as previously described by Fig A8.2.3.

Alternatively, when adding a new category the correct type must be ensured, i.e. incoming or outgoing call type etc. Having chosen the parameters for the new category the data can be entered as described by section A.8.2.2.

*Cancel button*




When the cancel button is enabled, by pressing it the current operation can be cancelled. For example, when entering data into the core database if a mistake has been made by pressing the 'Cancel' button the data entered will be ignored and the main core database screen will appear after conformation of the action.

*Save button*


Can be used when entering data. Will save the data to the core database.

*Delete button*


If a category or time period is no longer required then this can be removed from the core database. The appropriate category should be selected from the main core database screen and the delete button activated. A list of the time periods for this category will be presented and the appropriate time period(s) selected for deletion.

*Edit button*


If the data for a particular category needs modification then this can be achieved by selecting the appropriate category from the main core database screen and activating the edit button. All of time periods entered for the category can be selected once the edit button has been activated.

*Exit button*


Once activated the main simulation screen will appear as indicated by Fig A8.2.6.

## 8.2.4 The main simulation screen

The main features of the telecare simulation are operated from the main simulation screen, as indicated by Fig A8.2.6.

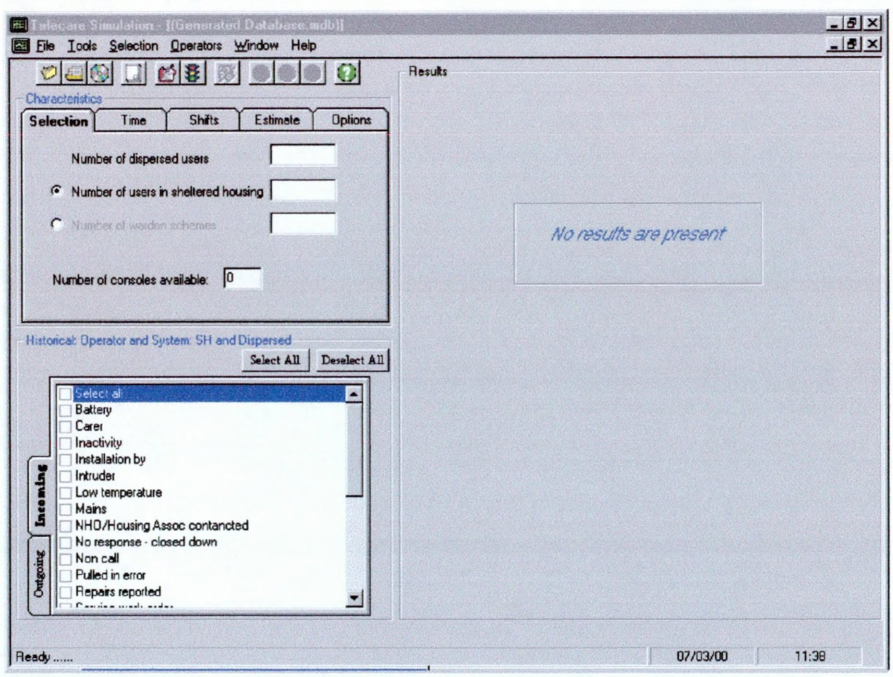



Figure A8.2.6: *The main simulation screen*

This screen enables the model characteristics to be defined and also presents the results. Using the 'Exit' button from the main core database will enable this screen to be evident. While it can also be obtained from the welcome screen (Fig A8.2.1) by opening a core database or loading the results of a simulation run, referred to as a profile.

When a core database is opened the categories to include in a simulation run are presented in the grid at the bottom left of Fig A8.2.6. This list of categories can be restricted to include only certain call types be choosing the 'Selection' drop down menu. The type of calls to include can be a combination of:

- Data time period: historical, predicted calls or both.
- Data type: operator involved calls, system only calls (no operator involvement) or both.

- Location: calls originating from sheltered housing locations, dispersed alarms (community based) or both.

When the data time period is set to 'Both' then an additional button is visible that allows the view to be changed from 'Historical' to 'Predicted' categories and vice-versa.

The 'Select all' button will select all options present in both incoming and outgoing calls (for Historical and Predicted if Data time period is set to both) of the current selection. If the selection is changed, perhaps from system calls to include both system and operator then all categories will be deselected. The 'Deselect all' button deselects all categories in incoming and outgoing call types.

*Modify selection criteria*

Having chosen the categories for inclusion in a simulation run these themselves can be modified. Based on the call dispersion entered in the core database the number and the duration of calls can be changed as indicated in Fig A8.2.7.

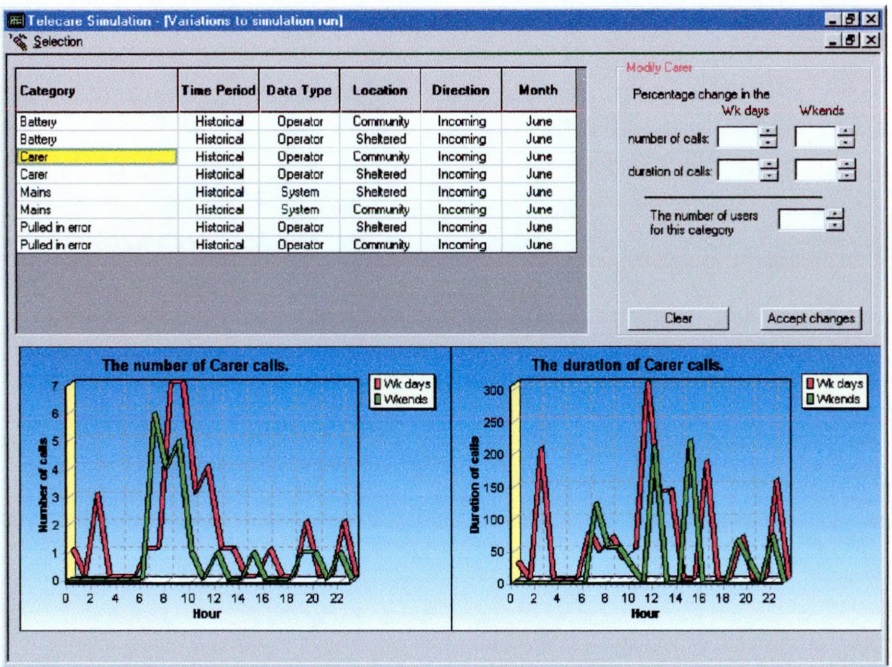



Figure A8.2.7: *Modify simulation categories*

The category that is to be modified must first be selected from the grid in the top left-hand corner of the modify screen. In the example of Fig A8.2.7 'Carer' has been selected. The number of calls generated in the simulation run can then be modified for weekdays and weekends, with both positive and negative values allowable. The number entered represents the percentage change, therefore if 100 calls had been entered in the core database then a by entering 10 the simulation will generate the number of calls as 110. If the call selected requires operator involvement then the duration of the call can be modified in a similar fashion.

The number of users per category can also be modified therefore if new technology becomes available, for example an effective fall detector, then the call characteristics can be entered in the core database and the simulation can mirror the call rates and workload at the control centre with varying numbers of users of this and any other technology. When the modifications have been made the 'Accept changes' button must be activated in order to save the modifications. The 'Clear' button will clear any modifications that have been previously accepted.

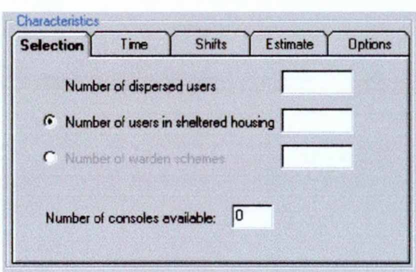
The two graphs representing the number and duration of the selected category can be enlarged by double clicking on them or choosing 'Enlarge graph' from the 'Selection' drop down menu.

Alternatively by selecting 'Modify all' from the selection drop down menu, all of the categories selected for inclusion in the simulation run can be modified as one. When the modifications have been made the window can either be minimised or closed, either option will save any modifications made.

### A.8.2.5 Simulation characteristics

At the top left-hand corner of the main simulation screen (Fig A8.2.6) the characteristics for the simulation run can be entered.

*Selection*

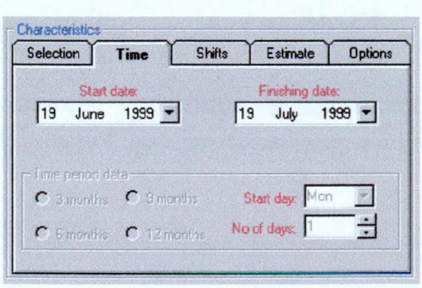



Under the selection tab the number of users to include in the simulation run can be entered. If both calls originating from sheltered housing schemes and users dispersed in the community are included then the number of people for each of these groups must be entered. Alternatively when entering the number of sheltered housing users the number of sheltered housing schemes can be used instead.

Also required is the number of consoles or terminals available. This represents the maximum number of positions where control centre operators can respond to calls.

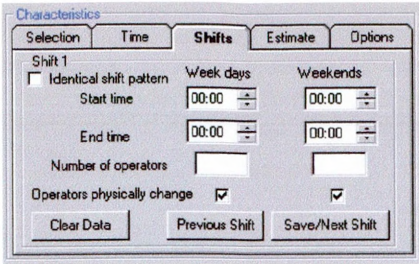
*Time*

The duration of the simulation is run is required and can be entered in one of two ways:




1. The simulation will run from a specified starting date to an ending date. For example, 19th June to the 19th July.
2. If data for the categories selected was grouped and entered as either 3,6,9 or 12 months then the appropriate time period can be selected. The starting day of the simulation run and the number of days over which the simulation will run can then be entered.

*Shifts*



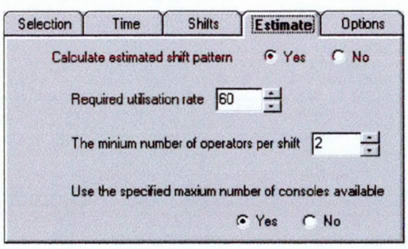

The availability of operators is required and is broken down into shift patterns for weekdays and weekends. If the shift patterns are the same then the 'Identical shift pattern' can be checked and the shift pattern will only have to be entered once.

When entering the shift pattern an option is given where staff physically change at the end of the shift. For example, if the present operator(s) leave and new operator(s) start at the end of the shift then this option should be checked. Alternatively, if one operator is on duty from 02:00 to 10:00 but from 08:30 to 10:00 an additional operator is available due to expected demand then the shift pattern should be entered as indicated in Table A8.2.2.

Table A8.2.2: *Indication of how operators physically change at the end of a shift*

| Shift number | Start time | End time | No. of operators | Physical change |
|---|---|---|---|---|
| Shift 1 | 02:00 | 08:30 | 1 | No |
| Shift 2 | 08:30 | 10:00 | 2 | Yes |

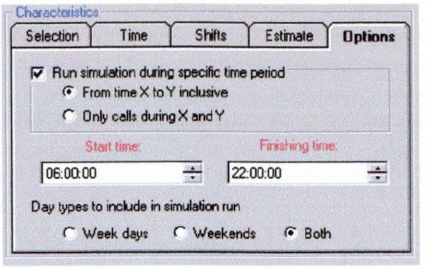
*Estimate*




In addition to the results based on the user defined shift pattern the model can also estimate an appropriate shift pattern. In order to achieve this three additional pieces of information are required:

1. Utilisation rate: This is the amount of time that operator(s) should be answering calls. For example, if 60% were to be entered then the simulation would generate a shift pattern based on 60% of the operators time being spent on calls and 40% of their time available for other tasks or spare capacity.
2. Minimum number of operators per shift: This indicates the minimum number of operators that should be on duty at any one time for example, if there should always be a minimum of 2 operators on duty then the simulation will ensure that the minimum suggested is at least 2.
3. Use the specified maximum number of consoles: The simulation will estimate the call pattern based either with the restriction of a maximum number of consoles available or without this restriction. If 'No' is entered the simulation calculates the ideal number of operators on duty and assumes that there are console positions available for any number of operators. If 'Yes' is entered then the simulation will restrict the estimated number of operators available at any one time to the physical number of consoles entered by the user.

*Options*




If January 1st and 2nd January were entered as the start and end dates then the simulation will run for 2 days, January 1st and 2nd. However, if results were only required from 06:00 on the 1st January to 22:00 on the 2nd January then this can be specified in the options section by checking 'From X to Y inclusive'.

Alternatively, by selecting the second option 'Only calls during X and Y', if the same times and dates were used as above then the results would only include calls that were received from 06:00 to 22:00 on the two days of the simulation run.

The final option allows only calls generated on a weekday, weekends or both to be included in the results. Therefore, by selecting weekday calls, any calls occurring in weekends are not included in the results.

### A.8.2.6 Running the simulation and interpreting the results

Having selected the categories and specified the model characteristics the simulation can be run and the simulated calls generated. This is achieved by pressing the 'Generate profile' button or by selecting this option from the 'Tools' drop down menu.

Depending on the number of days the simulation is run for, generating the results can take some time. As such, while the calls are being generated a progress bar is evident indicating the current state of progress. When the results have been generated they are displayed at the right of the main simulation screen (Fig A8.2.6). The left of the screen indicates which constraints were imposed to obtain the results. However, the categories at the bottom left hand corner of the screen are no longer evident.

If information regarding the actual categories used to generate the results is required then this information can be obtained by choosing 'Profile selections' from the 'Tools' drop down menu. Any modifications made to categories, for example increasing the number of calls by 10% is also highlighted.

If however a new simulation run is required then the categories can be displayed again by choosing "Display call options" from the View drop down menu.

*Summary*

The results are reported as indicated by Fig A8.2.8. The summary section reveals how many calls were generated during the simulation run. Results are shown on an hourly basis for calls not involving the operator (system calls) and those that did (operator). A breakdown is also given of the calls that originated from sheltered housing schemes and from dispersed alarm units or community based calls.

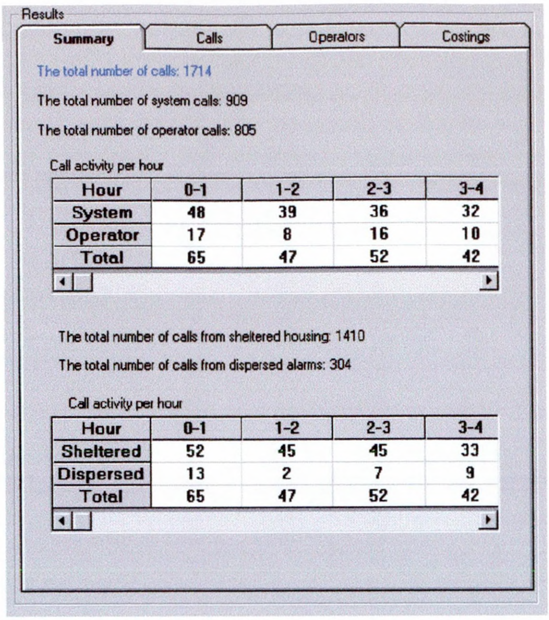



Figure A8.2.8: *Reporting the results of a simulation run*

*Calls*

Fig A8.2.9 indicates the results from the calls tab, with the grid at the top displaying the calls that were generated on an hourly basis for the duration of the simulation run. By double clicking on this grid or selecting the grid option under 'Enlarge calls' from the 'View' drop down menu, a breakdown of the calls are present on a half-hourly basis. To enlarge the graph the same process can be followed. Multiple windows of both the table and graph can be open at the same time for comparison purposes.

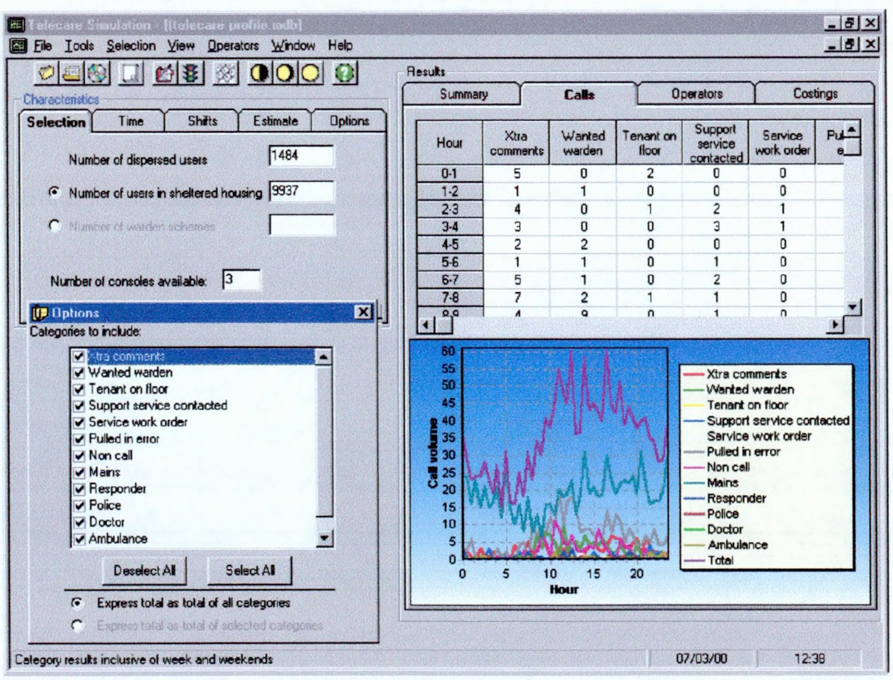



Figure A8.2.9: *Results on a call by call basis.*

When investigating the grid or graph in more detail by selecting only the categories for investigation from the options window (on the right of Fig A8.2.9) only those categories selected will be presented.

Different category selections can be made from both the data grid and graph once they have been enlarged.

From the View drop down menu there are various selection criteria for viewing the simulated calls on this screen:

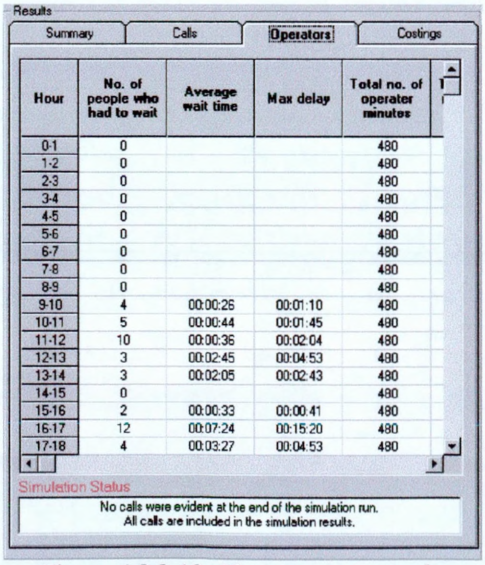
1. Generated/answered: Generated calls represent all calls that were generated under the conditions given, while answered calls represent all of the calls that were answered prior to the end of the simulation run. For example, if calls were received at the control centre just prior to the end of the simulation run, but these calls could not be answered until after the end of the simulation run, then these calls would not be evident in the answered section. However, they would be evident in the generated calls section.

2. Week, weekends and all days: By selecting 'Week days only' will only allow weekday calls to be presented and similarly for weekends. All days is the addition of both weekdays and weekends. If no calls were present for a weekday or weekend then no information will be evident for this selection and consequently it will not be possible to view that day type.

3. System/operator: System calls are calls that do not require any operator involvement, whilst operator calls are calls that operators have responded to. By selecting 'System/operator' the calls will be grouped into calls that were system and those that are operator. Selecting 'Individual categories' will return the view to each category that resulted in calls being generated.

*Operators*

The operator's results tab of Fig A8.2.9 shows calls that are answered by the operators and therefore 'Answered' must be selected from the 'View' drop down menu, as opposed to generated calls. If the operators tab is selected and generated calls are currently being viewed then notification will be given and the option available to view 'Answered' calls. When answered calls are being viewed a screen similar to that in Fig A8.2.10 will be evident.




| Hour | No. of people who had to wait | Average wait time | Max delay | Total no. of operater minutes |
|---|---|---|---|---|
| 0-1 | 0 | | | 480 |
| 1-2 | 0 | | | 480 |
| 2-3 | 0 | | | 480 |
| 3-4 | 0 | | | 480 |
| 4-5 | 0 | | | 480 |
| 5-6 | 0 | | | 480 |
| 6-7 | 0 | | | 480 |
| 7-8 | 0 | | | 480 |
| 8-9 | 0 | | | 480 |
| 9-10 | 4 | 00:00:26 | 00:01:10 | 480 |
| 10-11 | 5 | 00:00:44 | 00:01:45 | 480 |
| 11-12 | 10 | 00:00:36 | 00:02:04 | 480 |
| 12-13 | 3 | 00:02:45 | 00:04:53 | 480 |
| 13-14 | 3 | 00:02:05 | 00:02:43 | 480 |
| 14-15 | 0 | | | 480 |
| 15-16 | 2 | 00:00:33 | 00:00:41 | 480 |
| 16-17 | 12 | 00:07:24 | 00:15:20 | 480 |
| 17-18 | 4 | 00:03:27 | 00:04:53 | 480 |

Figure A8.2.10: *The operators results*

In a similar fashion to before the results can be viewed under different criteria, for example weekdays only etc. The grid on this screen presents several results on an hour by hour breakdown. The results are described in Table A8.3.

Table A8.3: *Descriptions of the results under the operators tab*

| Result | Description<br>*For a given hour....* |
|---|---|
| No. of people who had to wait | ..how many people who required the operator's assistance had to wait to be answered. |
| Average wait time | ..for those people who had to wait to be answered the average wait time. |
| Max delay | ..the maximum a caller had to wait to be answered. |
| Total no. of operator minutes | ..the total number of minutes operators were on duty. For example if 1 operator was on duty and the simulation ran for 4 days then the total, would be 240 minutes. (60 minutes on duty * 4 days). |
| Total no. of mins on calls | ..how many minutes were spent on calls during the simulation run. For example, if the simulation ran for 4 days and each day 10 minutes were spent on calls then the total would be 40 minutes. |
| Average daily no. of operator minutes | ..the daily number of operator minutes available to answer calls. |
| Average daily no. of minutes on calls | ..on a daily basis how many minutes are spent on calls. I.e. if for 4 days the minutes spent on calls are 20,30,20, 30 then the average daily figure is 25. |
| Operators utilisation | ..how much of the operator's time is spent on calls. I.e. 75% would indicate that 75% of the hour (45 min) was spent on calls and for 25% (15 min) of the hour the operator was ready to receive calls. |

At the bottom of the operators results tab, shown in Fig A8.2.10 are details of the simulation status. The simulation gives details of any calls that were evident after the simulation ending date in a grid and by double clicking on this grid details of the calls not included in the results can be viewed. In order to view more of the simulation results on the screen, the simulation status message or grid can be removed by checking 'View simulation status' from the 'Operators' drop down menu.

By double clicking on the operator results grid or by selecting 'Enlarge operators' from the 'View' drop down menu more detailed information is provided showing the results in half hour segments as indicated in Fig A8.2.11. As before several of these windows can be opened at the same time in order to compare different selection criteria.

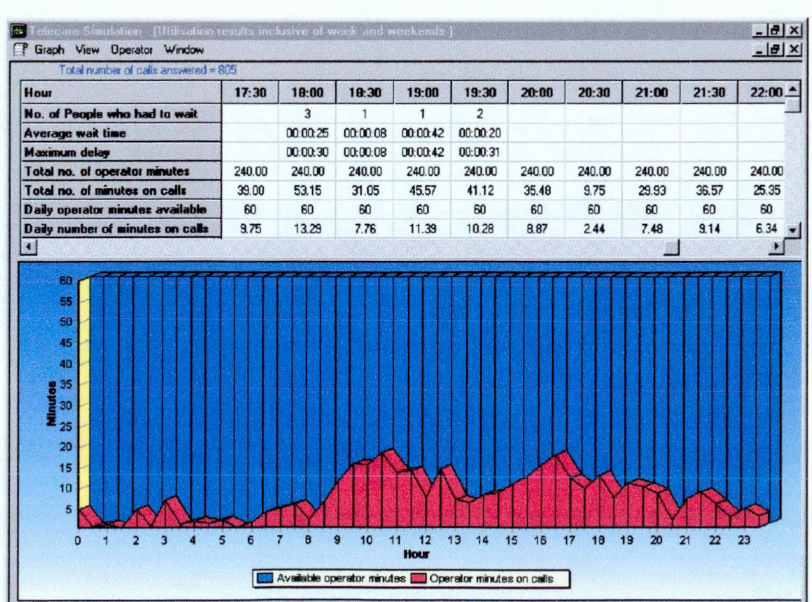



Figure A8.2.11: *Detailed operator results*

The graph on Fig A8.2.11 can be viewed as either a total of the whole simulation run or as an average of a single day. Interchanging between these options is provided from the 'Graph' drop down menu. The data grid on this screen highlights several different aspects of operator involvement as described previously in Table A8.3. The difference being that hour refers to a half-hour period, therefore 17:30 includes 17:30:00 to 17:59:59.

At the end of the data grid is a column indicated the total for each Result. Therefore, the operators utilisation figure expressed in the total column is the average of all 48 half-hour periods.

*Costing*

Results from the costing tab are based on the simulated calls received at the control centre and the shift pattern entered by the user. They are reported as indicated by Fig A8.2.12.

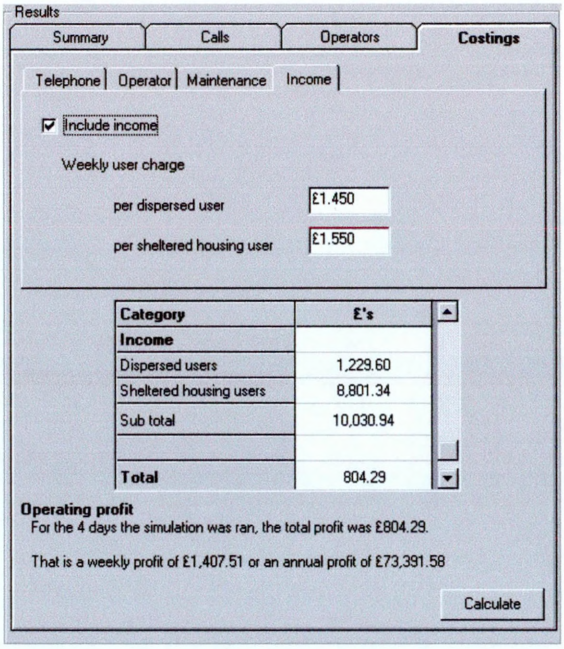
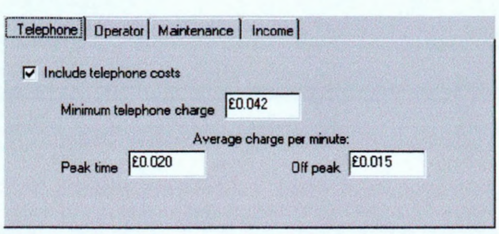



Figure A8.2.12: *The results of the cost analysis*

The information required is based on all or any of the 4 cost options:

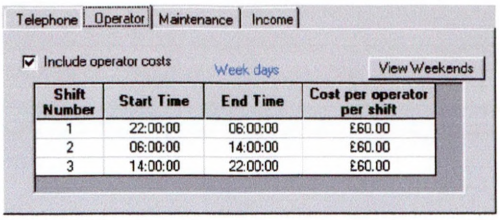
*Telephone*




The minimum telephone charge is the minimum call charge imposed by the service provider, for example if all calls have a minimum charge of 4.2p then £0.042 can be entered for this option.

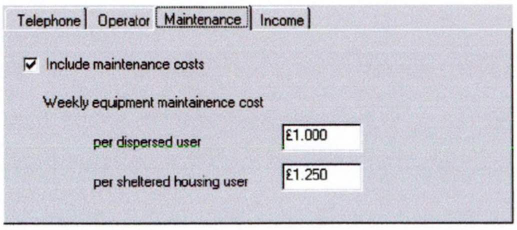
The remaining two boxes refer to calls that are above the minimum imposed call charge, and are the average cost per minute at peak and off peak times. Peak call times are set from 08:00 to 18:00 inclusive.

*Operator*



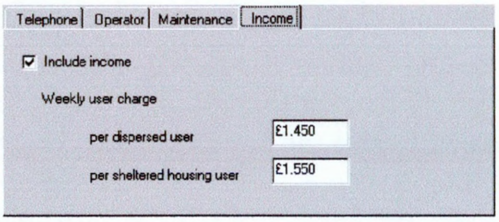

To calculate the operator costs the cost per operator per shift should be entered for both weekday and weekend shifts.

*Maintenance*




This option is the total weekly cost of offering the service. The only costs that should not be included are operator costs and telephone expenses. The costs entered should be apportioned by user type, i.e. for dispersed users and for sheltered housing users (or schemes).

*Income*




This refers to the weekly charge made to each user type (dispersed or sheltered housing user).

By entering the relevant information and clicking on the 'Calculate' button (see Fig A8.2.12) the results will be generated and presented. Changes can be made to the costs and the results recalculated by using the 'Calculate' button again.

### A.8.2.7 Delayed calls

If calls were delayed during the simulation run then details of the number and time of these calls are highlighted on a specific screen, see Fig A8.2.13. This can be obtained by selecting 'Delayed calls' from the 'View' drop down menu. However, this option is only available when at least 1 call is delayed during the simulation run.

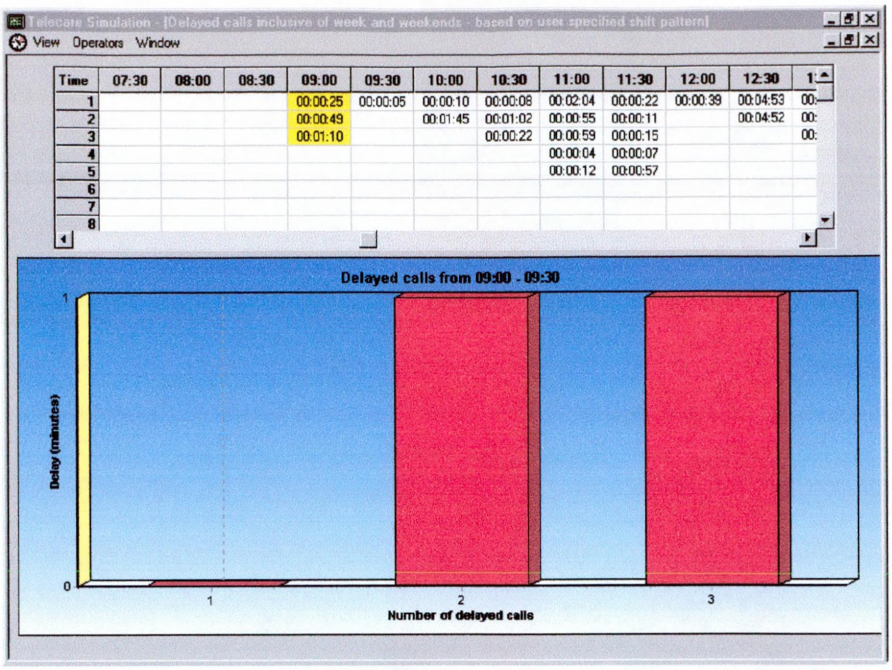



Figure A8.2.13: *Details of calls that were delayed during the simulation run*

Delayed calls can be viewed for weekdays, weekends or the summation of both these day types. While if calls were delayed, both the user specified and the estimated shift pattern (if available) can be investigated. By selecting a particular hour where calls have been delayed these calls will be shown in the graph. For comparison purposes multiple windows can be opened at the same time.

The number of delayed calls refers to the whole duration run and not a specific day. Therefore, if 10 calls were delayed in a given half hour period, and the simulation was ran for 5 days, then on average 2 calls per day would be delayed.

### A.8.2.8 SQL – (Standard Query Language)

The SQL option allows the simulation user to analyse the simulated calls with a great degree of flexibility. For example, by entering 'Select * from calls where answered >=#10:00:00# and answered <=#11:00:00#' in the text box at the bottom of the screen, as indicated in Fig A8.2.14, and pressing 'Execute' will display all of the calls answered between 10:00 and 11:00. This screen is only available when results are present and can be found by selecting 'SQL' from the 'Tools' drop down menu.

Changing the 'Operators' selection to 'Generated shift pattern' (if available) and entering the same SQL query will result in the calls between 10:00 and 11:00 that were answered with the estimated shift pattern.

Clicking on the grid headings will sort the data in descending order. To refresh the display to the original (i.e. order the calls in the way they were received and answered) the 'Refresh table' button can be used.

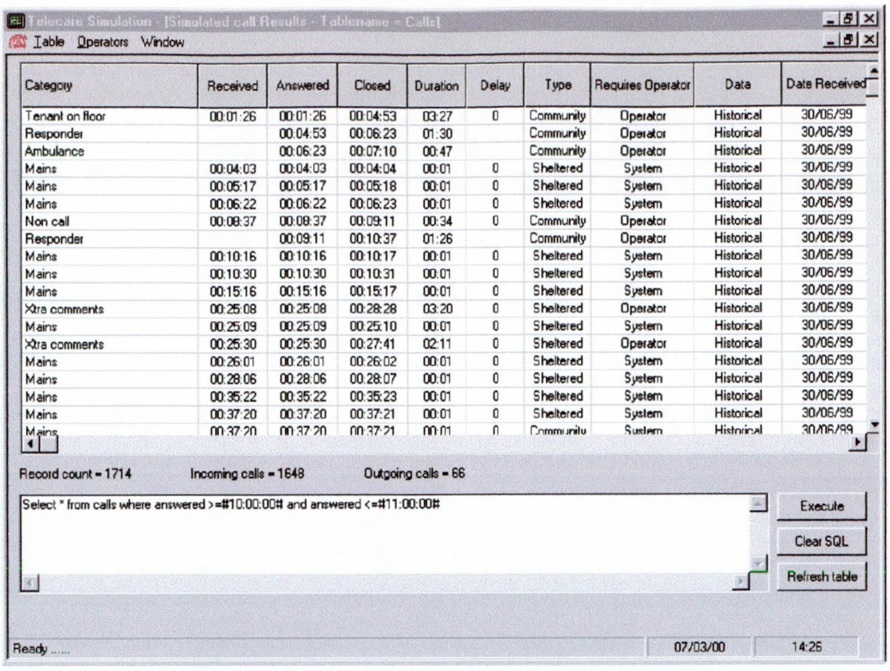



Figure A8.2.14: *Example of the SQL user screen*

## A.8.2.9 Working with profiles

When the simulation has completed a simulation run the results can be saved for subsequent analysis. These results are saved as a *Profile*.

When loading a profile, the generated results are evident in the results section of the main screen. The number of users, warden schemes, the shift pattern etc. used to generate the results will be presented in the characteristics section, at the left of the main simulation screen.

## A.8.2.10 Working with graphs

Many of the graphs in the programme can be *zoomed* into, therefore if a particular section of the graph is of interest, this section can be selected and enlarged. Zooming in on a particular area is achieved by selecting the top left hand corner of the required section, holding the left mouse button and dragging the mouse to the bottom right hand corner. The mouse button can then be released and the graph will show just the selected area.

To reset the graph to the original layout the reverse procedure is performed, i.e. dragging with the left mouse button, from a bottom right corner of the graph to a top left corner. Alternatively 'Reset graph display' can be selected from the 'Graph' drop down menu. (on the main simulation screen, Fig A8.2.6, 'Reset graph display' can be found under the 'View' drop down menu').

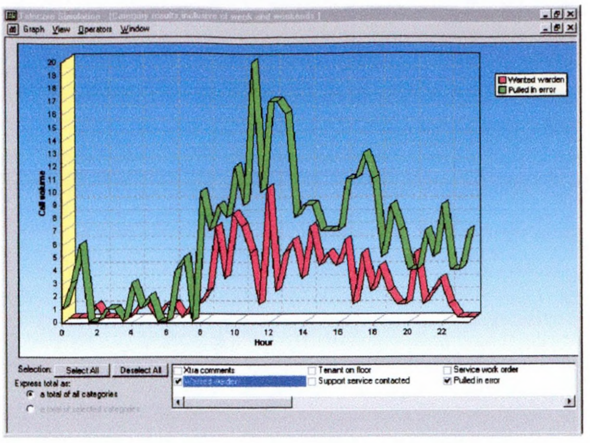


Figure A8.2.15: *The normal layout of a graph*

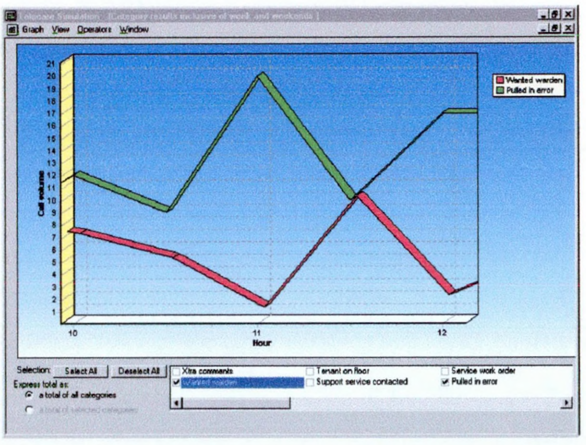


Figure A8.2.16: *The same graph as Fig A8.2.15, but zoomed in between 10:00 and 12:00*

# Appendix A9.1

## Model Outputs

Table A9.1.1: *Number of outgoing calls for June*

| June | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 368 |
| | 2 | 366 |
| | 3 | 382 |
| | 4 | 377 |
| | 5 | 385 |
| | 6 | 380 |
| **Average** | | **376** |

Table A9.1.2: *Number of outgoing calls for July*

| July | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 406 |
| | 2 | 374 |
| | 3 | 386 |
| | 4 | 415 |
| | 5 | 376 |
| | 6 | 376 |
| **Average** | | **389** |

Table A9.1.3: *Number of outgoing calls for August*

| Aug | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 384 |
| | 2 | 399 |
| | 3 | 370 |
| | 4 | 393 |
| | 5 | 432 |
| | 6 | 409 |
| **Average** | | **398** |

Table A9.1.4: *Number of outgoing calls for September*

| Sept | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 436 |
| | 2 | 424 |
| | 3 | 420 |
| | 4 | 408 |
| | 5 | 435 |
| | 6 | 447 |
| **Average** | | **428** |

Table A9.1.5: *Number of outgoing calls for October*

| Oct | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 448 |
| | 2 | 432 |
| | 3 | 418 |
| | 4 | 430 |
| | 5 | 448 |
| | 6 | 451 |
| **Average** | | **438** |

Table A9.1.6: *Number of outgoing calls for November*

| Nov | Model run | Number of outgoing calls |
|---|---|---|
| | 1 | 430 |
| | 2 | 444 |
| | 3 | 437 |
| | 4 | 421 |
| | 5 | 432 |
| | 6 | 434 |
| **Average** | | **433** |

Table A9.1.7: *Analysis for June with 20% more sheltered housing schemes*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 25,709 | 17,422 | 8,287 | 313 | 9:00 | 0:47 |
| 2 | 25,693 | 17,363 | 8,330 | 299 | 10:40 | 0:40 |
| 3 | 25,584 | 17,294 | 8,290 | 283 | 14:22 | 1:06 |
| 4 | 25,749 | 17,440 | 8,309 | 314 | 16:03 | 0:43 |
| 5 | 25,825 | 17,483 | 8,342 | 342 | 12:32 | 0:56 |
| 6 | 25,756 | 17,438 | 8,318 | 286 | 8:30 | 0:48 |
| **Avg** | **25,719** | **17,407** | **8,313** | **306** | **11:51** | **0:50** |

Table A9.1.8: *Analysis for June with 20% fewer sheltered housing schemes*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 17,132 | 11,642 | 5,490 | 84 | 7:31 | 0:42 |
| 2 | 17,067 | 11,572 | 5,495 | 79 | 4:04 | 0:36 |
| 3 | 17,069 | 11,569 | 5,500 | 62 | 4:00 | 0:44 |
| 4 | 17,105 | 11,617 | 5,488 | 78 | 3:53 | 0:31 |
| 5 | 17,106 | 11,643 | 5,463 | 84 | 4:03 | 0:35 |
| 6 | 17,066 | 11,610 | 5,456 | 100 | 4:03 | 0:41 |
| **Avg** | **17,091** | **11,609** | **5,482** | **81** | **4:36** | **0:38** |

Table A9.1.9: *Analysis for June with 15% more community and sheltered housing users*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 24,611 | 16,657 | 7,954 | 244 | 5:43 | 0:42 |
| 2 | 24,603 | 16,625 | 7,978 | 263 | 5:31 | 0:36 |
| 3 | 24,634 | 16,634 | 8,000 | 270 | 8:43 | 0:51 |
| 4 | 24,656 | 16,685 | 7,971 | 262 | 6:38 | 0:44 |
| 5 | 24,724 | 16,729 | 7,995 | 256 | 15:20 | 1:14 |
| 6 | 24,709 | 16,676 | 8,043 | 231 | 12:43 | 0:58 |
| **Avg** | **24,656** | **16,668** | **7,990** | **254** | **9:06** | **0:51** |

Table A9.1.10: *Analysis for June with 15% fewer community and sheltered housing users*

| | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| June | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 18,200 | 12,385 | 5,815 | 112 | 8:49 | 0:52 |
| 2 | 18,156 | 12,303 | 5,853 | 101 | 5:10 | 0:40 |
| 3 | 18,190 | 12,397 | 5,793 | 103 | 3:29 | 0:41 |
| 4 | 18,160 | 12,340 | 5,820 | 83 | 4:04 | 0:34 |
| 5 | 18,167 | 12,321 | 5,846 | 81 | 5:45 | 0:32 |
| 6 | 18,175 | 12,324 | 5,851 | 104 | 3:08 | 0:32 |
| **Avg** | **18,175** | **12,345** | **5,830** | **97** | **5:04** | **0.39** |

Table A9.1.11: *Analysis for June where the duration of calls is increased by 10%*

| June | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 21,364 | 14,513 | 6,851 | 171 | 5:23 | 0:42 |
| 2 | 21,350 | 14,480 | 6,870 | 185 | 12:49 | 0:47 |
| 3 | 21,412 | 14,522 | 6,890 | 169 | 5:43 | 0:43 |
| 4 | 21,385 | 14,546 | 6,839 | 168 | 4:17 | 0:32 |
| 5 | 21,325 | 14,420 | 6,905 | 201 | 6:24 | 0:42 |
| 6 | 21,353 | 14,489 | 6,864 | 191 | 13:16 | 1:08 |
| **Avg** | **21,365** | **14,495** | **6,870** | **181** | **7:59** | **0.46** |

Table A9.1.12: *Analysis for June where the duration of calls is reduced by 10%*

| June | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 21,391 | 14,492 | 6,899 | 145 | 3:48 | 0:35 |
| 2 | 21,284 | 14,439 | 6,845 | 118 | 9:44 | 0:43 |
| 3 | 21,318 | 14,470 | 6,848 | 155 | 8:19 | 1:11 |
| 4 | 21,358 | 14,483 | 6,875 | 136 | 6:41 | 0:56 |
| 5 | 21,344 | 14,467 | 6,877 | 131 | 5:32 | 0:33 |
| 6 | 21,297 | 14,441 | 6,856 | 157 | 7:50 | 0:42 |
| **Avg** | **21,332** | **14,465** | **6,867** | **140** | **6:59** | **0:47** |

Table A9.1.13: *Model results for July*

| July | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 22,076 | 15,431 | 6,645 | 162 | 4.53 | 0.42 |
| 2 | 22,096 | 15,446 | 6,650 | 184 | 6.03 | 0.46 |
| 3 | 22,011 | 15,361 | 6,650 | 163 | 5.25 | 0.49 |
| 4 | 22,065 | 15,394 | 6,671 | 192 | 5.17 | 0.45 |
| 5 | 22,050 | 15,403 | 6,647 | 175 | 5.41 | 0.42 |
| 6 | 22,066 | 15,389 | 6,677 | 202 | 3.43 | 0.35 |
| **Avg** | **22,061** | **15,404** | **6,657** | **180** | **5:10** | **0:43** |

Table A9.1.14: *Model results for August*

| Aug | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 21,514 | 14,480 | 7,034 | 189 | 6.52 | 0.45 |
| 2 | 21,537 | 14,500 | 7,037 | 160 | 14.57 | 0.50 |
| 3 | 21,371 | 14,363 | 7,008 | 182 | 4.58 | 0.37 |
| 4 | 21,468 | 14,412 | 7,056 | 177 | 18.41 | 0.46 |
| 5 | 21,548 | 14,517 | 7,031 | 185 | 14.05 | 0.38 |
| 6 | 21,389 | 14,355 | 7,034 | 201 | 5.11 | 0.35 |
| **Avg** | **21,471** | **14,438** | **7,033** | **182** | **10:47** | **0:42** |

Table A9.1.15: *Model results for September*

| Sept | Number of calls | | | | | |
|---|---|---|---|---|---|---|
| | Total | System | Operator | Delayed | Max delay | Avg delay |
| 1 | 21,247 | 14,714 | 6,533 | 153 | 4.25 | 0.38 |
| 2 | 21,271 | 14,752 | 6,519 | 108 | 3.33 | 0.37 |
| 3 | 21,425 | 14,838 | 6,587 | 135 | 5.38 | 0.42 |
| 4 | 21,219 | 14,632 | 6,587 | 144 | 8.15 | 1.01 |
| 5 | 21,276 | 14,735 | 6,541 | 131 | 5.02 | 0.49 |
| 6 | 21,205 | 14,697 | 6,508 | 148 | 9.04 | 0.44 |
| **Avg** | **21,274** | **14,728** | **6,546** | **137** | **6:00** | **0:45** |

Table A9.1.16: *Model results for October*

| Oct | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 21,942 | 14,748 | 7,194 | 137 | 2.26 | 0.26 |
| 2 | 21,950 | 14,797 | 7,153 | 133 | 10.01 | 0.47 |
| 3 | 21,869 | 14,649 | 7,220 | 170 | 6.16 | 0.45 |
| 4 | 21,947 | 14,763 | 7,184 | 140 | 3.26 | 0.36 |
| 5 | 21,895 | 14,684 | 7,211 | 139 | 2.07 | 0.33 |
| 6 | 21,848 | 14,661 | 7,187 | 185 | 6.22 | 0.36 |
| **Avg** | **21,909** | **14,717** | **7,192** | **151** | **5:06** | **0:37** |

Table A9.1.17: *Model results for November*

| Nov | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 22,657 | 15,312 | 7,345 | 367 | 3.05 | 0.40 |
| 2 | 22,618 | 15,289 | 7,329 | 380 | 4.42 | 0.38 |
| 3 | 22,662 | 15,322 | 7,340 | 401 | 6.07 | 0.52 |
| 4 | 22,556 | 15,240 | 7,316 | 355 | 3.31 | 0.40 |
| 5 | 22,659 | 15,313 | 7,346 | 359 | 3.48 | 0.42 |
| 6 | 22,587 | 15,277 | 7,310 | 345 | 5.30 | 0.48 |
| **Avg** | **22,623** | **15,292** | **7,331** | **368** | **4:27** | **0:43** |

Table A9.1.18: *Analysis of the 2nd generation system with 20% fewer calls*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 54,939 | 51,778 | 3,161 | 24 | 1:09 | 0:18 |
| 2 | 55,090 | 51,953 | 3,137 | 12 | 2:26 | 0:41 |
| 3 | 54,766 | 51,644 | 3,122 | 19 | 6:43 | 1:31 |
| 4 | 54,988 | 51,844 | 3,144 | 10 | 1:01 | 0:15 |
| 5 | 55,011 | 51,869 | 3,142 | 13 | 5:44 | 1:13 |
| 6 | 54,752 | 51,636 | 3,116 | 14 | 5:33 | 0:41 |
| **Avg** | **54,924** | **51,787** | **3,137** | **15** | **3:46** | **0:47** |

Table A9.1.19: *Analysis of the 2nd generation system with 20% more calls*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 82,686 | 77,977 | 4,709 | 47 | 18:18 | 1:34 |
| 2 | 82,544 | 77,834 | 4,710 | 55 | 3:17 | 0:33 |
| 3 | 82,555 | 77,864 | 4,691 | 52 | 6:01 | 0:55 |
| 4 | 82,552 | 77,855 | 4,697 | 57 | 11:57 | 1:28 |
| 5 | 82,486 | 77,804 | 4,682 | 56 | 8:23 | 1:14 |
| 6 | 82,696 | 77,996 | 4,700 | 42 | 4:56 | 0:28 |
| **Avg** | **82,587** | **77,888** | **4,698** | **52** | **8:49** | **1:02** |

Table A9.1.20: *The anticipated 2nd generation system including out of hours repairs*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| *Present* | *26,596* | *14,502* | *12,092* | *2,062* | *11.01* | *1:42* |
| 1 | 73,874 | 64,735 | 9,139 | 1,486 | 8:59 | 1:37 |
| 2 | 74,118 | 64,955 | 9,163 | 1,391 | 9:14 | 1:45 |
| 3 | 73,906 | 64,764 | 9,142 | 1,100 | 8:23 | 1:24 |
| 4 | 74,073 | 64,940 | 9,133 | 1,355 | 10:55 | 1:33 |
| 5 | 74,194 | 65,043 | 9,151 | 1,305 | 11:02 | 1:40 |
| 6 | 73,658 | 64,534 | 9,124 | 1,297 | 8:44 | 1:31 |
| **Avg** | **73,971** | **64,662** | **9,142** | **1,322** | **9:32** | **1:35** |

Table A9.1.21: *The anticipated 2nd generation system including out of hours repairs with 20% more calls*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 88,431 | 77,438 | 10,993 | 2,017 | 10:12 | 1:43 |
| 2 | 88,496 | 77,524 | 10,972 | 2,040 | 10:44 | 1:45 |
| 3 | 88,794 | 77,748 | 11,046 | 2,050 | 12:04 | 1:45 |
| 4 | 88,832 | 77,865 | 10,967 | 2,450 | 10:17 | 1:57 |
| 5 | 88,733 | 77,665 | 11,068 | 2,494 | 17:49 | 2:11 |
| 6 | 88,464 | 77,384 | 11,080 | 2,360 | 17:33 | 2.05 |
| **Avg** | **88,625** | **77,604** | **11,021** | **2,235** | **13:07** | **1:54** |

Table A9.1.22: *The anticipated 2nd generation system inc. out of hours repairs with 20% fewer calls*

| June | Number of calls | | | Delayed | Max delay | Avg delay |
|---|---|---|---|---|---|---|
| | Total | System | Operator | | | |
| 1 | 59,054 | 51,721 | 7,333 | 834 | 8:02 | 1:31 |
| 2 | 59,128 | 51,789 | 7,339 | 599 | 10:11 | 1:17 |
| 3 | 59,284 | 51,955 | 7,329 | 765 | 7:25 | 1:40 |
| 4 | 59,244 | 51,917 | 7,327 | 581 | 5:56 | 1:21 |
| 5 | 59,162 | 51,878 | 7,284 | 620 | 5:19 | 1:20 |
| 6 | 59,204 | 51,866 | 7,338 | 626 | 9:58 | 1:20 |
| **Avg** | **59,179** | **51,854** | **7,325** | **671** | **7:49** | **1:25** |

# Appendix A10.1

## Publications And Presentations

*Books*

1. Porteous J and Brownsell S. (2000). "**Using Telecare: Exploring technologies for independent living for older people.**" Anchor Trust and The Housing Corporation. ISBN 0 906178 56 8.

*Referenced journals*

1. Brownsell S, Williams G, Bradley D, Bragg R, Catlin P and Carlier J. (1999). "**Future systems for remote health care.**" Journal of Telemedicine and Telecare. 5: 141-152.
2. Brownsell S, Bradley D, Bragg R, Catlin P and Carlier J. (2000). "**Do community alarm users want telecare?**" Journal of Telecare and Telemedicine. 6:199-204.
3. Brownsell S and Porteous J. (2000). "**Technology for independence.**" Housing, Care and Support. 3(3). Pavilion Publishing: 27.

*Other journals*

1. Brownsell S and Doughty K. (1997). "**Healthcare in the Home - The impact of Technology on the Delivery of Services.**" Baseline - Journal of British Association for Service to the Elderly. No 65: 3-17.

*Article (invited)*

1. Brownsell S and Porteous J. (2000). "**Declaring independence.**" Housingtoday: 21.

*Article Other*

1. Brownsell S. (1999). "**With Respect to Old Age: Long Term Care - Rights and Responsibilities.**" Royal Commission. (Contributor).
2. (1999). "**Using Telecare: The Experiences and Expectations of Older People.**" Anchor Trust. ISBN 0 906178 54 1. (Editor).

*Referenced conferences*

1. Bradley D, Brownsell S, Bragg R, Catlin P and Carlier J. (1999). "**Do Users Want Telecare and Can It Be cost-effective**?" Proceedings of the First Joint IEEE BMS/EMBS conference 'Serving Humanity, Advancing Technology' October 13-16 Atlanta, GA, USA: 714.
2. Brownsell S, Williams G and Bradley D. (1999). "**Information Strategies in Achieving an Integrated Home Care Environment.**" Proceedings of the First Joint IEEE BMS/EMBS conference 'Serving Humanity, Advancing Technology' October 13-16 Atlanta, GA, USA: 1224.

*Other conference*

1. Brownsell S and Bradley D. (1998) "**Future Developments in Telecare.**" Proceedings of In Celebration of 50 years of the NHS, University of Wales Bangor.
2. Brownsell S, Poole P and Brownsell G. (1998). "**New alarm technology - will it lead to data overload**?" Proceedings of The technological Future for Sheltered Housing, The Strathallan Thistle Hotel, Birmingham.

*Other presentations*

1. Brownsell S, Poole P. (1998). "**The user survey**." Pemberley Road Residents forum.
2. Brownsell S, Poole P. (1998). "**Lifestyle monitoring**." Association of Community Alarm Providers National Conference.
3. Brownsell S, Poole P. (1999). "**Services for the retired**." 8th retirement association chairpersons' Boots.
4. Brownsell S. (2000). "**Community alarms to telecare: practical issues.**" Charted Institute of Housing: Community Alarm Group 7th Annual Conference. Toorak Hotel, Torquay.
5. Brownsell S. (2000). "**Preventative aspects of telecare**." Southern Institute of Health Informatics.
6. Brownsell S. (2000). "**An introduction to remote medical care**." Barnsley District General Hospital. Research Seminar.
7. Brownsell S. (2000) "**Assistive technology – the use of telecare**." Sheffield Hallam University Hospital. Research Seminar.

*Papers accepted for publication.*

1. Brownsell S, Bradley D, Bragg R, Catlin P and Carlier J. (2000). "**Is Telecare Cost Effective**?" Journal of Telecare and Telemedicine. In press.

*Papers currently in preparation.*

1. Bradley DA. Williams G. Brownsell S and Levy S. "**Community alarms to telecare: a systems strategy for an integrated telehealth provision.**"