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Improving Health Outcomes for the Elderly: An Analytic Framework

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An Analytic Framework

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Abstract

The authors present an analytic framework for investigating interactive gaming technologies and integrating a number of such technologies into a remote healthcare monioring system (ReMoteCare) to help improve the quality of life of the elderly, the chronically unwell and infirm whether they are living in their own homes or in aged care facilities. The framework covers population characteristics of the cohort, the interactive technologies as well as economic and environmental factors. It is anticipated that a series of interactive exercises, developed in conjunction with a Feldenkrais movement therapist who specializes in exercises for the elderly, will help to improve the physical and mental health outcomes of this cohort.

Keywords: Interactive, games, elderly, chronically unwell, analytic, framework

1 Introduction

Remote monitoring of health conditions is an essential step for collecting evidence for improving the physical and mental outcomes for the elderly, chronically unwell and infirm as well as for policy development for governments . However, it is also vital to encourage such people to do beneficial physical and mental exercises and support them throughout the process in order to maintain good health outcomes. Current information and communication technologies on assistive healthcare mainly focus on remote sensing

using the Internet and wireless sensor networks for collecting health condition data of elderly people. Examples include the *ReMoteCare* system (Fischer et al, 2008), (Lawrence et al, 2010) as well as the *Personal Health Monitor* developed at our university (Leijdekkers et al, 2007). Very little effort has been made to support collaborative planning, implementation procedures for physical training (such as callisthenics and cardiovascular exercise), mental training such as described by Chilukoti et al (2007) and assessment. Our proposed mobile interactive technology aims to allow people to perform fitness programs while their physiological conditions are sensed and functionally assessed remotely. We have used an Analytic Framework based on work by Jimison et al (2008) to investigate the aged population cohort, to study the econonomic and environmental facors and to help in assessing whether interactive technologies are useful for the elderly, chronically unwell and the infirm.

The percentage of aged persons over 65 is increasing dramatically both in Australia and worldwide and unfortunately, as people age, their mental and physical health deteriorates and impacts negatively on their quality of life. This paper specifically investigates ways in which Interactive technologies, such as the *Nintendo Wii* and *Project Natal* could help to overcome functional decline, maintain independence and preserve social connectivity and engagement among seniors (Jimison, 2008). Our project should, in time, reveal (a) the potential impact of interactive computer technologies on client and carer outcomes and satisfaction levels, (b) the potential impact of clients' abilities to adapt to the introduction of new technologies, and (c) the potential benefits and obstacles to the application of interactive technologies in aged care environments, both at client's homes and at aged care facilities (Lawrence et al, 2010).

In Section 2 of the paper we describe the analytic framework and in Section 3, we outline the population characteristics of the cohort. Section 4 describes briefly the *ReMoteCare* System and sets out sample studies as well as the interactive technologies we will introduce into *ReMoteCare*. Section 5 outlines economic and environmental factors. Section 6 contains the discussion of the known issues that must be solved. The conclusions are set out in Section 7

2 The Analytic Framework

The authors have modified the Analytic Framework used by Jimison et al (2008) in their landmark study on *Consumer Health Information Technologies* used by the elderly, chronically ill and underserved. Our modifications limited the technologies to Interactive Game Techologies and the *ReMoteCare* system rather than dealing with the full gamut of healthcare information technologies. Figure 1 below sets out the Analytical Framework which is described in the following sections.

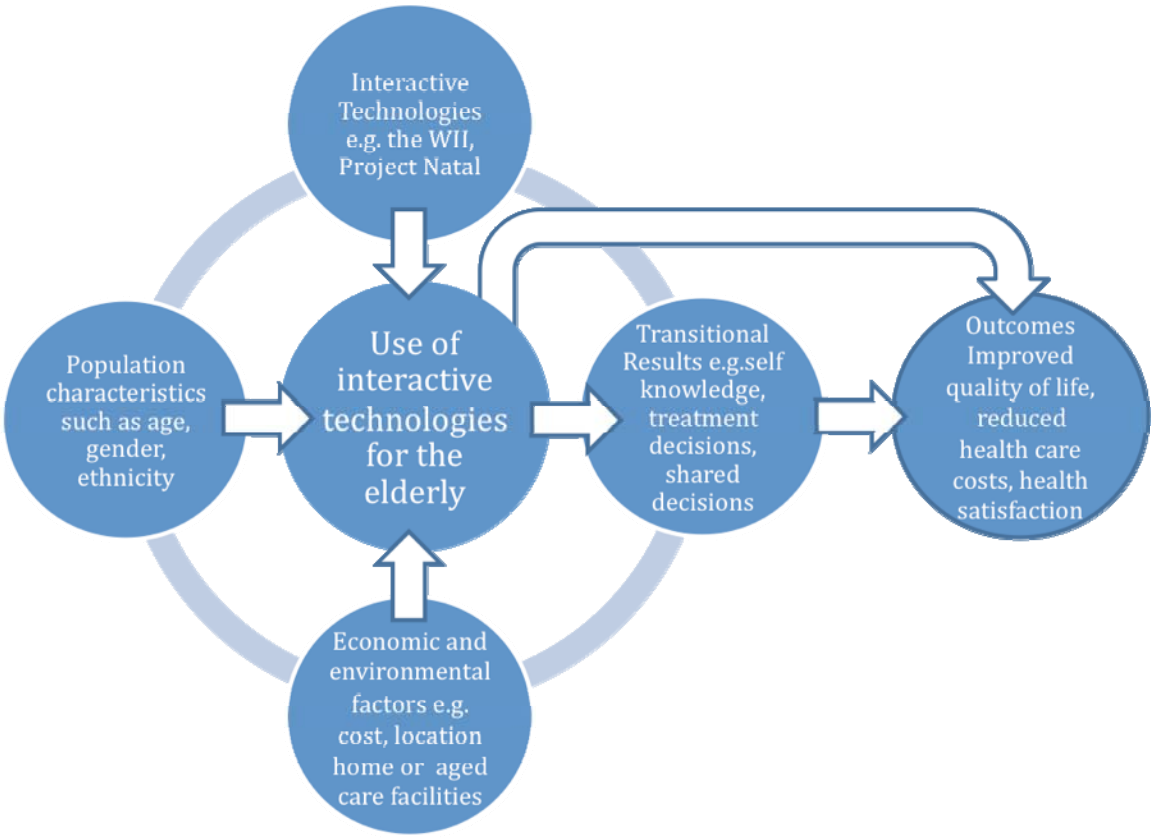

Figure 1: Analytic Framework (based on Jimison et al, 2008)

3 Population Characteristics

In the study by Jimison et al (2008) factors such as age, gender, ethnicity, education, language, chronic conditions, disability, income, literacy and numeracy, technical expertise, health belief, preferences and health insurance status were also examined. In this paper, we limit our disussion but the above factors will be studied when our trials begin in September 2010. Our research shows that the percentage of aged persons over 65 is increasing dramatically both in Australia and worldwide and unfortunately, as people age, their mental and physical health deteriorates and impacts negatively on their quality of life. It has been posited interactive technologies could help to overcome functional decline, maintain independence, preserve social connectivity and engagement among seniors (Smits, 2008). The worldwide population of people over the age of 65 is expected to more than double from 375 million in 1990 to 761 million by 2025 (Dishman, 2004). Within 40 years the number of people aged over 65 will almost triple, from 2.8 million today to around 7.2 million in 2047, or from around 13 per cent of the population today to over 25 per cent.

Inevitably, in a civilized society, community healthcare has to be extended to those in their own homes. The cost of caring for the increasing numbers of aged persons in private dwellings, nursing homes or hospitals will be a huge challenge for governments. For those seniors who prefer to live independently in their own homes, constant monitoring is essential to provide adequate care as there is an increased risk of falls, strokes and other health problems which could prove life threatening or impact negatively on their quality of life. In 2002, nearly 13,000 people aged 65 and older died

because of fall-related injuries (Gillespie et al, 2003). More than 60% of people who die from falls are 75 and older (CDC 2009). Falls are common among community-dwelling elderly people and can have a considerable impact on quality of life and healthcare costs (Hendriks et al, 2005). Gururajan et al (2005) stated most healthcare information is both time and life critical, so it must be captured and/or delivered whenever and wherever needed. Compared to young people, seniors are much more likely to suffer chronic diseases, heart attacks and dementia, therefore, more and more nursing services need to be provided for them. Many countries, including Australia, are facing a shortage of nurses (Felix Navarro et al, 2009).

The question of how to efficiently utilize human resources for aged care is attracting more public concern. In modern society, physical exercise, which is one of the best solutions to improve elderly people's fitness and protect them from suffering heart attack and chronic diseases, is not popular or indeed often not possible for many seniors. As well as lack of physical exercise, the state of seniors' mental health has very significant impacts on maintaining their quality of life (Kang et al, 2004), (Lawrence et al, 2010). According to researchers in Singapore, playing games could efficiently enhance seniors' health both physically and mentally (Cheok, 2005). On another level, treating the elderly in ill health situations is hampered by the fact that symptoms and signs may not be as clear as they are in younger patients. For example, research statistics from the United States of America indicate that less than 50 percent of patients over 80 years with myocardial infarction present with chest pain. In many elderly casualties, acute appendicitis does not produce the typical symptoms and signs. Only 50 percent of elderly casualties with surgically proven appendicitis present with such a diagnosis at the time (Merck.com, 2010), (Lawrence et al, 2010).

4 ReMoteCare Architecture and Interactive Technologies

We provide a brief overview of ReMoteCare in the section before elaborating on the selected interactive technologies.

4.1 ReMoteCare

The architecture of the ReMoteCare health monitoring system comprises the wireless sensor network (pulse oximeter and environmental sensor motes) connected via a gateway mote to the local host PC (Fischer et al, 2008). The sensor network communicates via the CodeBlue protocol (Malan et al, 2004) to the gateway mote which redirects the data to the local host for a first data analysis by a serial or USB connection, depending on the programming boards adopted (MIB510/MIB520). On the monitoring PC, Laptop or PDA, the ReMoteCare Graphical User Interface (GUI) (adapted from the CodeBlue software) shows the data gathered on the screen, the network topology and the patients (with Motes) connected as seen in Figure 2.

The data are locally stored on log files and then sent by an SNMP-proxy connection to the remote host. The general architecture is structured as follows. A gateway board called Stargate is the central device. The ReMoteCare base mote is plugged into the standard mote connector of the Stargate. This mote is responsible for transferring the data from the WSN to the Stargate. On the Stargate the serial forwarder application sends this data to the Ethernet port. It uses TCP port 9000 to allow other applications

like *ReMoteCare* to connect to this port. The serial forwarder transmits the queries of the *ReMoteCare* application to the base mote as well.

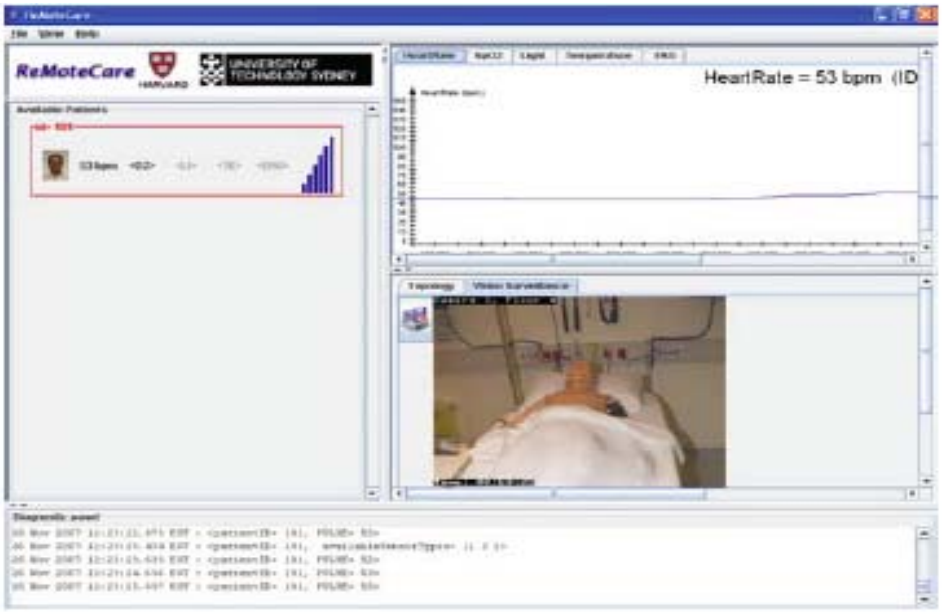

Figure 2: ReMoteCare screen showing video (Fischer et al, 2008)

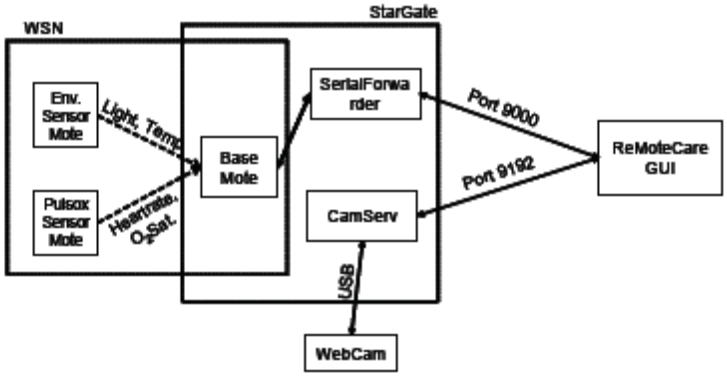

Figure 3: ReMoteCare Architecture (Fischer et al, 2008)

A USB camera is also connected to the Stargate and runs via a Video4Linux driver. The web streaming application *camserv*[1] continuously reads pictures from the camera and publishes them on TCP port 9192. *ReMoteCare* has to establish two TCP connections to the Stargate. One connection is to port 9000 to connect to the WSN and the other one is on port 9192 to read the video stream. Figure 3 shows the block diagram of the *ReMoteCare* architecture. Figure 4 shows a diagram of the *ReMoteCare* setup.

[1] http://cserv.sourceforge.net/

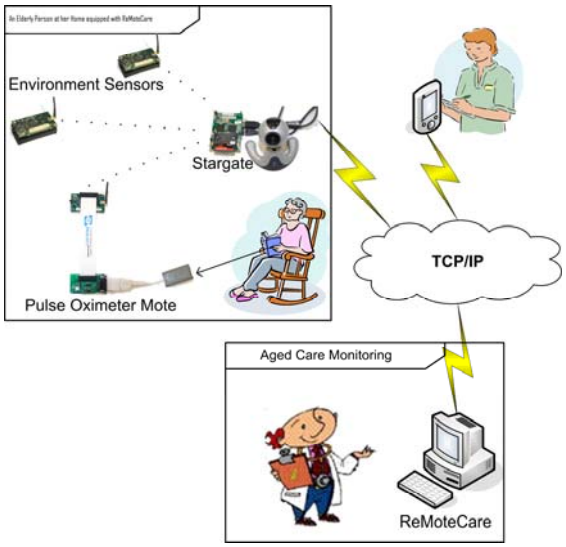

Figure 4: ReMoteCare Health Monitoring System (Fischer et al, 2008)

4.2 Sample Health Interactive Technologies

Gamberine et al (2008) state that *videogames have proven to improve elderly people's cognitive abilities and take care of psychological problems accompanying illnesses and social isolation.* Jimison et al (2008) have provided in their paper an extensive overview of web based and game based applications for therapy and rehabilitation of elderly people and believe that interactive technologies represent a viable solution to meet the various physiological and psychological needs of this population cohort. Selected results of their work on consumer health information technologies are contained in Table 1.

Study	Activity	Description	Outcomes	Issues
Crosbie, 2006 Qualitative Study, N=20	Stroke	Stroke rehabilitation, user moves arms and hands in a virtual environment and interacts with familiar objects	VE allowed pts with limited movement to experience sense of 'presence'	Virtual reality made some of the healthy users motion sick
Kressig, 2002 Cohort, N=34	Physical activity for elderly	computer system for exercise promotion (questionnaire with tailored recommendations)	N.A.	Most problems had to do with survey issues, not computer. 22% questions were mouse related.
Cleland, 2007 Qualitative Study, N=12	Asthma	Electronic peak flow meter linked to a mobile phone with an interactive screen to record current asthma symptoms transmitted to and stored in a server	Fast, easy to use, time saver. Staff agreed that technology was easy to use and wildly popular with patients	Problematic cable attachments and data head, sensitivity of piko meter, absence of a good cell signal
Kim, 2005 Qualitative Study, N=42	Diabetes mellitus	Access a website via their mobile phone or Internet and input their blood glucose levels every day; patients were sent the optimal recommendations by both the mobile phone and the internet	Easy to use	N.A.
Kosma, 2005 Qualitative	Physical disability	Web-based physical activity motivational with and without discussion, weekly motivational	Rated easy to use – 4.5/5	Rated helpful – 3.4/5

Study, N=25		messages		

Table 1: Sample Interactive Technologies Studies (Jimison et al, 2008)

4.3 Assistive Activities for Physical and Mental Health

As part of our framework investigation, we disovered that mental stimulation postpones the onset of dementia and might actually reverse the process (BJHCIM, 2008). New evidence from the Alzheimer's Society suggests that the progression of Alzheimer's can be slowed by the use of computer-based puzzles. Chilukoti et al (2007) describe a promising assistive technology system they developed to promote both physical exercise and cognitive stimulation for patients suffering from Alzheimer's disease and other dementias. Their system combines a portable mini stationary bike with an interactive visual multiple choice question game. The bike provides the physical exercise component. The cognitive stimulation is provided by the game that targets areas such as memory, judgment, problem solving, recollection and matching to help impede dementia. Chilukoti et al (2007) included certain multi-sensory stimulants such as fibre optic lights and selective colours to relax and control agitation of patients with dementia. They believe their system provides a safe and fun way for patients with dementia to complete physical and mental exercise. Figure 5 shows the Mini Stationary Bike with its interactive screen.

Figure 5: Mini Stationary Bike and Interactive Screen (Chilukoti et al, 2007)

4.4 Selected Interactive Game Technologies for the Population Cohort

In our research we found that Interactive Video games such *as Dance, Dance Revolution, Rock Band and Guitar Hero* help people to become active by following the rhythm and imitating the dance steps. Other areas for investigation included online Live Video conferencing. Reports have shown a high acceptance of this mode of communication. In the training area the elderly and/or caregivers could interact with the exercise experts in real time and at a time of their choosing (Lawrence et al, 2010). Some useful and easy to implement collaborative technologies include WebEX (Cisco WebEX, 2010).

4.5 4.5 Wii for the Elderly

In this section we discuss the selected interactive game technology we intend to couple with *ReMoteCare*. As a competitor of Microsoft's Xbox 360 and Sony's PlayStation 3, Nintendo Wii (pronounced /ˈwiː/) is a home video game console with a wireless controller, the Wii Remote, which can be used as a handheld pointing device and detect movement in three dimensions (Nintendo, 2010). According to the information from Wii's homepage (Nintendo, 2010), there are over thousands of Wii games which can be installed on the console. Seniors could play baseball games and golf games by using the Wii Remote under a nurse's instruction. These sports games could help seniors to exercise their arms and waist. Besides the Wii Remote, there are several game controllers available on the market, such as Dancing Carpet and Wii Fit. By using the dancing carpet as the game controller, the elderly could dance on the carpet to exercise their knees, calf and toe muscles. Nintendo balance board, which is called Wii Fit, is another game controller for the feet. Seniors could use the Wii Fit to play Yoga and other games to improve their balance and strengthen knees and ankles. A simple Wiimote that resembles a TV remote with which most elderly people are familiar easily controls the Wii. It enables the elderly to participate in games they enjoyed in their earlier years such as golf and bowls and to keep their minds active (Lawrence et al, 2010). The Nintendo Wii is an ideal tool for the elderly because its controller can track spatial movement, which allows game play with normal human movements (Nintendo, 2010).

Figure 6 shows a senior interacting with a Wii console and Wiimote whilst other elderly persons watch the results (Sale, 2010). The incorporation of this highly interactive technology into our existing systems will present many challenges but we believe that the mental and physical training benefits for the patients will be enormous, not least because of the fact that these devices should prove popular with the aged cohort we are targeting as many of them will have previously played real games of golf and bowls.

Figure 6: Using a Wii to Improve the Health of the Elderly (Sales, 2010). *A Wii bowling "competition" at a JFCS senior center in Phoenix (Sales, 2010)*

Australia's Minister for Ageing, whilst referring to information from the Policy and Evaluation Branch of the Department of Health and Ageing, stated: *We are now seeing baby boomers begin to retire; they are changing ageing in forever. They are healthy,*

active and want to live at home as long as possible (Elliot, 2008). Besides the contribution on the physical health, interactive games help seniors improve their mental health as well. According to the research of (Gamberine et al, 2008), seniors may release their mental stress and forget their loneliness and depression when they are playing games (Gamberine et al, 2008). At the same time, interactive games could help those lonely elderly make new friends when they are playing games.

> *"The Wii is suitable for care homes as it can be controlled and adapted to suit users of varying abilities. People can play as individuals or in groups so there is plenty of opportunity for everyone to join in socially."* (Gamberine et al, 2008)

4.6 Project Natal for the Elderly

Our second targetted game is Project Natal. Microsoft announced their new product Xbox 360 'Project Natal', which can be operated without controller, in June 2009 (Stien, 2009). Figure 7 show a person interacting with Project Natal due for release in 2010. The main concept of this non-controller game console is that the user is the controller. This is the next step in interactive gaming. Players can navigate through menus by using hand gestures – such as swiping left or right. Its inbuilt camera and microphone enables facial and voice recognition. Project Natal will recognize the seniors' faces and sign them in automatically. The advantages are endless as the senior can simply do the movements and not bother about using any controller. Games can be controlled by users' gestures, actions and voice, which are captured by the sensors and camera.

> *"See a ball? Kick it, hit it, trap it or catch it. If you know how to move your hands shake your hips or speak you and your friends can jump into the fun – the only experience needed is life experience"* (Project Natal, 2010)

Figure 7: Project Natal Interaction without a controller (Rigby, 2010)

5 Economic and Environmental Factors

In our Analytic Framework we also investigated economic and environmental factors. We have already mentioned the problem of the shortage of qualified healthcare nurses and caregivers for the aged cohort under study. Another economic issue is the fact that governments must spend a huge proportion of their health budget on this aged cohort.

> *"The cost of caring for aging U.S. residents by 2030 will add 25% to the nation's overall health care costs unless those residents actively work to stay healthy and preventive services are provided to help them"* (Medical News Today, 2007).

Preventative measures such as improving the physical and mental health of the elderly, chronically unwell and infirm must form a vital part of government strategy to improve economic healthcare outcomes.

Researchers in Australia (Clark et al, 2010) investigated the feasibility of using the Wii's skiing and snowboarding attachment, *the balance board*, to help rehabilitate people who have had a stroke. Physiotherapists measure the centre of pressure of a person's foot to assist a stoke patient to relearn how to stand. The laboratory grade "force platforms" needed to do that cost more than £11,000 - putting them out of the reach of many physiotherapy clinics so Clark et al (2010) investigated the balance board to ascertain its suitability for assessing balance in stroke patients. These researchers at Melbourne University, Australia, took apart a Wii balance board and hacked into its strain gauges and accelerometers to tap into their raw data. Clark et al (2010) verified that the Wii Balance board data is clinically comparable to that of a force platform:

> *"We found the data to be excellent. I was shocked given the price: it was an extremely impressive strain gauge set-up. The low price of the Wii kit is now seeing it used to assess rehabilitation after stroke, traumatic brain injuries and to examine standing balance in children who were born pre-term."* Clark et al (2010)

6 Incorporating Interactive Games into ReMoteCare

We have discussed the aspects of the Analytic Framework as they relate to our aims. Such interactive games satisfy two aspects of the criteria namely the senior interacts directly with the technology and the computer processes the information in some way. We believe, however, they fall short in providing the elderly person or carer with patient specific information in return. This is why we must integrate them into the overall health monitoring system – such as the *ReMoteCare* prototype (Lawrence et al, 2010).

We set out below the way in which we would incorporate the data from, for example, the Wii game into our existing system. Whilst the senior is playing a game (for example golf) his heart rate will be monitored and captured by our system. Should his heart rate increase over a certain threshold the video will pop up in the display and an alarm sounded on the system for the monitoring caregiver. Special user interfaces for the elderly must support an easy-to-use user experience. As not all elderly persons have

experience with computer systems and may not have used a mouse and keyboard in their lives it is of critical importance to make interaction as intuitive as possible. We consider both the Wii and Project Natal should satisfy the above need (Lawrence et al, 2010).

As every person will have his/her own training and exercise program, an account management system will be required. Because of the users' lack of computer knowledge and/or possible physical and/or mental impairments the computer system must be intelligent enough to recognize users automatically. We are planning on integrating face recognition software in order to provide automatic account sign in so that users are not to login, as they might forget their user name and/or password frequently. This face recognition software already exists in Project Natal so it is appropriate for our system.

We are planning on using out of the box training and game solution initially in order to obtain early feedback and to test the feasibility of the set up. Ultimately our goal is to develop training routines and exercises that are tailored to the need of users. These exercises will be designed to improve specific health issues of the elderly. We plan to develop our exercises in conjunction with a Feldenkrais movement therapist who specializes in exercises for the elderly. One game will concentrate on balancing exercises to improve the elderly pers on's sense of balance, strengthen leg muscles and decrease the number of fall significantly (Lawrence et al, 2010).

Our ultimate goal is to move away from the out of the box games and develop our own games and user interfaces optimized for elderly users. A conducted user acceptance test on a pilot should prove if the elderly are willing to use such a system on a daily basis. One of the greatest challenges we are facing will be on the usability of the system. This system will be a success only if the elderly can handle it with ease and find joy and pleasure from interacting with the games. From a technical perspective it is essential that the game modules are totally integrated into the *ReMoteCare* or other health monitoring systems. The monitoring module has to be aware that users are doing physical exercises which means their vital signs will change accordingly, for instance, the heart rate will increase. Thus the system will need the intelligence to adjust the vital sign thresholds in order to avoid false alarms on our interfaces.

Research has shown that the effectiveness of these technology interventions depends on ensuring that the systems provide a complete feedback loop (Gamberine, 2008) Modern interactive technologies have the capacity to assist the elderly to improve their quality of life by helping to keep their mental and motor systems active, as well as providing elderly care centres with additional social spaces that could potentially benefit the elderly persons' emotional wellbeing.

7 Conclusion

The analytic framework assisted us in investigating the characteristics of the aged population cohort, the economic and environmental factors and the specific interactive technologies we believe will work with the *ReMoteCare* system. The aim of our enhanced *ReMoteCare* is to assist the aged, chronically unwell and infirm to attain better physical and mental health outcomes so that they are more able to understand their limitations and gain self knowledge about their health status. In turn they should be able to understand treatment decisions and make shared decision with their caregivers and doctors. Utlimately it is hoped the system will contribute to an improved quality of

life, reduced healthcare costs and health satisfaction (Lawrence et al, 2010). Physical injuries such as falls happen more frequently as people age. The following figures from the Centre for Disease Control and Prevention demonstrates the serious situation.

> *"In 2005, 15,800 people 65 and older died from injuries related to unintentional falls; about 1.8 million people 65 and older were treated in emergency departments for nonfatal injuries from falls, and more than 433,000 of these patients were hospitalized."*(CDC, 2009)

CDC also pointed out that falls are the most common cause of injury deaths among older adults (CDC, 2009). In our proposal, we will apply some adapted sports games on Wii consoles and Project Natal devices to integrate these interactive technologies into our existing *ReMoteCar*e system so we can monitor the effect on the elderly patients' health outcomes. As well as physical health, good mental health is very important in nursing care according to the researchers from Oakland University, senile dementia is another significant mental disease affecting elderly citizens' heath (Chilukoti, 2007). Once we integrate the interactive games into ReMotecare this year hope the power of games and fun exercises will help the elderly to stay healthier. It also has the potential to save health systems significant amounts of money.

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