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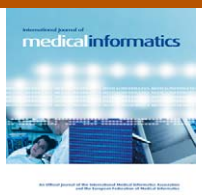

Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users

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ABSTRACT

Introduction: Ambient intelligence technologies are a means to support ageing-in-place by monitoring clients in the home. In this study, monitoring is applied for the purpose of raising an alarm in an emergency situation, and thereby, providing an increased sense of safety and security. Apart from these technological solutions, there are numerous environmental interventions in the home environment that can support people to age-in-place. The aim of this study was to investigate the needs and motives, related to ageing-in-place, of the respondents receiving ambient intelligence technologies, and to investigate whether, and how, these technologies contributed to aspects of ageing-in-place.
Methodology: This paper presents the results of a qualitative study comprised of interviews and observations of technology and environmental interventions in the home environment among 18 community-dwelling older adults with a complex demand for care. These respondents had a prototype of the Unattended Autonomous Surveillance system, an example of ambient intelligence technology, installed in their homes as a means to age-in-place. The UAS-system offers a large range of functionalities, including mobility monitoring, voice response, fire detection, as well as wandering detection and prevention, which can be installed in different configurations.
Results: The respondents had various motives to use ambient intelligence technologies to support ageing-in-place. The most prominent reason was to improve the sense of safety and security, in particular, in case of fall incidents, when people were afraid not to be able to use their existing emergency response systems. The ambient intelligence technologies were initially seen as a welcome addition to strategies already adopted by the respondents, including a variety of home modifications and assistive devices. The systems tested increased the sense of safety and security and helped to postpone institutionalisation. Respondents came up with a set of specifications in terms of the operation and the design of the technology. False alarms were also regarded as a sign that the ambient intelligence technology is functioning. Moreover, a good integration of the new technologies in the provision of health

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care is indispensable, and installation should be done in an acceptable and unobtrusive manner. Ambient intelligence technologies can contribute to an increased safety and security at home. The technologies alone offer no all encompassing solution as home care and additional environmental interventions are still needed to support ageing-in-place. Results of the study are used to further improve the ambient intelligence technologies and their implementation.

1. Introduction

According to The Netherlands Institute for Social Research [1] the vast majority of older adults (persons aged 65 years and over) in the Netherlands – 93% of 2.2 million – live in the community. Over the years, the demand for care has gradually been increasing due to the ageing of society and a growing number of chronically ill people. Most of this care is given by family carers at home. Community-dwelling older people, who have acquired the right to receive nursing home care based on the Dutch Exceptional Medical Expenses Act (AWBZ in Dutch; EMEA), ask for a substantial level of long-term care. Such care can be supplied by home care visits from care professionals, which allows older persons to age-in-place.

Apart from receiving family and professional care at home, engineering offers architectural and technological solutions to facilitate ageing-in-place. On the level of the individual occupant, the desire to age-in-place leads to home modifications and retrofitting, moving, or simply living under less favourable conditions. At the same time, only 0.5 million dwellings in The Netherlands are intended for habitation by older adults, and there is a shortage of 40% in the number of such dwellings to cope with the demand. This leads to enormous pressure on the existing housing stock [1].

Technology, home automation, telehealth services, and 'ambient intelligence' are increasingly becoming tools to support and monitor older adults with or without cognitive impairments, by improving their sense of safety and security as a means to support ageing-in-place [2–5]. Moreover, such technologies form a welcome support for family carers and care professionals. In short, residential monitoring technologies aim to support frail people live more safely and securely, more capably, and longer in their location of choice [6].

1.1. *Ambient intelligence: the Unattended Autonomous Surveillance system*

One such technological solution is the Unattended Autonomous Surveillance (UAS) system. This system has been under development by TNO Defence, Security and Safety, The Netherlands, since 2001. The UAS-system aims to support ageing-in-place and delaying the demand for expensive institutional care by increasing the clients' and family carers' sense of safety and security through unobtrusive monitoring at home. Clients and, in turn family and professional carers, may benefit from the expected increase in self-care capabilities.

1.1.1. *Functionalities*

The UAS-system offers a large range of functionalities, which can be installed in different configurations, and which are described in more detail below. These functionalities include mobility monitoring, voice response, fire detection, as well as wandering detection and prevention.

Movement sensors continuously monitor the whereabouts of a care client within his or her dwelling. The system registers how many people are present in the dwelling, and in which room a person is located. The system responds when a client is inactive when he or she should be active; the duration of inactivity depends on the function of a space. For instance, this duration is shorter for the corridor than for the living room. In cases of emergency, a text message containing information on the alarm situation is sent to a mobile phone of a health care professional. This person can then check on the client via two cameras that are present in the dwelling. The operation is described in Section 1.1.2.

In case of an alarm, the system contacts non-psychogeriatric clients via telephone first (voice response) in order to minimise the number of false alarms. This functionality may also be omitted in somatic clients, who have lost the ability to speak. This voice response functionality sends out spoken messages to all telephones in the home of a client, before sending off an alarm to the central care centre. If the situation turns out be a false alarm, the client can block the alarm by pressing a button. If the button remains untouched, an alarm is again sent via SMS to a health care professional.

In every home, one or two smoke detectors have been installed. When one of the detectors triggers an alarm, the UAS-system automatically activates the second smoke detector in the home and makes it alarm, too. When the voice response functionality is installed, the client can indicate whether the alarm is true or false. In case, the client is not at home, the alarm can be sent directly to a care centre, or to a family carer via SMS.

In case of psychogeriatric clients, the UAS-system offers a functionality for wandering detection. This functionality detects when a client leaves his or her dwelling unwanted. Magnetic contacts are applied to the doorframes of the front and back doors. When these contacts send out a signal to the UAS-system that doors have been manipulated, the movement sensors inside the dwelling check for the presence of the client. This wandering detection functionality does not require the client to wear any technology. Whenever a client leaves his or her dwelling, a phone call is made to the client. This telephone is situated near the exit doors, in order for the client to be able to hear it. When the client turns around to answer this phone call, he or she gets a spoken message. This

functionality is called wandering prevention. In case the client leaves the home, and no one else is present, an alarm is sent to the central care centre, the care professional in charge, or a family carer. The wandering detection can be activated during the night only, or can be programmed with a certain delay, for instance, alarms are triggered only half an hour after an event if the person has not returned. The UAS-systems counts the number of people present in the dwelling, and accounts for visitors and carers. Moreover, the wandering detection can also be used to monitor restlessness at night.

1.1.2. *Hardware and operation*

The UAS-system is based on ZigBee, which is a low-power, low-cost but relatively long-range wireless network intended for applications such as home automation and personal health care applications [7]. A ZigBee network is made up of a master unit and many slaves that are designed so that they can remain in a powered-down sleep mode most of the time, periodically waking up to interrogate the master [7]. The UAS-system consists of more than ten wireless sensors placed in various parts of the home (living room, bedroom, kitchen) along with a black box containing hardware components located in the living room or meter cupboard (Fig. 1). This allows the clients the freedom of not having to wear or carry system equipment themselves (for instance, a neck-worn pendant emergency response system). The black box is based on the TCP/IP protocol and XML, and is connected via the Internet to a call centre, which can be an external emergency room, a local manager, or a mobile team of professional carers.

Newly developed software analyses the information that is collected from sensors in the dwelling and compiles it to obtain a complete picture of events. For instance, by monitoring the movements of a client the system can recognise a fall incident. For each room, a certain duration of inactivity is pre-determined, which is used to set the alarm. The alarm is turned off automatically when going to bed, and is activated when waking up, or when leaving/entering the home. When a smoke detector in the kitchen triggers an alarm, the UAS-system knows from the movements recorded in the kitchen that there are pans on the stove, and so its first response is to contact the resident. In case of an alarm, the system contacts non-psychogeriatric clients via telephone first (voice response) in order to minimise the number of false alarms. When the client does not respond within 1 min, an alarm is given off to the call centre. Professionals then judge whether to send a care professional or to call the national emergency number. Also, two small cameras in the dwelling can be activated in cases of emergency for verification of the alarms (Fig. 1). These cameras are installed in a dwelling in agreement with the client. This also means that from a privacy point of view, no cameras are placed in restrooms and bathrooms. If there is an alarm call from a room in which no camera has been installed, the care professional can still access the cameras and use the voice response. When the actual situation of the client is unclear of when a client is in need, the care professional visits the client at home. The response time is 20 min at most. Moreover, professionals in the call centre can have screen-to-screen contact with the clients via the television, or have contact via an audio system, for instance, to ask how people are doing. In short, the system analyses and interprets the actual situation at home on a continuous basis and draws conclusions from the data gathered. This makes the UAS-system an intelligent alarm system, which can check whether there are actual emergency situations at home or whether psychogeriatric clients are wandering.

When longer periods of malfunctioning of the UAS-system are reported during the experiment, the system can be switched off, which leaves the client with an emergency response system (mainly pendants) only. The UAS-system can also be switched onto the so-called idle mode, which means that only TNO Defence, Security and Safety receives alarm calls given off by the system, not the care organisation.

1.1.3. *Experimental set-up and configurations*

A prototype version of the new UAS-technology is being implemented among community-dwelling older adults in the towns of Baarn and Soest in The Netherlands, who participate in this study. The target group is entitled to receive nursing home care (at home) based on the EMEA. There are three configurations of the UAS-system that are being installed in the clients' homes where this study was conducted: configuration 1, containing all functionalities for clients that are mobile and are able to answer the telephone; configuration 2, without speech interface for clients that are mobile but unable to answer the phone (mainly psychogeriatric clients); and configuration 3, without speech interface and without movement monitoring for clients that are unable to move (bed-ridden) and answer the phone. The choice for a certain configuration depends on the health and cognitive status of the client and her/his personal wishes/needs concerning the system, and is also made based on the professional judgment of a care professional from the care supplier involved in the project.

In addition to the UAS-system, clients can make use of an additional set-top box for videotelephony via the television set (SCOTTY and Eye Catcher systems). Moreover, the clients still use their emergency response systems. These response systems are not part of the UAS-system but are connected to it. When an alarm is raised in an emergency situation, the cameras of the UAS-system are activated, and the situation at home can be verified by a health care professional. The response systems were kept by the respondents in line with recommendations by the medical ethical committee consulted for this study. In practice, clients do not distinguish between the separate technological appliances. They regard the total set of technology as a single unit. Therefore, all the technological appliances present in the home are included in this study, and not just the UAS-system. In the latest commercial version of the UAS-system, the aforementioned emergency response system will be part of the total system.

1.2. *Aim of the study*

The aim of this study is to examine the needs and motives of the users of ambient intelligence technologies (and their carers and other stakeholders) (demand), and the solutions offered by the ambient intelligence technologies installed in the home environment (supply) in an interdisciplinary manner. Furthermore, to determine whether these two aspects of supply and demand match according to the users and, if so, how aspects of demand and supply complement each other.

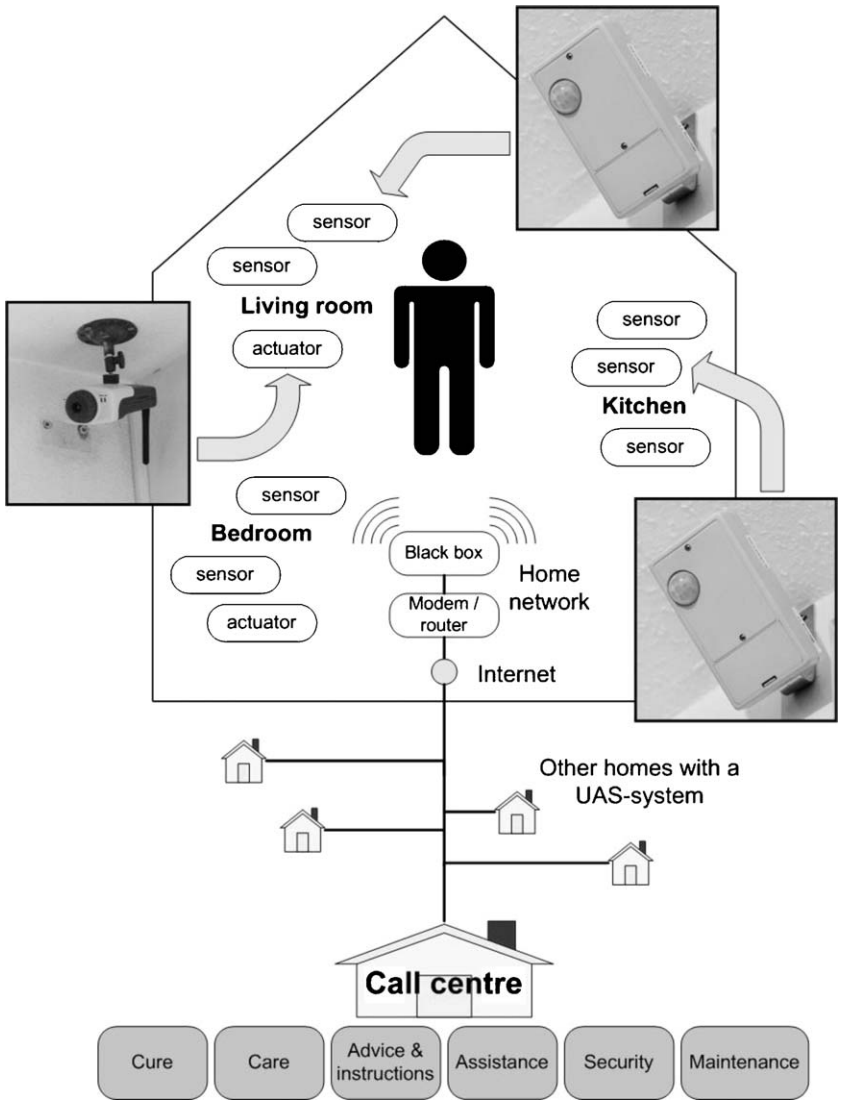

Fig. 1 – Model of the UAS-system and its functionalities.

The stakeholder approach follows from Dewsbury et al. [[8], p. 191], who stated that "*designing 'smart homes' or homes that contain elements of 'smart home' technology for disabled or older people is not different from designing the home for people without any form of impairment on the one hand. On the other hand, there is a perceptual shift that is required in order to ensure needs are met from all stakeholders. There is a need to determine the needs of the occupant(s) and reflect these needs within the overall design.*"

The main research questions of the study were related to the expectations of users in relation to ageing-in-place with the use of new ambient intelligence technologies within a context of supply, demand and fit. These questions were:

- What are the motives for ageing-in-place, and how can ambient intelligence technologies help according to the users of ambient intelligence technologies?
- How do the users of ambient intelligence technologies experience their sense of safety and security?
- How do the users of ambient intelligence technologies view their privacy at home after the installation of the technologies?
- What are the engineering solutions taken by the users of ambient intelligence technologies to assist with ageing-in-place and which challenges do these solutions address?
- What are the requirements to the organisation of care and carers in relation to the ambient intelligence technologies?
- What are the requirements to the ambient intelligence technologies in terms of operation and design, with emphasis on people with dementia?
- What are the requirements to installers of new technologies?

2. Methodology

In the following sections, the choice for the research methodology of the study is described, as well as how literature and interviews were used. Also, the origin and selection of respon-

dents and their characteristics are described. Thereafter, a description of the interviewing techniques and analysis is provided, as well as a description of how results are presented.

2.1. Research methodology

Based on the assumption that adequate support lies in the world of the client or the user of ambient intelligence technologies (i.e., the respondent), this study makes use of an interpretative research approach. A qualitative research methodology is chosen to find the answers to the abovementioned research questions. In this study, we look for trends in the process of giving meaning to events, which are presented in the overview of results. Because these results can reflect a wide range of thoughts and experiences, we have chosen to present this diversity, as far as legibility allows.

2.2. Interviews

Data acquisition took place through qualitative interviews. The reconstruction of the point of view of the interviewed person comes first, which requires 'role-taking'. This resulted in an interview method in which respondents felt invited and comfortable to share their experiences with the interviewer. The interviews took place within the homes of the respondents, as the way of life and experiential world is expressed best at home and since observation of the living environment plays an important part in the interviewing. An exception was made for one of the respondents, who was interviewed at the day care centre due to circumstances.

2.3. Topic lists

A topic list, an overview of research themes and accompanying questions, was used for this study. The themes of the topic lists were based on a literature study including the work by Bijsterveld [9], Pool et al. [10], Demiris et al. [11], and The Netherlands Centre for Ethics and Health (CEG) [12]. The themes were discussed and adjusted with the care supplier and with Vilans, a national centre for long-term care. The topic list was divided into a structured and a semi-structured section. First, background information, including questions on gender, date of birth, family status, pets, education, and type of domicile, on the respondents was collected to gain insight into variation within the study population. The topic list contained topics grouped around a number of main themes: (i) morbidity and use of assistive aids; (ii) demand for care, home care received, and satisfaction with care services; (iii) importance of ageing-in-place and accompanying challenges; (iv) views on independent functioning; (v) sense of safety and security; (vi) communication with carers and relatives; and (vii) concerns regarding technology and personal thoughts about the future.

There were two rounds of qualitative interviews using the topic list, which was extended and adjusted during the course of the research based on the experiences shared by the respondents. The goal of the first round of interviewing was to map the experiences concerning independent functioning, the use of technology, as well as the quality of care. The second round of interviewing focused on over-time differences in the experiences concerning safety and security in relation to the installed ambient intelligence technologies, the integration of the ambient intelligence technologies into the home environment, and the organisation of care.

2.4. Origin and selection of respondents

The respondents of the study were clients of the participating care supplier (*Stichting Zorgpalet Baarn-Soest*, SZBS). SZBS has been providing nursing care at home since 1989. The organisation's mission is for their older clients to age-in-place for as long as possible. In some occasions, clients receive six to nine visits at home by a professional carer per day. Clients have access to an emergency response system or service system to indicate when they are in need of help or assistance as they do not receive so-called '24-hour care'. These systems were not sufficient to support the care processes, and an additional care support system was, therefore, needed. This need was emphasised by wandering behaviour of psychogeriatric clients and problems controlling the alarm system by severely somatically impaired clients. Also, clients used the alarm system for non-emergency situations that were related to the disablement process in general. In 2003, SZBS chose to implement the ambient intelligence technologies as the systems do not require the clients to actively wear and control components of the system, which is seen as a clear advantage over conventional alarm systems. Furthermore, the UAS-system can be relocated if a client moves to another dwelling or passes away (many clients have a short life expectancy).

The respondents of the study were selected by the care coordinators of SZBS. Fortunately, this resulted in a large variety in respondents, which increases the chances in qualitative research to gain as broad an insight as possible in the phenomena studied. For the selection and inclusion of the respondents, a number of criteria were applied which focus on the target group of the UAS-system:

- The client is mobile and has the tendency to fall, or the client is bed-ridden and wants no bedrails. In such situations, mobility monitoring in combination with cameras may be desirable to check whether a client is in need of assistance.
- The client has a tendency to wander. There is a need for wandering detection/prevention.
- The client activates the alarm once or twice a day via his/her emergency response system/service system. Professional carers want to have a method to check whether the alarm is false or valid, using a video connection.
- The client has feelings of loneliness and needs social contacts. Via the so-called EyeCatcher technology, the client can contact care professionals and relatives.
- The client feels unsafe/insecure at home, or professional/family carers have doubts about the safety situation at home.

2.5. Respondents

The ambient intelligent system was installed in 16 dwellings (Table 1). A total of 18 older adults (including two married couples) participated in the study (Table 2). Based on assessments of the regional health care assessment centre (*CIZ*), the

Table 1 – Functionalities and technologies installed for each configuration in the 16 homes of respondents.

Functionality		Configuration 1 ($n=8$)	Configuration 2 ($n=4$)	Configuration 3 ($n=4$)
UAS	Mobility monitoring	x	x	
	Voice response	x		
	Fire detection	x	x	x
	Wandering detection/prevention	x	x	
Other	SCOTTY and Eye Catcher	x	x	x
	Emergency response system	x	x	x

respondents chosen for the project are entitled by the EMEA to receive institutional nursing home care (not placement per se), i.e., they require 24-h surveillance. Of these respondents, seven cope with mild to moderate psychogeriatric health problems, including dementia. The other respondents have (severe) somatic health problems. The majority of participants deal with a variety of comorbidities. The respondents were living without pets, except for two female respondents, who cared for a cat (Mrs. N) and a bird (Mrs. K), respectively. Also, Mrs. K was the only respondent without children. The variation in needs of the respondents led to the installing of three configurations of the UAS-system, which enabled us to study more than one variety of the system. During the study, six of the respondents passed away, were institutionalised, or were not able to participate and, therefore, left the study. Thus, of the 18 initial respondents of the first round of interviews, only 12 participated in the second round.

The region of this study is populated by persons with a high social economic standard. Many of the respondents have had professional education. Well-educated people tend to reside in their own (modified) homes longer than less-educated people due to better access to home care services and better financial resources, although many eventually end up in institutional settings as well [1].

2.6. *Privacy, anonymity and ethics*

In the presentation of results, respondents are indicated by letters, not names. In order to maximise the legibility of the quotes, they have been edited and translated as closely as possible to the original. At the same time, some of the quotes have been adapted where appropriate to maximise anonymity and privacy of the respondents. To inform clients and respondents, ZPBS has made it possible for respondents, and professional and informal carers to visit a demonstration home where the UAS-system is installed so that they could see how the system functions.

From all respondents informed consent was obtained. The research set-up has been approved by the medical ethical committee of iRv, Hoensbroek, The Netherlands.

Another issue during the study was to guarantee a minimum level of 'safety and security'. In order to protect the respondents during the study period, the emergency response systems (pendants) that were already in use by the respondents were maintained during the study period on advice of the medical ethical committee. As the current response system is not part of the ambient intelligence technologies, the voice response system was not applied in case of false alarms. Instead, respondents had to use a reset button of the separate alarm equipment. In case no response was given by a respondent during an alarm situation, care professionals could monitor the home via the cameras to check on their status.

2.7. *Interviewing and analysis*

The first part of the study, performed between December 2006 and March 2008, included 18 respondents or participants (Tables 2 and 3). The interviews were carried out within a range of 3 weeks prior to or directly after the installing of the ambient intelligence technologies. The respondents or participants were aware that they were getting these technologies installed. The second part of the study was conducted between October 2008 and May 2009 and included 12 respondents (Table 3). The duration of the interval between the two interviews was 8–23 months, which was depending on the respondent/household.

During the interviews, conversations were audiotaped. Some of the respondents were assisted during the two rounds of interviews by their (family) carers, mainly daughters and sons (in-law). The presence of relatives was not only appreciated (partly because their views were included in the study), but in the case of psychogeriatric respondents, such a relative can serve as the spokesperson. During the interviews, an observation of the home environment for assistive technologies and home modifications was carried out by the interviewer by looking around in the dwelling from the position the interview took place (method triangulation). When items had been identified, they were discussed with the respondents during the interviews. This was a means to verify whether respondents were complete in answering questions on architectural and technological solutions, and whether they identified seemingly everyday items in, and features of, the home environment as engineering solutions. After the interviews, the conversations were transcribed and analysed using the MAXQDA 2 program. First, each transcript was read in its entirety. Then, they were read a second time to develop codes that were grouped into themes, which emerged from the narratives and the topic lists, consistent with the interviews, To be considered a major theme, the code had to have appeared in more than a quarter of the narratives and more than once in each of the narratives. Third, quotes that summarised the essence of each person's subjective experience were recorded. Researcher triangulation was applied during the entire process.

Table 2 – List of interviewed respondents, arranged by age, gender, health status, UAS-configuration, and living conditions. The health status of the respondents influences the need for assistance and environmental interventions. The housing status influences the need for environmental interventions including home modifications, and the possibility to carry out such interventions without the permission of a third party.

Respondent	Gender	Age at time of first interview	Age at time of second interview	Somatic/ psychogeriatric health condition	Disease/disorder	Physical and sensory limitations	UAS-configuration*	Type of housing**	Ownership
A	Female	65		so (bed-ridden)	Rheumatoid arthritis, bronchitis	Mobility, vision, breathing	3	Terraced housing	own home
B	Female	82	84	so	High blood pressure, lung disease	Mobility, vision	1	ALF	rent
C	Male	87		pg	Cataract, transient ischeamic attack	Hearing, mobility	1	Apartment	own home
D	Female	84	86	so	Chronic back problems, lung embolism, osteoporosis	Mobility, vision, equilibrium	1	Terraced housing	rent
E	Male	82		so	Brain haemorrhage	Mobility	2	ALF	own home
F	Female	77	79	pg	Cardiac arrhythmia, surgery to knee, cataract	Mobility, vision	3	ALF	rent
G	Female	85	87	pg	Parkinson's disease, transient ischeamic attack, cataract	Speech, mobility	3	ALF	own home
H	Female	80		so (bed-ridden)	Depressive feelings, surgery to the hip plus complications due to MRSA infection	Mobility	3	ALF	rent
J	Female	63	64	so	Multiple sclerosis	Mobility, vision	1	Terraced housing (corner)	rent
K	Female	81	82	so + psychiatric health problems	Parkinson's disease, Renault's disease	Mobility, equilibrium, vision	1	Terraced housing	rent
L/M	Female	76	77	so	History of laryngeal cancer, heart failure, diabetes ♂; retinitis pigmentosa ♀	Hearing (♂), mobility, vision (♀)	1	Apartment, ground level	rent
	Male	84	85	so					
N	Female	81	82	pg	Surgery to hips, high blood pressure, stroke	Hearing, short-term memory	2+WD	Semidetached home	own home

– Table 2 (*Continued*)

Respondent	Gender	Age at time of first interview	Age at time of second interview	Somatic/ psychogeriatric health condition	Disease/disorder	Physical and sensory limitations	UAS-configuration*	Type of housing**	Ownership
O	Female	80		pg	Dementia	Cognition, mobility	2	Apartment	own home
P	Female	85		pg	Diabetes, depressive feelings, surgery to hip- and knees	Hearing, vision, mobility, cognition	2+WD	ALF	rent
Q/R	Female	75	76	so	Early dementia, heart failure♂; asthma, dust mite allergy, rheumatism, heart failure♀	Cognition (♂), vision	1	Apartment	own home
	Male	76	77	pg					
S	Female	83	84	so	Parkinson's disease	Mobility, equilibrium	1	ALF	rent

* WD: Wandering detection.
** ALF: sssisted-living facility.

Table 3 – Overview of dates of interviews and duration of interval.

Respondent	Date of baseline interview [yyyymmd]	Date of second interview [yyyymmdd]	Duration of period between interviews [months]
A	20061207		
B	20061207	20081105	23
C	20061207		
D	20070124	20081114	21
E	20070124		
F	20070405	20081031	19
G	20070405	20081114	19
H	20070912		
J	20070912	20081105	14
K	20070912	20081031	14
L/M	20071024	20081031	12
N	20071024	20081114	13
O	20071024		
P	20080313		
Q/R	20080313	20090520	14
S	20080313	20081105	8

3. Results

3.1. *The importance of ageing-in-place and sense of safety and security: before installation*

In general, there was a strong aversion against institutionalisation. One of the concerns was the supposed lack of privacy in an institutional setting. There was also a strong need to be able to have visitors when residents themselves wanted. Mrs. D: "*I have no need for [a] 'compelled' living room [in a nursing home] where you sit down with all residents chitchatting and where everybody speaks for him/herself.*" For couples, institutionalisation could mean an end to living together after a long period of marriage and being together.

All the respondents in this study want to stay in their current dwelling because of attachment to the own home, memories of the past, and their possessions in the home, as well as the quality of the neighbourhood. Some of the respondents even moved to their current home in anticipation of a worsening health status. Mrs. J was offered a small home in the direct vicinity of a nursing home. "*I'm happy I didn't accept. It was too small to bring all my stuff. I'm happy to stay in my own home so I cannot only keep my things, but also walk into the garden [. . .] when the weather is fine. I couldn't do all these things in the new home.*"

Independence is valued by all respondents in this study. Mr. M has multiple somatic health problems and still lives together with his wife: "*We try to do everything ourselves as much as possible, and we don't want to be a burden to others. [. . .] We really don't! [. . .] We just don't want to just give up this independence.*" The gradual diminution of the health status is not a real hindrance or continuing ageing-in-place for most respondents for the time being. Technology was seen as a way to support the wish to age-in-place and, therefore, embraced, accepted or tolerated as a support tool.

The sense of safety and security at home is a multifaceted phenomenon, which is one of the prerequisites for ageing-in-place. Apart from a fear of burglars and intruders and the risk of power outages (in the case of electrical assistive devices), falling, as well as the risk of fires, were items of great concern. The majority of respondents in this study have emergency response systems. There were a number of safety and security issues mentioned during the interviews which were seen as a threat to the respondents' sense of safety and security.

Most respondents are, due to their age and health status, worried about burglary. In order to keep burglars out, extra locks and catches have been installed, and windows have been barred.

Fire and gas are a source of concern for frail persons as they may not notice this type of hazard before it is too late to get out of the home. Nine respondents already had fire alarms installed prior to the installation of the new technology. The majority of respondents no longer have gas cooker tops installed. They no longer use the kitchen because they receive meals from meals-on-wheels. The gas in Mrs. N's home has been shut off because she forgets to turn it off due to her impaired short-term memory.

Some frail persons are heavily dependent on modern technologies. Mrs. A, for example, worries about power outages as her automated inflatable mattress deflates and as the telephone is her only means of contacting the outside world and sending alarms. She recounted her experience of not being able to open her electric door and on another occasion of being struck by telephone failure for two and a half days.

Some of the respondents have a higher risk of falling because of disturbances of equilibrium. Mrs. D indicates that she has fallen in the bathroom once, and also near the toilet a couple of weeks before. Mrs. D: "*When I dropped in the bathroom, it was really unexpected. I had just drunk some water, and turned around to go to the toilet. And suddenly I was lying on the floor. At the same time, I fell against the door of the washing machine, which closed with a bang.*" Despite these incidents, she is not afraid to fall. This illustrates how the majority of respondents perceive falling.

All but three respondents have emergency response systems: neck-worn pendants, wrist bands, and audio/voice alarm systems. These alarms give people a great sense of security. At the same time, the speed at which professional carers can reach the respondents in cases of emergency (which should be 20 min at maximum) worries many of the respondents. Mrs. D does not have a lot of confidence in the

emergency response system/service system (neck-worn pendant) as her husband wore one when he passed away after having a heart attack. Mrs. D: "*Well, [when I press the alarm], help does not arrive immediately.*" Daughter: "*Yes, it is not like they are ready to go. I mean, it is not like they are waiting with the engines started until someone presses the alarm button.*" The respondents presumed that with the new technologies, help can reach them faster and without having to rely on them pushing buttons.

3.2. *The importance of ageing-in-place and sense of safety and security: after installation*

After installing technology, respondents spoke of the same reasons why they wanted to continue living in their current dwellings. These largely matched with the statements made during the interviews that took place prior to the placement of technology. Installing technology did not change the motives for ageing-in-place.

As a sense of safety and security at home can contribute to ageing-in-place, the improvement thereof was one of the main goals of the technology installed. The majority of respondents are satisfied with the new ambient intelligence systems in relation to their sense of safety and security. The new technology is seen as a welcome addition to safety and security because the majority of respondents do not continuously wear the emergency response systems, or because of the fear of not being able to use the emergency response system in cases of emergency. Their children, especially, are very satisfied with the new technology. Only one of the respondents (Mrs. B) had the new technologies removed upon her personal request. In addition, two of the respondents (Mrs. J and Mrs. K) are not very content with the system due to false alarms but want to keep it out of health concerns. Overall, there seems to be a supplementary value of the new technologies in terms of improving the sense of safety and security among the respondents.

A major perceived benefit of the ambient intelligence technologies the apparent 24-hour care it provides. Mrs. L and Mr. M are very satisfied with the UAS-system, because it provides them with a real sense of safety and security. Together, the couple makes use of only one emergency response system. The couple states that they do not want to live without the UAS-system as they feel like they cannot reach help via the telephone in cases of emergency. The UAS-system, however, operates satisfactorily in such times, according to the couple.

Mrs. D has the impression that she can reach for help and assistance 24 h a day through the use of her emergency response system. In most cases, though, she simply calls her daughter. Mrs. D says she is getting a sense of peace and safety from the UAS-system. She does not have the system installed on the top floors of her home as she never goes there unattended. Her initial reserves against the system are now gone.

Mrs. S indicates that the UAS-system gives her a sense of safety and security. She once had been lying on the floor from 03:30 a.m. and no one came to her rescue. "*And I have been there on the floor until 08:30 in the morning. I was so cold. It took me fourteen days to get warm again. And you are just by yourself. And then you're getting cold. [. . .] And there is no way to escape.*" Mrs. S has already used the UAS-system in a falling incident. Everything went automatically. Mrs. S, therefore, has great confidence that the system will work the next time she finds herself in an emergency situation. She does regret that the system does not work on her balcony. When asked how she feels about having the UAS-system in her home, Mrs. S answers: "*Oh, I love it. I have a sense of being cared for!*"

There are some issues concerning the operation of the technology, which may impact the safety and security of the respondents. Prior to the interview, Mrs. N placed a large flower pot right in front of the camera of the SCOTTY-system, which, as a result, could not transmit images. In homes with balconies, respondents remarked that the systems are not yet working on their balcony.

The new technologies have a positive impact on relatives. In general, because the systems monitor their parents and, therefore, remove some of the concern, the children see the technologies as being supportive.

Mrs. F says the UAS-system provides her with a sense of safety and security. The system is a great help for night-time unrest. Though there had been no previous emergency situations, the family has been trying out the system to see if it works.

The son of Mrs. N indicates that the system is much appreciated by the children. "*Whether the system really works remains to be seen. At least it is [better] than nothing.*" Mrs. N's son also mentions that his mother sometimes falls asleep without having the door locked. The UAS-system does not yet provide a solution for this problem. The son is also pleased with the installation of sensors in the kitchen area and upstairs.

There are a number of side-effects of the ambient intelligence technologies, including false alarms and the production of sounds (see also Section 3.4.2.1). These effects can have both negative and positive impacts on the respondents. For instance, the UAS-system does not give Mrs. J an increased sense of safety and security. A reason for this may be found in the number of false alarms that were generated after the initial period during which the system operated without malfunctioning. Mrs. J mentions that the UAS-system is very sensitive. "*It was so strong. I was just sleeping in a chair for only ten minutes and then the telephone rang. People didn't detect any movement in the home.*" Mrs. J does, however, have a general feeling that help is present when needed in cases of emergency.

Once, when the home of Mrs. L and Mr. M was being cleaned with a steaming device, the fire alarm went off by mistake. They both regarded this incident as a sign that the UAS-system was working.

Mrs. B was the only respondent who had all the new technologies, which did not give her a sense of safety and security at all, removed from her home. These technologies even made her feel uneasy and restless. Mrs. B joined the project at an early phase, which means that she had to deal with the initial problems concerning the system. Mrs. B stated that the technology functioned satisfactorily during the first year, but that there was a turning point around the end of 2007 and the start of 2008. She started to feel uneasy, then started to panic, and developed a 'fear' of the equipment. A large amount of her criticism pertains to features of the SCOTTY-technology and the number of false alarms that occurred. Mrs. B had a tendency to go to the hallway in her home and remain there for some time which generated an alarm as the allowed duration of inactivity in the home was exceeded.

Privacy does not seem to be a major issue in relation to the new ambient intelligence technologies. Prior to installing the ambient intelligence technologies, people expressed worries about institutionalisation, and the supposed lack of privacy in an institution. Only one of the respondents was worried about privacy in relation to the ambient intelligence technologies. Mrs. B, who had the technology removed from her home, expressed serious criticism in terms of her privacy as she felt watched. In general, the new technologies did not pose any breeches of privacy. In the case of Mr. R, the new technologies provided an additional sense of privacy. Mr R experiences unrest and arousal when having visitors and then leaves the home to feel comfortable. Mr. R says that the system does not give him any sense of invasiveness whatsoever. This means that the system is incorporated into daily living and that the technology is not perceived as a hindrance. His wife, Mrs. Q, says that the system often goes unnoticed in their dwelling. Mrs. Q: "*Sometimes, visitors say: 'What do you people have installed over here? [. . .] Do you have an alarm system?' Yes, it is for our health*."

Mrs. N does not give much thought to all the technology installed in her dwelling. This vision is shared by most of the respondents, who see the technology with all its implications as a part of the home or as a part of the interior design.

The remarks made in regard to the privacy issue relate to the infrared movement sensors of the UAS-system and the television-mounted camera of the SCOTTY-system. When asked for objections against modern technology, the daughter of Mrs. D says: "*The consequence [of the UAS-system] will be [that you can stay in your own home longer]. You don't want to go to a care or nursing home, and then you have to make some concessions of course. [. . .] And as long as you are not spied on by anyone, [. . .] it is not like Big Brother, it is just a sort of assistive device to stay here for longer, just like a chamber pot underneath your bed. They can only watch you through the camera in case of an alarm. It's not like 'let's have a look how Mrs. [D] is doing tonight', and that they turn on a camera. It doesn't even work like that.*"

Mrs. D summarises her thoughts as follows "*If they want to watch me, they should just go ahead!*" However, this idea does not reflect the actual operation of the system, which requires an emergency situation before professionals can use the cameras for observation. Mrs. D's daughter is aware of this essential precondition. The respondents with psychogeriatric health problems, in particular, express no privacy-related issues. Respondents do not feel watched or monitored, and some are even not fully aware of the presence of the UAS-system at home.

3.3. *Engineering solutions*

The respondents make use of a range of assistive devices, technologies, and home modifications to support ageing-in-place and facilitate care (Table 4). The number and intensity of use of these architectural and technological solutions differ per household, but have not changed notably over time.

3.3.1. *Architectural solutions*

Many respondents lived in homes with home modifications already existing before moving in or had these modifications carried out themselves. These modifications mainly relate to mobility. Some of the homes were spacious and single-floor dwellings, while other respondents dealt with the limited opportunities to enlarge a shower. Showers and stairs were the most problematic and challenging areas in the home.

Many solutions deals with the support of (instrumental) activities of daily living (Table 4). Most of the toilets and showers have grab bars and handles. A number of respondents had shower seats to assist during showering. There are no grips in Mrs. J's shower as she receives help showering. "*Installing grips and bars may even make the shower smaller. Some of these bars are rather large*." During the testing period, Mrs. J also had a new toilet bowl installed, which includes technological features as a built-in bidet.

Particularly those who are bed-ridden or severely mobility-impaired have had few modifications to their homes. Mrs. L: "*We have a very spacious bathroom, [. . .] and the door openings are wide too. It is a big advantage that the moment you get a problem with your health you can stay living [in this house]*."

Some of the solutions are used to improve mobility or compensate for mobility problems. All respondents with severe mobility problems and respondents in assisted-living have electronic devices to open the front door. Some of the control buttons are placed near the bed for the bed-ridden respondents/participants.

Stairs provide great challenges. Mrs. D is actually living on the ground floor. Her shower cabin is on the first floor, and there is no stair elevator to help her get upstairs. The shower had been moved to the kitchen by her son, so that Mrs. D did not have to climb the stairs to get to the shower. The newly installed shower was too small and failed expectations, and was hence no longer used. It has now been removed. At present, Mrs. D goes upstairs once a week to have a shower with the aid of home care assistance. Mrs. J's home is equipped with a stair elevator, which she uses on a daily basis. "*I have to save [my physical] energy. I'm afraid to climb the stairs. [I'm afraid to fall] and I have to climb with both hands and feet*."

The respondents had other issues of concern regarding modifications to their home environments. Mrs. J does not want the thresholds to be removed because she does not want to end up with gaps in the sailcloth floor covering. Mrs. K had a special threshold installed at the corridor door for protection against draughts. In case of a fall, she would not experience a cooling sensation as much with the new threshold. Apart from needing modifications themselves, modifications may also support the social context of respondents and hence the wish to age-in-place. Mrs. Q and Mr. R reside in a single-floor apartment, which has wide doors. Their daughter had an accident and is in a wheelchair. The special features of her parents' home enable her to keep visiting her parents.

3.3.2. *Technological solutions*

All but two respondents have some form of mobility aids, including wheeled walkers and wheelchairs. Other items regularly found in the homes are (home-like) hospital beds, lifter chairs, and large-button telephones. A number of respondents have patient lifts to assist during showering. Apart from the emergency response systems, most technological solutions are low-tech devices. The majority of needs expressed by the respondents can be solved by low-tech solutions and do not require the immediate installation of high-tech solutions,

Table 4 – Overview of respondents and the assistive devices and home modifications present in home.

Respondent	Architectural solutions			Technological solutions
	IADL*	Mobility	Others	Assistive devices
A		Automated front door	Locks against burglars	Glasses for watching TV, touch stick, emergency response system, inflatable bed
B	Bars in the shower, grips and bars in toilet space and bathroom			Wheeled walker, reading glasses, emergency response system. Mrs. B used to have an alarm pull cord in the bathroom
C	Bars and grips in bathroom	Single floor apartment without thresholds, ramp near balcony door and front door		Wheeled walker, reading glasses, wheelchair, electric wheelchair, videophone, hospital bed, smoke detectors, emergency response system
D	Raised toilet seat	Home is free of thresholds (except for toilet space). Mrs. D only has access to the ground floor of her home		Commode, emergency response system
E	Shower chair, grips in toilet space and bathroom. The bathroom door has been removed for extra space	Ramp near balcony door		Wheelchair, reading glasses, wheeled walker, patient lift (incidental), emergency response system
F	Shower chair	Window-sill with rounded corner (protection). Home largely without thresholds. Stable heavy non-tippable tables (in relation to getting in and out of chairs)		Wheeled walker, wheelchair, commode, hospital bed, emergency response system, mobile stand-up hoist, glasses, telephone system next to bed for night-time unrest
G	Shower chair. Bars and grips in bathroom	Smooth carpet in bedroom (for patient lifter). Lowered thresholds	Barred kitchen window (burglars)	Wheeled walker, hospital bed with trapeze bar, wheelchair, lifter chair, emergency response system, grasping stick
H			Additional locks on doors (burglars)	Reading glasses, hearing aids, wheelchair, wrist protector, emergency response system. The home care organisation is working on a special chair for Mrs. H. that could be used for showering, as Mrs. H is always being washed in bed
J	Shower seat, toilet with built-in bidet, grips near toilet. Mrs J would like to have a larger shower cabin	Stair elevator	Anti-burglar bars	Mobility scooter, tripod, elastic stockings, lifter chair, emergency response system, pedal exerciser
K	Shower seat, grab bars in corridor	Carpets and rugs have been removed. Anti-draught threshold near corridor (more 'comfort' in case of falls)		Reading glasses, magnifying glass, wheelchair, wheeled walker, automated medication dispensing system, hospital bed downstairs, patient lifter (incidental use), emergency response system, modified arm chair

– Table 4 (*Continued*)

Respondent	Architectural solutions			Technological solutions
	IADL*	Mobility	Others	Assistive devices
L/M	Additional lighting, white paint on adjacent balcony for increased daylight access, large bathroom, wide doors		Anti-burglar bars	Hearing aids, white cane. The couple wish for a videophone for the front door
N	Small shower seat	Rugs have been removed for safety	Clasps from door have been removed for safety	Lifter chair, emergency response system, large-button telephone
O	Minor adaptations to the sanitary fittings			Wheeled walker, emergency response system
P				Wheeled walker, hearing aids, reading glasses, emergency response system, large-button telephone, lifter chair
Q/R	Grab bars near bathtub			Magnifying glass, electrical bicycle, home trainer, videotelephone for the front door with a built-in camera
S	Grips in toilet space	Ramp placed on top of threshold		Reading glasses, emergency response system, grasping stick, personal computer for chatting, hobbies and study

* Instrumental activities of daily living.

which are regarded as a supplement to the technologies and devices respondents already use.

Some of the respondents have a mobile phone that is used for communication and raising an alarm. Respondents mention that they have no need for modern devices to communicate. Only Mrs. S has a personal computer, which she uses for a whole range of purposes such as chatting and study. Mrs. S has a very positive attitude towards new technologies; whereas, the other respondents are worried about the use of new technologies or no longer wish to use them.

3.4. *Requirements to ambient intelligence technologies for health care*

The following sections describe the fit between the (technology-related) care requirements of the respondents and the way the ambient intelligence technologies supplement these requirements. There are three categories of requirements, namely, requirements to the organisation of care and carers in relation to technology, requirements to technology in terms of operation and design, and requirements to installers of new technologies. The results reflect the thoughts of the respondents.

3.4.1. *Requirements to the organisation of care and carers in relation to technology*

The respondents highly appreciated the professional care and assistance they receive and are grateful. Mrs. D about receiving care: "*It is very unpleasant [that I am dependent], but at the same time you have to be glad that there is help.*" Her daughter stresses that installing the UAS-system was a necessity in order for her mother to stay at home, and not have to be institutionalised. Mrs. S states that people should not be controlled too much by home visits from health care professionals, and she thinks the UAS-system can help in regard to this matter. She compliments the care organisation for the integration of the system within the care that is being supplied. Although Mrs. G's son acknowledges the potential benefits of the technological systems, he adds that it does not work for his mother as his mother has personal assistance at home.

Respondents are generally very satisfied with the care they receive. Still, they would like to have care professionals be able to answer basic questions about the UAS-technology. Prior to the introduction of the technologies, professional carers received extensive information about how the system works. Although the professional carers were able to visit the demonstration dwelling to get acquainted with the technology, respondents indicate that not all of the professional carers fully understand the fundamentals of the UAS-system.

In practice, it is difficult to make adaptations to the home environment or stop with using technology without proper communication with care clients. This is illustrated by Mrs. K's experience with an occupational therapist. This care professional sawed off the legs of her chair and added small wheels to make her get in and out of the chair more easily. Mrs. K feels like the chair is now broken. Also, carpets were removed for safety without her consent, even though she understands it was done to increase her safety.

Mrs. L is worried that the UAS-system is to be removed when the initial period of testing is over. "*And then there is the chance that you can only benefit [from the system] for just over a year.*

[. . .] And then everything is uninstalled again. And I don't know in regard to such a system – it is a good project – how long it stays, whether I like it, and how's the financing taken care of?. . ." The continuation of the trial is partly related to financing.

3.4.2. Requirements to technology

There are two types of requirements to technology which are described in the following sections: (i) requirements to the operation, and (ii) requirements to the design.

3.4.2.1. Operation of technology. Almost all respondents have made remarks about the operation of the technologies, in particular the amount of false alarms during the initial phases of the project and the sounds and light flashes coming from the SCOTTY technology. These flaws are experienced in different ways. These incidents and thoughts of the respondents are reflected in the following paragraphs and can be used to improve both the design and operation of the technology and its integration within the provision of health care.

False alarms were a frequently mentioned item. Mrs. S had been dealing with a large number of false alarms (2–3 per week), which has led to an upgrade of the system and the sensors. Most of these alarms were related to the movement detectors. She accepts these technological flaws as a part of a learning and development curve. Mrs. K says she curses the technology installed in her home. She wants the technology to be removed immediately as she is somewhat annoyed by false alarms. Mrs. G's son has written on a sheet of paper 'FALSE ALARM'. "*That is for the times that the emergency response system/service system activates the camera by mistake. [. . .] The camera signals that there is no one in the main chair. To prevent unnecessary worrying the 'false alarm sign' was introduced*."

During the study, there were respondents that did not regard false alarm as something negative. They even consider a false alarm to be a positive sign that the UAS-system responds to the home environment, whether it is justified or not. Data supplied by TNO Defence, Security and Safety show that the recorded amount of false alarms was one alarm per 2 weeks, which matches the design goals of the UAS-system as defined by ZPBS. A further decrease in this number could coincide with emergency situations going unnoticed.

Apart from the false alarms, there were unwanted sound effects produced by the new technologies. Mrs. D has specific comments in relation to the SCOTTY-technology, which produces sounds that are perceived as nasty and which give an uneasy feeling. During the night, these sounds woke her up.

Mrs. J says that the SCOTTY-technology and the camera placed on top of the television have been switched off. "*Those have been switched off too, because during the night it turned on. You are on your bed, and suddenly the thing starts to wail. [. . .] They just pulled out the cables. I told them: 'I don't want this to happen again during the night*"'. The sound was so loud that even the neighbours could hear it.

Mrs. K says that she wakes up at night from the humming sound produced by the SCOTTY-technology. This makes her upset and leaves her annoyed. All she sees are green dots of the LEDs found in the appliances. She then simply pulls out the plugs. But when the alarm next goes off, the telephone does not work either.

The son of Mrs. G has a nickname for the technology that is part of the SCOTTY-system. A blue piece of equipment is nicknamed 'toaster' as it resembles this piece of common kitchen equipment in terms of appearance. "*The system itself is well thought through, but it has no additional value for my mother. So it is only a source of entertainment for the grandchildren, or [a source] of technical malfunctions, in particular the jingling and flashing 'toaster'*."

Some of the new technologies interfered with the old technologies. The UAS-system in the home of Mrs. D interacted with the telephone during the first period after installation, that is, it took a long time before a connection could be made. These problems, however, have now been resolved. Mrs. G and her son have a large connection of DVDs and watch television together. The SCOTTY-technology often interfered with the TV set. "*Then, an exciting finale of an episode of a television series is pushed away as a turning square cross stating 'care station 140' appears, which is sometimes preceded by sounds and flashes of light which come from the apparatus I call 'toaster'. [. . .] Only the TV screen changes, and after frantic attempts to stop it with the control panel [. . .] the current solution is to use the remote control of the television and to switch it back from the AV1 channel to the TV screen. But well, about then the end of the whodunit is over and you find yourself in the middle of the commercial break*."

There were a number of other comments regarding the operation of technology. The large number of technological devices in the home becomes too much to handle for some of the respondents. Mrs. B could no longer handle the technology in her home, as she had the impression that the sensors were turned on all of the time. From her bed, she had a clear view of all the technology.

During the study, respondents hardly used the videotelephony function of the SCOTTY-technology as respondents find it difficult to operate the technology. Videotelephony did not lead to an improvement in social contacts or the loneliness some of the respondents experienced. Two of the respondents were institutionalised during the trial partly because of loneliness.

Mrs. N has a cat, and the UAS-system's software has had to be amended to deal with the pet. Mrs. N can now let the cat out of the home in the morning, and the infrared movement detectors no longer register her pet. The SCOTTY-technology requires the television set to be on stand-by day and night. The children of Mrs. N have taped off the infrared portal of the television and have tied together the doors of the television cabinet so that their mother cannot turn off the television or close the cabinet doors as she used to do. There is also a piece of text put in place saying that the cabinet doors need to remain open. These examples show that persons with cognitive impairments require specific approaches to the use of technologies.

3.4.2.2. Design of technology. There are some comments made by the respondents regarding the use of technology at home. These comments illustrate the importance of good design of technology for frail persons from the perspective of usability and acceptance.

Mrs. L has problems with electrical appliances at home due to her impaired vision. Special equipment that is ordered

is often no longer available in the market place. A 'talking' microwave oven only spoke English, whereas Mrs. L does not. Mrs. L has no idea where to turn to for the provision of home modifications. Mrs. L states that she knows how to operate current technology in her dwelling, but that she has problems inserting plugs in sockets as she cannot see the holes. The daughter of Mrs. F: "*From the perspective of technology, my mom has stood still from the days of the gramophone. [. . .] I once gave her a portable phone, and she got completely confused. Every [piece of technology invented] afterwards won't work*."

Respondents made numerous remarks concerning the design, appearance, and implementation of the ambient intelligence technologies installed in the dwelling. The majority of respondents had no complaints about the design or implementation and mentioned that the system went unnoticed or blended in with the interior design. Complaints and comments pertain to the amount of cables used and the placement of the black box of the UAS-system in the living room. Mrs. S even compares the appearance of the sensors to an anti-burglary system she used to have in a former home. It should be mentioned that the system evaluated in this study is a prototype that deviates from the UAS-system, in terms of design and appearance, which will be put on the market.

3.4.3. *Requirements to installers*

The respondents have made remarks about their contact moments with the installers and service professionals. These contact moments were experienced in various ways. The majority of respondents were satisfied with the way the technicians carried out their work. Home visits from these professionals are considered as unavoidable and necessary. Some consider the presence of installers as pleasant occasions, being able to have a little chat, and even serve the installers coffee and tea. At the same time, there are also issues that should be taken into consideration when working with and in the homes of frail older people.

Mrs. F's daughter mentions that the doorbell can make her mother go panic. When the installers called, her mother got "*completely upset, because she cannot open the door by herself. She then does not know what to do.*"

Some respondents experience the presence of strangers in the home as a matter of concern. Mrs. J experienced the installation of the UAS-system with four installers in her home as a crowded event As mentioned before, Mr. P has problems with the presence of strangers in his home, including installers and the cleaning lady. During visits from these professionals, Mr. P leaves his home to go cycling.

Mrs. B, who joined the project in the earliest phase, has specific comments that are relevant. During the installation of the UAS-system in the home of Mrs. B, seven men were at work in her home. Mrs. B felt overwhelmed and started to panic. The technology has been removed from Mrs. B's dwelling upon her request. About de-installing the technology, Mrs. B has other comments. "*When de-installing the [systems], I thought [the installers] were very impolite. [. . .] One climbed on top of my white table. [. . .] They even left the [drill] holes open.*" The way in which the de-installation took place was not how Mrs. B had hoped it would be.

3.5. *Summary of results*

The motives to use ambient intelligence technologies to support ageing-in-place are manifold. In general, there was a strong aversion against institutionalisation. All the respondents in this study want to stay in their current dwelling because of attachment to the own home, memories of the past, and their possessions in the home. Safety and security are important indicators for ageing-in-place: burglary, fire, and fall incidents are a source of concern. All but three respondents have emergency response systems: neck-worn pendants, wrist bands, and audio/voice alarm systems, which were kept during the study to guarantee a functional system capable of raising an alarm in case of emergency. The new ambient intelligence technologies were initially seen as a welcome addition to strategies already adopted by the respondents to age-in-place, including a variety of indispensable home modifications and assistive devices. The new technologies contributed to an increased sense of safety and security among the respondents, particularly in relation to fall incidents and when feeling unwell, when the person in question is not able to use a traditional emergency response system. The respondents did not have concerns related to their privacy. Some of the respondents are worried that the UAS-system will be removed when the initial period of testing is over.

The technology installed has to fulfil a number of specifications in terms of the operation and the design in order to be useful. The number of devices and cables used should be minimised, and these devices should be easy to operate. Technology should be designed and installed in such a way that it can also be used by persons with a cognitive impairment or sensory deficits. In addition, false alarms are seen by some respondents as a sign that the technology is working, and are not necessarily a bad thing. Ambient intelligence technologies should not interfere with technologies that were already found at home, such as telephones and televisions. Humming and buzzing sounds produced by technology should be reduced to an acceptable level.

The respondents asked for a better integration of the technologies in the provision of health care. For instance, care professionals should be able to answer basic questions about the ambient intelligence technologies. Respondents asked for a sufficient amount of information to be given to them on the technological solutions and their placement at home. Moreover, respondents mentioned that the installation of technology should be done in an acceptable and unobtrusive manner that matches the sense of being in one's private home.

4. Discussion

First, motives for ageing-in-place and the related use of technology are discussed, followed by a closer look at the technology-related aspects of safety and security, and privacy and ethics. This section is followed by a discussion on engineering solutions that are implemented to assist with ageing-in-place, with specific emphasis on users with dementia. Then, there is a discussion of the costs and benefits of

ambient intelligence technologies for ageing-in-place in relation to the implementation in the provision of health care. Finally, the strengths and limitations of the study are discussed.

4.1. *Motives for ageing-in-place and use of technology*

The motives of respondents wanting to age-in-place are very similar to those found in two studies from Sweden by Dahlin-Ivanoff et al. [13] and Haak et al. [14] dealing with 40 single-living people aged between 80 and 89 years. The home seems to have a central place in the lives of these people as this is where they live and spend much time. According to Dahlin-Ivanoff et al. [13], home means security and home means freedom. Haak et al. [14] showed that home is strongly linked to independence, and being independent is much valued. Also, the ageing process was found to influence people's perception of themselves as independent persons; from being independent in activity performance to experiencing independence in being able to make autonomous decisions concerning daily life at home. In a study by Lewis [15], respondents placed great value on independence and not "being a burden" to anyone. This matches statements made by Mr. M, who also does not want be a burden to others.

According to Mahmood et al. [16], there are four major themes that are important for older adults to age-in-place: safety and independence, social interaction, use of technology in the past, and the desire for support. These four themes were of importance for the respondents in this study, in particular, the familiarity with technology. Respondents who have a positive attitude towards technology and have used a wide array of technologies during their lives are more accepting of the UAS-system and other technologies as tools to support ageing-in-place. Steele et al. [17] conducted a qualitative exploratory study through focus group sessions of the perceptions, attitudes, and concerns of older adults towards wireless sensor network technologies in relation to their use in health care. These attitudes were generally positive, and match the outcomes of this study, for instance, the negative views of institutional care settings and the significance of independence. The wish to age-in-place, in combination with a positive attitude towards the use of technology, seems to be major indicators of technology use in relation to care support and supporting ageing-in-place.

4.2. *Sense of safety and security*

The sense of safety and security examined in this study does not only include the effects of ambient intelligence technologies, but rather the sense of safety and security in general, including how respondents think about the possibilities of burglary and intrusion, the risk of power outages, fires, and falls. Safety and security issues in the latter categories are related to the health status of the respondents, who are frail and are afraid they are more vulnerable in cases of emergency. All respondents have taken architectural or technological solutions to decrease the risks. Moreover, the majority of respondents in this study wear an emergency response system although some of the respondents have serious doubts whether the system will work in cases of emergency. Some of these doubts are related to previous emergency situations in which the system did not provide a solution.

The dependence of some respondents on modern technologies makes them worry about the risks of power outages. These worries are also shared in relation to the new ambient intelligence technologies. There might be an over-reliance on new technologies in relation to care and ageing-in-place, which makes frail persons prone to system failures [2] or power outages.

After the installation of the new ambient intelligence technologies, the majority of respondents have experienced an increase in their sense of safety and security. This sense of safety and security does, to a small extent, address issues such as intrusion, burglary and fires (the UAS-system includes smoke detectors). As stated before, many respondents do not wear the emergency response systems or fear that they may not be able to use the systems in cases of emergency. The new ambient intelligence systems are, therefore, considered a welcome addition; the 24-h monitoring functionality increases the sense of safety and security. In practice, the UAS-system has been activated in cases of emergency and proved its additional value to the respondent in question. However, safety and security in practice may be influenced in a negative way if respondents do not fully understand the systems' operation. The case in which a flower pot was placed in front of one of the cameras is an example of misunderstanding in relation to the operation of technology. In practice, you see respondents and relatives 'try out' the systems at home to see if they really work. If alarms are generated, this gives the persons involved a sense of confidence in this system. False alarms, however, are found to be perceived in two ways. On the one hand, some respondents are annoyed. On the other hand, other respondents see them as a sign that the technology is actually functioning. At the same time, these false alarms and the limited number of true alarms generated by the UAS-system, in general (1–3 per week per respondent), make it difficult to draw a final conclusion on the acceptance and efficacy of the technology at this moment, although the system undeniably contributes to an improved sense of safety and security.

4.3. *Privacy and ethics*

The personal integrity of respondents in relation to their surroundings and technology and the accompanying ethical aspects and privacy form an important aspect, which is gaining importance as a field of discussion and study [2]. The respondents in this study, apart from Mrs. B, did not experience any problems in terms of privacy and did not encounter any obvious situation with dubious ethical implications.

4.3.1. *Interference of technology with daily life*

In a study concerning the installation of smart home technology in the home of nine residents, Demiris et al. [18] found that the residents expressed overall positive perceptions of the sensor technologies and did not feel that these interfered with their daily activities. The process of adoption and acceptance of the sensors included three phases: familiarisation, adjustment and curiosity, and full integration. Perhaps, the dissatisfied respondents involved in the current study were

not adequately familiarised in relation to the technologies installed in their homes. Also, some of the respondents lost track or awareness of the presence of the technologies that were installed over time. This reaction could have an impact on ethical and privacy-related issues in similar projects.

The flower pot incident (Mrs. N placing a flower pot in front of a camera) matches concerns expressed during a focus group study with dementia family carers, in which questions were raised whether persons with dementia might attempt to tinker with and/or remove sensors and cameras [19]. Users of ambient intelligence technologies should be aware that actions in daily life can influence the operation of technological applications, which in turn may have serious consequences when people find themselves in an emergency situation.

4.3.2. *Privacy*

Even though all respondents in this study (or their legal representatives) signed informed consent, there might be some ethical considerations according to Demiris and Hensel [5], which have been considered for the study. The possible lack of technical familiarity among the respondents, their relatives and carers can "*hinder this process because the discussion of security and privacy concerns or issues of accuracy and reliability of sensor systems or other computing applications often require basic understanding of networking and data transfer*" [[5], p. 110]. According to Demiris and Hensel [5] it is not easy to determine whether participants have been informed fully in the context of smart homes. Therefore, ZPBS has provided respondents and relatives with information during special gatherings and via written material.

van Hoof et al. [2] and Demiris and Hensel [5] have addressed issues of privacy and confidentiality, such as, the right to control the access to and the use and dissemination of information gathered by the smart home technologies, as well as a secure means of the transmission and processing of data. Just as in the present study, residents in the study by Demiris et al. [18] did not express privacy concerns. In the aforementioned study by Steele et al. [17], participants stated that the incorporation of a camera into a monitoring system would be too intrusive, while monitoring 24/7 would not be a problem. In this study, views are somewhat different as cameras can only be switched on in cases of emergency. Mrs. D – a critical respondent in the early days of the study – was not opposed to being watched, and the same is true for other respondents. However, there are some fundamental concerns related to the privacy issue and older adults with disabilities. Do they fully understand what the technologies installed in their homes offer? Do they comprehend how valuable privacy is even though they are so easily willing to give it up in exchange for safety and security? At the same time, in the context of these issues, one could question the validity of the informed consent signed by the respondents.

4.3.3. *Ethical considerations*

Mahoney et al. [6] have raised a number of questions relating to home monitoring technologies that are relevant to the current study. These include questions on how much surveillance is helpful; when technology starts to infringe upon personal dignity; and whether home automation can maintain or improve human functioning without frustrating the user. They state that if a technology is dehumanising and takes away personal control, it is because of the way that humans envisioned and developed the application [6]. Moreover, Rauhalaa and Topo [20] point out possible side effects of the testing of alarm systems and automatic personal health or safety systems at home. Trial participation may cause distress and anxiety, which should be recognised by parties involved in these studies. The abovementioned literature is relevant to the case of Mrs. B, who left the study as she no longer wished to live with the sensor system installed in her dwelling. van Hoof et al. [2] have summed up a number of ethical considerations that a system should fulfil for people with dementia. The technologies used in the current study meet these criteria, since they serve the well-being of the residents in the first place. Nevertheless, it is of the utmost importance that the participants remain monitored to see whether the system keeps meeting expectations and preferences and that the desired quality of care is kept.

Demiris and Hensel [5] raise some ethical consideration in relation to technology at home, such as the potential overreliance on automation, and the 'medicalisation' of the home environment (home as an intensive care unit). This overreliance is illustrated by Mrs. A and power outage, during which her bed deflated and communication with the outer world was hampered. Demiris and Hensel [5] further claim that the installation of sensors or other technologies that become integral to the residential infrastructure introduces a medicalisation of the home setting. When asked about this idea of medicalisation of the home, none of the respondents in this study agreed with such a notion. Demiris and Hensel [5] also state that smart home technologies also affect the circle of family members and friends who enter the home. This was illustrated by remarks, however innocent they may seem, from Mrs. Q, whose friends commented on the UAS-system and its sensors.

New technologies may even threaten the home as a 'safe harbour', especially in relation to the installation, maintenance, and operation of these technologies [5]. Relevant professionals should not violate the personal space of the occupants or alter their daily routines.

Demiris and Hensel [5] also mention the risk of stigmatisation due to the visible presence of devices or sensors and mention aspects of obtrusiveness. "*Technology that one person perceives as obtrusive may not be perceived as such by another*" [[5], p. 112]. This is also seen in the current study, in which some said that the technology blended in with the dwelling (Mrs. Q), whereas Mrs. B was very outspoken in the other direction, and Mrs. J and Mrs. K were somewhere in the middle.

There are also issues that apply to the organisational level. The use of technology to support people with dementia should be informed by an ethical framework that is translated into explicit organisational policies and procedures, and informed by legislation and national policy [21].

4.4. *Engineering solutions*

In the following sections, architectural and technological solutions that are implemented to assist with ageing-in-place are discussed.

4.4.1. *Architectural solutions*

The majority of modifications identified in the homes of the respondents seems to have been carried out by previous home owners or tenants, and are occasionally used by the current residents. Also, the provision of home modifications is unclear to some of the respondents, and this might be a reason why many of them have not carried out many home modifications. As the majority of people prefer to continue living in their own home in the face of disability and ageing, homes should be designed to be adaptable to disability. Having access to home modifications is essential in being able to age-in-place, for example, getting a stair elevator for those living in a multi-storey house. Sufficient care and monitoring technologies alone are not solutions to all problems faced by people in daily life.

In this study, the respondents with psychogeriatric health problems had a number of environmental interventions carried out, although none of these interventions specifically targeted dementia, as identified by van Hoof et al. [22]. Tanner et al. [23] examined the experience of older people living in the community, who were recipients of a home modification service. Home modifications were found to have the potential to enhance the experience of home as a place of significant and unique personal and social meaning. At the same time, however, an awareness of the meaning of home should be embedded in the policy and practices surrounding the provision of home modifications. Tanner et al. [[23], p. 204] further found that "*reducing the demand of the environment through modifications strengthens the personal home as a place of security, safety, comfort, and control rather than one of risk, dependence, struggle, or even imprisonment*". This may indicate that also the presence of adaptations at home may contribute to a sense of safety and security, in addition to the ambient intelligence technologies. This, however, has not been studied separately.

4.4.2. *Interaction between architectural and technological solutions*

In contrast to the amount of home modifications, every respondent used some type of assistive device or supportive technology to help with activities of daily living. In order to use these devices, small home modifications were carried out, for instance, to allow for wheelchair access. According to Dewsbury et al. [8], there is little point in putting the latest technology into a home where both care clients and carers are unable to benefit from it because the design of the home is not supportive, or where the external spaces are inaccessible (for example, see Mrs. J and Mrs. S). Dewsbury et al. [8] further state that technology should be considered as an augmentation to the overall design of a home, and that it technology can also be disempowering to the user if it is not suitable, not reliable, or does not perform the functions it was intended to perform [8]. This may be the case with people with dementia, as is discussed in a later section.

4.4.3. *Technological solutions*

Technology is designed primarily to serve the 'person' as the consumer of this service. By contrast, many home telemedicine technologies view the clinician as the consumer of the service and the person at home as his or her 'patient' [6]. Therefore, it was important to investigate whether the introduction of the new technologies in this study was not just the next product of a technology push by mapping the needs and experiences of the respondents. Also, one may ask whether it is good for very care-intensive persons to remain living at home with the use of technologies. Mahoney et al. [[6], p. 218] quote an anonymous grant reviewer: "*In an institutional setting, many factors are taken care of (medical administration, hygiene, daily activities, etc.). [Ageing-in-place] presumably places the patient at risk for these not occurring. This is not mentioned at all as a patient safety concern and shows a lack of understanding of the [medical] domain.*" The UAS-system is not the only means of providing daily care to the respondents as they continue to receive care from professional and family carers for personal or domestic care as usual.

4.4.3.1. *Technological solutions for users with dementia.* Technology for older people should be designed in such a way that they are useful for all types of care clients. People with early and moderate dementia are explicitly included in the target group of the technologies in this study. There are many specific challenges related to the design and implementation of technology for people with dementia and the understanding thereof [2], the installing of the technology, and also to the family carers. Selecting the appropriate assistive technologies can be a challenging endeavour. People with dementia may react differently to various assistive technologies. According to Cahill et al. [24], there are no quick fix solutions in dementia care, nor do solutions necessarily have to be highly technical. The ambient intelligence technologies studied here were not specifically designed for people with dementia. Still, respondents with dementia were given the opportunity to participate in the study.

A focus group study with dementia family carers by Kinney et al. [19] showed this group did not think of themselves as being particularly savvy about technology. At the same time, and seemingly paradoxically, carers used a range of technologies in everyday life, mainly low-tech technologies and personal computers. Some had devices to monitor, communicate with, and maintain the safety of their relative with dementia. There were also perceived limitations of technology: some challenges in caring cannot be addressed by technological solutions. As an example, scratching during bathing a loved-one is addressed. The technologies offered in this study are not solutions to all problems encountered by the respondents (both with and without dementia), but a mere tool for support. Other carers, in the study by Kinney et al. [19], mention that monitoring is not a panacea for all persons with dementia, and that it should not be considered as a substitute for the presence of family carers.

Technology that is to be used with people with dementia should meet certain design qualifications that are specific for this group of older people. The nature of dementia may make people cautious and suspicious of trying out new devices [24]. Orpwood et al. [25] and Cahill et al. [24] came up with a number of guidelines for technology so as to be appropriate for people with dementia. Smart home technologies should keep interaction with users to a minimum, be familiar in appearance, should not require new learning on the part of the person with dementia, and incorporate verbal prompts and reminders.

Given the fact that there are three configurations of the UAS-system, and that the choice for a certain configuration depends on a variety of indicators, it should be questioned if the system is applicable for people with dementia or cognitive impairments. The challenge for people with dementia is that they do not fully understand the system or know why it is installed in the first place. People with dementia cannot simply work around problems whenever they occur. In addition, people with moderate to advanced dementia require intensive forms of care at home and are prone to early institutionalisation. Relatives that are often supporters of having technology installed to assist their loved-ones should be aware of the challenges related to new technologies. As the choice of configuration is mainly dependent on the degree of physical mobility, true acceptance of the system relies more on psychology and cognition.

Apart from certain requirements to the design and implementation of technology, there are issues concerning the installation. For instance, Mrs. F's daughter mentioned that her mother was upset by the installation of the technologies. The literature offers information on this matter. When working with a person with dementia, he or she may not remember why an installer is working in a home, or who this installer is. This, therefore, may be a cause of distress. Installers should preferably work in pairs, as this allows one of the two to leave the site without loss of access upon return [26]. When equipment is installed, installers should answer user questions repeatedly, listen, and be sensitive to the state of mind of the person with dementia. Moreover, installers should proceed only with equipment that has been agreed upon by the family [27].

4.5. *Costs and benefits*

Ambient intelligence technologies may hold the promise to delay the need for institutional care, which has economic consequences for both society and the persons in question. Some of the cost aspects, including the costs of the UAS-system itself, are discussed below. These aspects are, together with human aspects as well-being of clients, among the most important indicators for a successful implementation of ambient intelligence technologies in health care.

For the current trial, a total of 20 UAS-systems (prototypes) were produced by TNO Defence, Security and Safety. Not all of these systems were used for the study. Some homes were very large and required the application of more sensors. In this study, two systems (configuration 3) were used for spare parts to enlarge the other 18 systems. During the project, 16 UAS-systems were (re-)used. Some of the respondents were unable to use the voice response of the system to alarm carers. Other respondents were not mobile and therefore, did not use the mobility monitoring function. For these reasons, not all respondents used configurations 1 or 2 of the UAS-system (Tables 1 and 2). One consequence of the configuration-based system is that care clients do not get more technology installed than needed, which creates a possibility for a good fit between needs and technology, and thereby saving resources and energy. Because of the limited average life expectancy of many of the care clients, the system is designed in such a way that it can be moved out of the home and installed in another dwelling. Also, if persons move to another place, the UAS-system can be brought along easily without having to install complex infrastructure including numerous cables. Some of the benefits of the current system have been described in relation to a different project by Skubic et al. [28]. They describe a system that could be installed in any home with minimal time and effort and especially with minimal wires and cables. Apart from the obvious economic motives, people receiving such systems care about the looks of their homes, and they do not want extraneous sensors, wires, and computers cluttering up their space. These views are shared by some of the respondents in this study. Moreover, Skubic et al. [28] raise the questions of how many sensors to use, where to place them, how to mount them securely, and how to maintain them. Such issues as replacement of batteries by professionals were also encountered in this study. As in the project described by Skubic et al. [28] most of the sensors used in this study were small, wireless, and lightweight enough to be mounted on the wall or ceiling with double-sided foam adhesive or with screws if needed. Despite the reduction in costs for installing, some of the sensors that were attached using Velcro or that were attached to an uneven wall (Mrs. D, Mrs. N) became loose. Also, as in the case of Skubic et al. [28], sensors falling down caused a gap in the transmission of data.

Assistive technologies and smart home technologies for ageing-in-place have a number of economic impacts in terms of costs and benefits. The costs per UAS-system are relatively high, as the scale of production is still small as long as the system is not launched commercially. The most elaborate configuration of the system (number 1) costs approximately € 13.500.

During the pilot project, a number of respondents quit the project for various reasons: death, institutionalisation, or in one case wanting to stop with the project because of objections to the technology. With five respondents, the UAS-system did not delay the moment of institutionalisation. For three of the psychogeriatric respondents, such a delay has occurred, and in one of these three cases, institutionalisation (nursing home placement) has been prevented. With six respondents, the UAS-system serves as a tool to support ageing-in-place. If the UAS-system had not been available, these respondents would, however, have looked for other means to age-in-place. Respondents and their relatives perceive the current living conditions with the UAS-system as safer and more secure than without the technology. The social network around the respondents also contributes to being able to age-in-place. In order to optimise the implementation of new ambient intelligence technologies, a good integration in the provision of health care is indispensable, not only on the level of the management but also on the level of health care professionals in the field. Training is thus required for staff, which comes at a prize. At the same time, the UAS-system supplements or substitutes the care provided by ZPBS and staff. A professional carer can see what is going on in a dwelling when an alarm is transmitted and then reach the care client by telephone or go to the client's home.

For The Netherlands, € 6000 to € 16,000 (2004 price level) could be saved per person if people aged-in-place instead of being institutionalised. These figures are contingent on the health status of the individual [29]. Roughly, the UAS-system

has a payback time of around 1 year. In order to maximise profits and benefits for both clients and society, the presence of the UAS-system at home should be guaranteed. Rauhalaa and Topo [[20], p. 210] have discussed what happens to the technology that has been tested after the trial is over. "*The subjective meaning [. . .] a technology for a person who has become used to and dependent on it during the trial can be significant for the well-being of that person*." Apart from the effects on costs, this statement correlates with relevant ethical questions. These include whether technology should be removed and participants or users return to the original state, especially if these participants or users have already felt possible advantages of the technology tested.

There are other studies that deal with cost aspects of telehealth and telecare systems. A Canadian study by Vincent et al. [30] investigated a nurse-staffed telesurveillance system for community-dwelling frail older people ($n = 38$) over a 9-month period. Only 5% of the calls were found to be health-related (6-month period). Similar outcomes were found in this current study, where some of the respondents used their emergency response system to complain about the meals-on-wheels services. The Koala project is a pilot experiment in telecare from the Netherlands, where the client is able to call for contact with a nurse in a medical service centre via video interaction. In a cost-benefit analysis of the project, Wortmann et al. [31] concluded that for care purposes the benefits lie with the clients as well as with the providers of care and cure services. They concluded that video-based telecare does not easily pay off, although labour hours can be saved and the clients' well-being improves. About 40% of the clients' calls are leading to a reduction of medical services. As the vast majority of clients only used Koala infrequently, the investment could not be justified. Telecare can be made economically feasible as long as the project covers a substantial region of clients, in the order of magnitude of ten thousands. For cure clients, the savings in economic terms (shorter hospital stays, reduction in medical consults) are limited. In order for the UAS-system to be economically feasible, a larger number of users may be required, although the use of the system itself has obvious non-economic benefits for the users, such as increased well-being and safety and security.

4.6. *Strengths and limitations*

The current qualitative study knows a number of strengths and limitations. The choice for a qualitative methodology was fitting for the aim of the study, which was to investigate the motives of people for accepting new technologies as a strategy to age-in-place. The study has resulted in a number of directions which can be studied in more depth using quantitative approaches.

One of the strengths of this study is that the sample contains both somatic and psychogeriatric respondents, which went together with a large variation in needs, although the latter category of respondents was smaller in number. In addition, most of the respondents made use of a configuration 1 UAS-system, whereas the number of respondents using configurations 2 and 3 was slightly smaller in number. This may have influenced the variation in views and motives. There were only two couples participating, whereas living together goes together with different needs and motives compared to living alone. The current study focuses mainly on clients of the care organisation as the main stakeholders. Perhaps, family carers and professional cares should be been explicitly included in the current, or a separate, study.

The large differences in between-interview duration (8–23 months) allowed for the identification of varieties in experiences that may come into existence over time. At the same time, there was the disadvantage of respondents leaving the study. As there was no third round of interviewing, there is no data on possible changes in people's attitudes and motives over a longer period of time. As people may pass away during the study period, the population size should be larger.

Another strength of the study is that it studies the introduction of ambient intelligence systems in a broad context of ageing-in-place and the use of other engineering solutions, including assistive devices and home modifications. This is one of the first studies doing so. Moreover, the results of the study are used in practice for improving ambient intelligence technologies, their implementation in health care, and their installation.

5. Conclusions

The wish to age-in-place is one of the most explicit desires of community-dwelling older adults, even if this goal seems to be difficult to achieve. In this study, new ambient intelligence technologies were considered to be welcome additive tools to support ageing-in-place by the vast majority of respondents. Also, these technologies were believed to support respondents when traditional emergency response systems could not be used to send out an alarm call. The new ambient intelligence technologies have contributed to a greater sense of safety and security at home, which is an important indicator for the continuation of living in the community. These feelings are shared by relatives. Relatives form an important link to a successful implementation of new monitoring technologies. The present study provides examples of notions of violation of the personal space. This is why awareness of such phenomena is needed among professionals from both the fields of technology and health care.

Despite the large differences in independence and the type of care respondents received, motives for wanting to age-in-place were similar for most respondents. Installing technology did not change these motives. The respondents are well aware of the safety and security-related functionalities the installed technologies have to offer. At the same time, they are not exactly aware of which technology is installed. The technologies tested in this study may not be entirely suitable for daily care of people with dementia who are living alone. In addition, the study shows that for people with impaired mobility, there are few problems regarding the operation of the UAS-system in all three configurations. Therefore, further studies may be needed on usability.

Stand-alone ambient intelligence technologies do not provide an all-embracing solution for people who wish to age-in-place. These technologies can only function within the context of other solutions. Interoperability is needed with the UAS-system, as well as with the care provided to the clients

Summary points
What was already known on the topic?

- Ambient intelligence technology is being installed in the homes of frail older persons, although the views of the users are not well studied.
- Older people use a multitude of strategies to support ageing-in-place.
- Installing technology in the home of older people poses requirements on installers.

What this study added to our knowledge?
First ambient intelligence project in the Netherlands that is studied from the perspective of real users, which taught us:

- Ambient intelligence technology alone is not sufficient to age-in-place.
- Privacy-related concerns that exist among researchers are not a major concern to users.
- Ambient intelligence technology can contribute to perceived safety and security.

and with a modified home environment. This study shows that the UAS-system provides people with safety and security. At the same time, it provides extra eyes and ears for the care professionals in cases of emergency. Therefore, the UAS-system is intended to reduce the number of care professionals needed to provide complex long-term care or during night shifts.

In general, respondents are not worried about privacy-related issues in relation to the new technology. Moreover, they are aware that the care organisation involved in the project cannot use the cameras to monitor one's home without first having received an alarm call. The design of the technology or the way this technology was installed were a main source of concern. The preparation and placement of the technology should be talked through thoroughly with the respondents, given that some of them were upset. During the trial period, the interaction between installers and respondents improved, possibly due to an iterative learning process. As in the early days, the new technology interacted with the telephones in some of the dwellings; therefore, installers should tell respondents about possible interactions. Respondents should not be surprised by such events, and the availability of sufficient information can benefit the acceptance of new technologies.

Contributions

J. van Hoof is the main author and conducted the interviews. J. van Hoof and H.S.M. Kort created the topic lists and analysed the data. H.S.M. contributed to the methodology of the study and to the interpretation of the results from the perspective of health care, (geron)technology and environmental interventions. M.S.H. Duijnstee contributed to the methodology section of the study and to the interpretation of the results from the perspective of health care. P.G.S. Rutten contributed to the interpretation of the results from the perspective of integrated building design. All four authors contributed to writing the manuscript.

Competing interests

None.

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