

# Unattended autonomous surveillance in community-dwelling older adults: a field study

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**Abstract**—The Unattended Autonomous Surveillance (UAS) system is placed among 18 older adults, who are entitled to receiving nursing home care at home, as a means to support ageing-in-place by providing a sense of safety and security. In order to investigate the expectations and needs of the clients, phenomenological qualitative research was carried out. Results showed a positive attitude of older adults, and of their informal carers in particular, towards the system, which is to take away a part of the burden of care. Apart from the UAS-system, additional home modifications may be needed to support ageing-in-place. The over-time contribution of the UAS system to independence is to be studied further.

## I. INTRODUCTION

ABOUT 85% of adults aged 65 and older in the Netherlands want to remain living in the current dwelling [1]. This wish, regardless of the condition the home, neighbourhood, and health, is often a personal choice, which is influenced by the personal health status and that of a spouse. The vast majority of the older citizens -93% of 2.2 million- lives independently in their own home [2]. At the same time, only 0.5 million dwellings in the Netherlands are intended for habitation by older adults, and there is a 40% shortage to deal with the demand for such dwellings. Ageing-in-place often goes together with an increase in costs for home care, home modifications and transportation. There is an enormous pressure on the existing housing stock, given the fact that the amount of specialised senior housing can hardly keep up with the demand [2]. Not only the need for specialised senior housing increases, the demand for care also increases due to ageing of the society and an increase in the number of chronically ill people. Therefore, the number of dwellings that can facilitate ageing-in-place and compensate for functional limitations caused by (chronic) diseases that result from biological ageing needs to increase. Only 15% of older people in the Netherlands receive professional home care [3]. However, community-dwelling older people, who have the acquired the right for receiving nursing home care based on the Dutch Exceptional Medical Expenses Act (AWBZ; EMEA), ask for a substantial level of long-term care that, for instance, can be supplied by home care visits. Some clients receive as many as eight home visits per day by various health care

professionals. Home automation that allows for telecare services is increasingly becoming a tool to support older adults live independently and to improve perceived safety and security, and forms a welcome addition to the home visits. In short, residential monitoring technologies aim to support frail people live more safely, more capably, and longer in their location of choice [4].

The Unattended Autonomous Surveillance (UAS) system that has been under development by TNO Defence, Security and Safety, the Netherlands, since 2001, is an integrated system that combines many functionalities for community-dwelling older adults, who -based on the EMEA- are entitled to receiving nursing home care. The new UAS-technology is implemented among people in the towns of Baarn and Soest in the centre of the Netherlands. The UAS-system aims to support ageing-in-place and delaying the demand for expensive institutional care; a form of care that is under pressure due to the ageing and hazing of society with respect to the available capacity of formal and informal care, by increasing the clients' and family carers' sense of safety and security. Besides the benefits for the care recipient, informal or family carers are supported in care through the technology installed as well. Professional carers can benefit from the expected increased self care capabilities of the care recipient.

The aim is to study the perceptions of independent living, the role and quality of care received, and how people think technology can support them in their daily lives, as a method to assess if, and how, the UAS-system can contribute to a delay in the need for institutional forms of care and improve the sense of security and independence at home. This paper presents data from the first round of interviewing, and particularly focuses on the technological aspects related to independent functioning.

## II. METHODOLOGY

### A. The UAS-system

The UAS-system is a system that offers clients a large range of functionalities including automatic fall detection, wandering detection and prevention (magnetic door contacts), bed pressure sensors, detection of smoke and fire, emergency response system, video observation and video telephony. The main goal of the system is to provide a sense of safety and security to users, which is the basis of remaining to live at home. The ZigBee-based UAS-system consists of a number of wireless sensors in the home (living room, bedroom, kitchen), along with a black box containing hardware components located in the meter cupboard [5], without clients having to wear or carry

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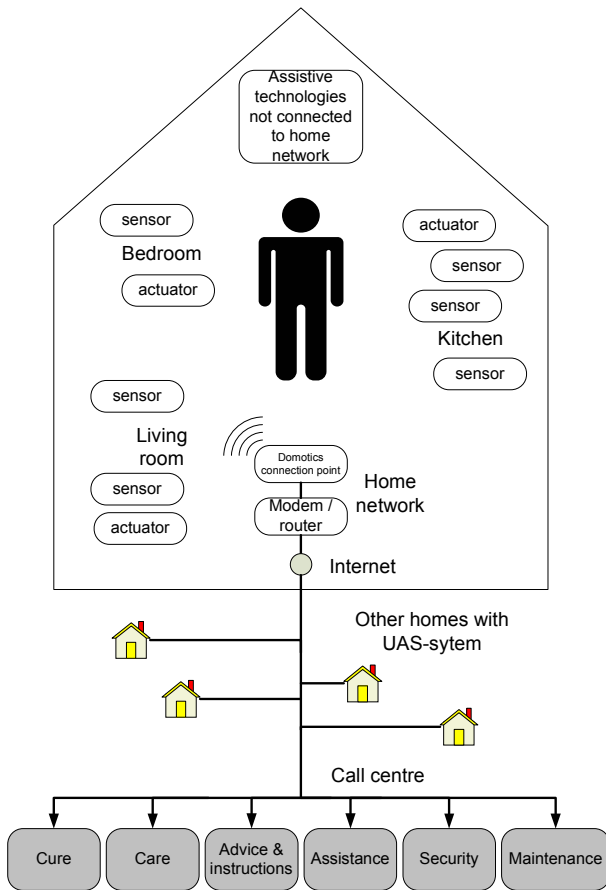


Fig. 1. Model of the UAS-system and its functionalities. The domotics connection point is based on the TCP/IP protocol and XML.

system equipment themselves (such as emergency response systems). The black box 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 (Fig. 1). Newly developed software analyses the information that is collected from sensors in the dwelling, and compiles it in order 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 [5]. In case of an alarm, the system contacts somatic clients via telephone first (voice response) in order to minimise the number of false alarms. When the client does not respond within a minute, 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 [6]. Also, two small cameras in the dwelling can be activated in cases of emergency for verification of the alarms. Moreover, professionals in the call centre can have screen-to-screen contact with the clients via the television, or have contact via a sound-system, for instance, to ask how people are doing [6].

There are three configurations of the UAS-system that are being installed in the clients' homes: 1 containing all functionalities for clients that are mobile and are able to answer the telephone; 2 without speech interface for clients that are mobile but unable to answer the phone; and 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 status of the client and her/his personal wishes/needs concerning the system, and is also made based on the professional judgement of a care professional from the care supplier involved in the project. Because of the limited average life expectancy of the clients, the system is designed in such a way that it can be moved out of the home when people pass away or move to another place, and be passed on to another user.

### B. Subjects

In order to investigate the expectations and needs of the clients, phenomenological qualitative research is carried out among a group of 18 older adults living in their own home with support of home care services (Table I). These clients have been selected by the care coordinators of the participating care supplier (Stichting Zorgpalet Baarn-Soest). Based on assessments of the regional health care assessment centre (CIZ), the clients chosen for the project are entitled by the EMEA to receive institutional nursing home care. Of these clients, seven cope with mild to moderate psychogeriatric health problems, including dementia. The other clients have (severe) somatic health problems. Most subjects deal with comorbidities.

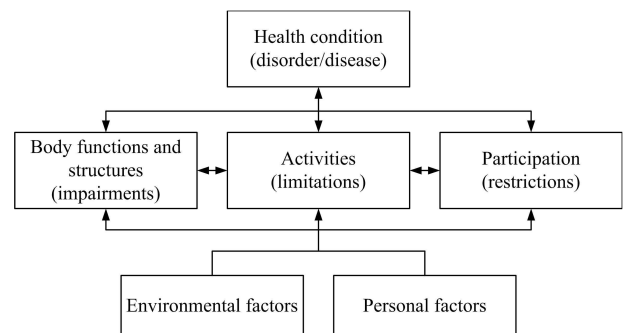


Fig. 2. International Classification of Functioning of the World Health Organization used to describe a person's health condition.

### C. Interviewing

In order to investigate the needs of the users, phenomenological qualitative research is carried out among a group independently living older adults, assisted during the interviews by their (family) carers, using semi-structured questionnaires. These questionnaires covered a range of items, including (i) family status, finances and living condition, (ii) morbidity and use of assistive aids, (iii) demand for care, home care received and satisfaction with care services, (iv) importance of ageing-in-place and accompanying challenges, (v) perception of independent functioning, (vi) perception of safety and security, (vii) perception of communication with carers and relatives, and use of technology to support communication, and finally

(ix) concerns regarding technology and personal thoughts about the future. Most of these items are an integral part of the International Classification of Functioning (Fig. 2). The questionnaires were based on earlier work by Bijsterveld [7] and Demeris *et al.* [8]. The first part of the study, performed between December 2006 and September 2007, included 18 subjects. The interviews were carried out prior to or directly after the installing of the UAS-system, within a range of 3 weeks. The subjects were aware that they were getting the new UAS-system. All interviews took place within the homes of the clients, since observation of the living environment plays an important part in the questionnaire. An exception was Mrs. O, who was interviewed at the day care centre.

The transcripts were analysed using the MAXQDA 2

program, in line with an earlier study by Braudy Harris [9]. First, each transcript was read in its entirety. Then, they were read a second time to develop codes that were grouped into themes consistent with the interviews, which emerged from the narratives and the interview guides. To be considered a major theme, the code had to have appeared in more than 25% 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. Due to the large amount of qualitative data, only the data on (the perception of) independent functioning in relation to the home environment and the use of technology was used for this paper.

Table I. List of clients, arranged by age, gender, health- and social status and living conditions.

Client	Gender	Age	Somatic / psychogeriatric client	Marital status	Number of children	Pets	Is the income sufficient?	UAS- configuration**	Education*	Type of housing***	Ownership
A	female	65	so (bed- ridden)	divorced	2	no	yes, for the time being	3	Sec	Terraced housing	own home
B	female	82	so	widowed	2	no	no	1	Sec	ALF	rent
C	male	87	pg	widowed	2	no	yes	1	Un	Apartment	own home
D	female	84	so	widowed	5 (1†)	no	yes	1	Sec + Prof	Terraced housing	rent
E	male	82	so	widowed	3	no	yes	2	Sec + Prof	ALF	own home
F	female	77	pg	widowed	2	no	yes	3	Sec	ALF	rent
G	female	85	pg	widowed	4	no	yes	3	Un (not completed)	ALF	own home
H	female	80	so (bed- ridden)	widowed	4 (1†)	no	yes	3	Sec	ALF	rent
J	female	63	so	widowed	2	no	could have been better	1	Prim	Terraced housing (corner)	rent
K	female	81	so	widowed	0	bird	could have been better	1	Sec	Terraced housing	rent
L/M	female male	76 84	so so	married	3	no	yes	1	Sec + Prof Sec + Prof	Apartment, ground level	rent
N	female	81	pg	divorced	3	no	yes	2+WD	Prim	Semidetached home	own home
O	female	80	pg	widowed	4	no	yes	2	Sec	Apartment	own home
P	female	85	pg	widowed	4	no	yes	2+WD	Prim + sewing school	ALF	rent
Q/R	female male	75 76	so pg	married	3	no	yes	1	Sec Sec + Prof	Apartment	own home
S	female	83	so	widowed	3	no	yes	1	Prof	ALF	rent

\*Prim (Primary education); Prof (Professional education); Sec (Secondary education); Un (University). \*\*WD (Wandering detection). \*\*\* ALF (Assisted-living facility)

## I. RESULTS

### A. The importance of living at home and challenges

The interviewees have reported a number of reasons for wanting to remain living independently, and all have different views on their level of independence, despite their need for assistance and nursing care at home. Most subjects want to stay because of attachment to the own home and their possessions in the home, as well as the quality of the neighbourhood. Some even moved to the current home to anticipate a worsening health status, and some even appreciated the current home modifications available to help. Another concern 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, although in practice there are no restrictions to receiving visitors in a nursing home. Another reason was expressed by Mrs. L and Mr.

M, who asked for a flat in assisted-living. They were told that only one of them was entitled to institutional residence, which would mean separation after 54 years of living together. Mrs. D: "I have no need for this 'compelled' living room [in a nursing home] where you sit down with all residents chitchatting and where everybody speaks for him/herself." Mrs. J was offered a small home next to 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, sit on the pavement when the weather is fine. I couldn't do all these things in the new home."

Important challenges that need to be overcome in many households are the stairs and the inability to climb them safely, along with small shower cabins. Impaired mobility and need for support in personal care and activities of daily living were considered major threats to independent living. A loss of autonomy and

independence were often mentioned as unwanted side effects of declining health. Most people, however, highly appreciated the care they received.

#### *B. Perception of safety and security: general*

Many people are, due to their age and health status, worrisome about burglary. Many people do not open the door when the doorbell rings, unless they have an appointment. Most professional carers have access the homes and do not need to ring, but still do so out of respect for the client. To keep burglars out, many people have installed extra locks and catches, and barred windows. Daughter of Mrs. F's: [The doorbell] can make my mother go panic. [The installers of the UAS-system] called the other day, and then she is completely upset, because she cannot open the door by herself. She then does not know what to do." Mrs. H has had intruders in her home, people pretending to upholster chairs and even children asking to do groceries.

Due to disturbances of equilibrium, some of the subjects are prone to falling. Mrs. D calls her movements wobbly. She indicates that she's fallen in the bathroom once, and also near the toilet a couple of weeks ago. Mrs. D: "When I dropped in the bathroom, it was really very 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. Mrs. K: "I had these wonderful carpets, including a beautiful Persian carpet. [...] It all had to go; else I'd break my neck. [...] I did not [ask for it to be removed myself]. People came and took them. I was furious. And then other came every day, [telling me how beautiful my floor is]. I then thought to myself, 'I feel cheated'. [...] The carpet cannot be put back, then I might break my neck."

Mrs. B has the tendency to fall asleep early in the evening while watching television. "It happens occasionally that I wake up at half past midnight, [...] and realise I missed about half of the TV programs. It is something that happens only recently. I'm also tired".

Mrs. A had a power outage a while ago. "In case of a power outage, my bed deflates [...] and becomes hard." The only means of contacting the outside world is by telephone, which did not work too during the outage, and Mrs. A could not even open the door. Two weeks prior to the interview, Mrs. A. was struck by a telephone failure, which lasted for 2 days and a half. This example illustrates the dependency of some frail people on modern technology.

#### *C. Fire alarms and gas*

Of all the participants, 9 already had fire alarms installed before the installation of the UAS-system. Mrs. H tells about a time that her daughter forgot about cooking, and that the fire-fighters arrived a little later.

Many subjects do no longer have gas cooker tops installed, and most do no longer use the kitchen because they receive meals from meals-on-wheels. Mrs. L was

taught to put the pan on the cooker top and then light the gas. She always feels if gas is flowing out. "I should have taken an electrical cooker top right away. But if I change now, I can't cook anymore." The gas in Mrs. N's home has been shut off, because she forgot to turn it off. Her family was very afraid about her safety.

#### *D. Emergency response systems*

All but three subjects have emergency response systems; such as a transmitter that can be worn on a pendant (necklace-type), wrist bands, and voice systems. These response systems give people a great sense of security. At the same time, the speed of professional carers in cases of emergency worries many of the subjects.

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." Mrs. D has also used the response system once, to report a missing meal. Mrs. K: "One [day], I had these horrible stomach aches, [...] and I had to go to the toilet so much. It was ten past six, I called [...]. The man on the phone: 'Well, listen. In 50 minutes from now, [the regular nursing aide] will stop by.' [...] I just slammed the horn on the hook, [...] and crawled on hands and feet [towards the toilet]. [...] Crawling, because when you stand [there's a bigger chance] of losing it." Mrs. G often forgets to use the necklace in cases of emergency. Still, the emergency response system is used once per month or once per two months. Mrs. A. used the telephone to send out alarms, as she cannot press a regular alarm button due to impaired hands.

The UAS-system is seen as a welcome addition to the safety and security of the subjects, although some subjects have accepted the system after subtle pressure from their relatives. In addition, quality of care will increase further, since professional carers are able to make a better judgement about the alarming with the help of the video connection.

#### *E. Assistive devices*

All but two participants have some form of mobility aids, including walkers and wheelchairs. Many subjects have lifters and shower seats to assist during showering. Other items found in many homes are adjustable beds and lifter chairs, and special large-button telephones. Two people have special grasping sticks. Mrs. K also has a medication dispenser with a built-in timer that alarms when it is time to take medication. The home care organisation is working on a special chair for Mrs. H. that could be used for showering. "I never take a shower, and I'd love to so badly." Mrs. H is always being washed in her bed.

#### *F. Technology at home*

Many people, including all people with severe mobility problems and people in assisted-living, have electronic devices to open the front door. Some of the

control buttons are placed near bed for the bed-ridden subjects. Mrs. L has problems with electrical appliances at home due to her impaired vision. Special equipment that is ordered is often no longer available on the market place. A ‘talking’ microwave oven only spoke English. Daughter of Mrs. F’s: “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.” Some of the subjects do have a mobile phone that is used for communication and alarming. Most people 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 her study of genealogy. In general, Mrs. S has a very positive attitude towards new technologies; whereas many are worried about the use of new technologies or do not longer wish to use them.

### G. Home modifications

Many people had had small home modifications carried out. Some of the homes of the subjects are spacious and single-floor, while other subjects deal with the limited opportunities to enlarge a shower. Most of the toilets have grab bars and handles, just as the showers. 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 remain living here.” Stairs provide the biggest challenges. Mrs. D’s daughter: “My mother actually lives on the ground floor.” Mrs. J’s home is equipped with a stair elevator, which she uses on a daily basis. “I have to save energy. I’m afraid to climb the stairs.” There are not grips in Mrs. J’s shower as she gets help showering. “Installing grips and bars may even make the shower smaller. Some of these bars are rather large.” Apart from the interior of homes, Mrs. S mentions the quality of the pavement outdoors as a limitation to her mobility.

### H. Indoor environment and lighting

The interviews revealed a possible extension to the applications of the UAS-system, namely in the field of controlling indoor climate (temperature), ventilation and lighting applications. Mrs. L stated that she and her husband never left the windows open since they were afraid of burglars. Also, there were no ventilation openings for the supply of fresh air. Mrs. N had had a new thermostat even though due to her impaired short-term memory as a result of a stroke, she does not know how to operate it, even though the family put the instructions next to it on the wall. Her daughter explains: “The instructions do not stick to her mind. Sometimes, the thermostat is turned on 34°C, and then you think it’s rather hot in here. Today it was set on 18°C and you think it’s rather chilly.” Mrs. N continues: “O, well, I did not find it cold.” Daughter: “Lovely. Those are among the things you should keep in mind.”

Later, the daughter mentions that the knobs of the radiator panels were removed. “Mother turned the radiator knobs instead of using the thermostat, something she never did before. Then she says: ‘It’s not very comfortable in here, let me turn up the thermostat’, which results in a very hot home and that is why we took off the knobs.” At the same time, Mrs. S shows that for people with impaired equilibrium, for instance, due to Parkinson’s disease, radiator panels can be a cause of serious injury when falling.

### I. Privacy

Of the people interviewed, 11 closed the curtains or other window covers, while 4 left them open during the dark hours. The latter group of people lived in apartments and had no people that could look into the house from the street. Apart from privacy reasons, safety and security reasons were also mentioned. Mrs. J: “Though I shut the curtains against priers, I prefer them to be open”. Mrs. F: “Cars out on the street and flashing headlights distract me from watching TV. I cannot forbid people to drive their cars.” 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.”

## II. DISCUSSION

### A. Supportive technology

Technology is designed primarily to serve the ‘person’ as the consumer of this service. By contrast, home telemedicine technologies view the clinician as the consumer of the service, and the person at home as [a] ‘patient’ [4]. Therefore, it was important to investigate whether the introduction of the UAS-system was not just the next product of a technology push, by mapping the needs and perceptions of the care clients involved. Also, one may ask whether it is good for very care-intensive clients to remain living at home. Mahoney *et al.* [4] state: “In an institutional setting, many factors are taken care of (medical administration, hygiene, daily activities, etc.). Ageing-in-place may place the client at risk for these not occurring, something that often goes unmentioned as a patient safety concern, and which shows a lack of understanding of the domain of care.” The UAS-system is the not the only means of providing daily care to the clients, as they continue to receive care from professional and informal carers for personal or domestic care. It is just a system that provides people

with an increased sense of safety and security. At the same time, it provides extra eyes and ears for the care professionals in cases of emergency. At one interviewed couple (L/M), the UAS-system was placed on their own special request after seeing a demonstration of the system on television. In order to investigate the effects of the UAS-system, care professionals and informal carers should be included in a parallel study.

Prior to the introduction of the UAS-system, professional carers received extensive information about how the system works. Zorgpalet Baarn-Soest has made it possible for clients, professional carers, and informal carers to visit a demonstration home where the UAS-system is installed, so that they can see how the system functions.

### B. Subjects and interviewing

One of the strengths of this study is that the sample contains both somatic and psychogeriatric subjects. The region of study is one of the richest in the Netherlands, and many of the subjects 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 health care institutions as well [2]. In general, qualitative research makes no claim to be representative of the population it is examining. The purpose of this methodology was to present a picture of the phenomenon of perception of safety and independence, and to identify indicators that contribute to the success of the UAS-system. From the narratives comes a better understanding of the issues and complexities people deal with in maintaining their independent residences, including the use of technologies and the implementation of home modifications.

### C. Ethics

Mahoney *et al.* [4] have stated a number of questions relating to home monitoring technologies that are relevant to the UAS-system, such as on the level of surveillance that is helpful, and when technology starts to infringe on personal dignity, as well as on 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 human envisioned and developed the application [4]. Van Hoof *et al.* [10] have summed up a number of ethical considerations that a system should fulfil for people with dementia. The UAS-system meets these criteria, since they serve the well-being of the residents in the first place. Nevertheless, it is of the utmost importance that the subjects remain being monitored to see whether the system keeps meeting expectations and preferences, and that the desired quality of care is kept.

## III. CONCLUSION

The quality of care is to be increased by the use of the

UAS-system, since the system monitors critical aspects of daily care and can assist professional carers through a video connection in cases of emergency. Ageing-in-place is facilitated because clients feel more secure when having the UAS-system. In the future, the range of the system's functionalities could be enlarged by controlling the indoor environment and providing comfort, and by allowing for maintaining social contacts. Moreover, the total home environment of the clients should be appropriately adjusted to their needs, in order to enlarge the chances of being able to age-in-place. Also, technology applications should take into account that taking care of someone is a combination of 'head, hand and heart tasks' and should be designed based on this combination.

## EPILOGUE

Mrs. A, Mr. C and Mr. E have passed away. Mrs. B has had the UAS-system removed. She has lost confidence in the system and felt watched.

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