# Safety and monitoring technologies for the homes of people with dementia

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*M. Riikonen, K. Mäkelä, S. Perälä. Safety and monitoring technologies for the homes of people with dementia. Gerontechnology 2010; 9(1):32-45;* doi:10.4017/gt.2010.09.01.003.00 A three-year pilot programme during 2004-2006 was carried out in Finland to investigate home care assistive devices and safety technologies for people with dementia. The evaluation of the effectiveness of the technology used was carried out in 2006 and 2007. Twenty-five elderly persons living at home and diagnosed with Alzheimer's disease participated in the study. The age group of the people with dementia ranged from 54 to 90 years; the average age was 79 years. Family caregivers were less than 65 years of age in 20 cases, and five were over age 65. Twenty-nine different technologies were tested. The technologies used could be divided into three categories: risk preventive technology, assistive technology and emergency technology. The choice of technology was based on the individual needs of the person with dementia. In general, the most readily accepted and most useful were passive devices that did not require active control or activation by the person with dementia. Individual devices were in use during the study for an average of 7.5 months. The cost of the devices installed was between €30 and €2,100, the average cost of the devices was €600. On average, the technology installed was evaluated to have increased the 'home time' of the elderly persons by an average of eight months (range 0 to 12 months and over) resulting in a clear postponement of a need for institutional care. Since the average expenses for a person with dementia in institutional care are approximately €3,000/month in Finland, technology taken to homes is cost effective in the long run. There are a great number of devices aimed at home care, thus professionals need information on available technologies and the criteria for their use. If used appropriately, home care technology can have a significant positive impact on home care of people with dementia.

**Keywords: dementia, safety technology, safety net, home care technology**

Cognitive, functional and psychiatric symptoms create a challenge for people with dementia and their ability to cope with living at home safely. Cognitive symptoms that impact on safety are memory loss, inability to reason and poor judgment. Functional problems include the loss of the ability to recognize objects, persons, sounds, shapes or smells, the loss of the ability to execute or carry out learned familiar movements, the loss or impairment of the ability to produce and/or comprehend language[1].

Psychiatric symptoms that impact on safety are, for example, angry outbursts, depression, delusions and hallucinations. Also spatial disorientation and insomnia could increase the risk of injury[1]. A person with dementia can become confused regarding time and place and can become lost in unfamiliar surroundings[2].

Currently there are an estimated 24.3 million people with dementia in the world. This figure is expected to rise dramatically to 81.1 million by the year 2040. The increase will be greatest in developing countries[3]. In 2005 there were 120,000 people with dementia in Finland**;** 85,000 people with moderate and severe dementia and 32,000 persons with mild dementia. Of these, approximately 55,000 live at home alone or with the support of a relative[4].

By 2005, the care of people with all stages of dementia incurred a total cost of 3.1 billion euros per year, which represents 6% of the total national expenses in social- and health care. The mean cost of institutional care for people with dementia is €36,400 per year, whereas the average cost of home care for this people group is €14,600 per year[5]. People with dementia have a greater risk than others for ending in long term institutional care[6]. It has been found that 80-85 % of patients in institutional care suffer from distinct cognitive deterioration or dementia[7]. By increasing home care for people with dementia, it is thus possible to achieve significant savings.

Previous researchers have indicated that technology has the potential to aid in independent living for people with dementia and reduce family caregivers' burden[8]. The use of technology, however, requires sufficient familiarity with the technology in question, as well as technical support and clear user instructions[9-11].

Technology can be used to aid memory, orientation and tasks requiring cognitive functions. In addition, technology can aid in performing tasks that could otherwise not be performed by an elderly person, increase social contacts thus improving social networking and enrich everyday lives by providing new sources of activity and stimulus[12]. Technology is a tool that can aid in independent living and autonomy and it can improve the wellbeing of both the person with dementia and family caregivers by reducing the workload of the family caregiver[13]. Technology can have many roles and functions in everyday lives of persons with dementia. These roles include reminders, technology for stimulation, relaxation, behavior management, safety, surveillance, control assistance for relatives, service coordination technology and technology for communication[8,14].

As there is still relatively little information available on the cost-benefit ratio and effectiveness of technology installed at home, no clear conclusions can therefore be drawn on the subject[8]. The assessment of the cost impact has been found extremely challenging because so many issues affect it. In addition to the actual costs of the devices themselves, installation expenses, training and the maintenance of the devices have to be included as well as the cost of care support at home and institutional care. Cautious estimates from previous researchers indicate that there are possible cost benefits involved in the use of home care technology, in particular when compared to the costs of institutional care[15,16].

More specific information is, however, required to determine which technologies are most suitable for use by the people with dementia, and which technologies are more appropriate for family caregivers[9]. The initial reaction to technology on the part of people with dementia is often one of apprehension and possible disorientation[10]. It is therefore necessary to study in more detail the utility of technology, since its implementation can often cause adverse reactions[17, 18]. The progress of dementia or any changes in the living environment or health of the person

using the devices has always to be considered when assessing the use and usability of home care technology[10].

## Aim

This research forms part of a larger project, running from September 1, 2004 until February 28, 2006 that aimed at studying the formation of safety nets for people with dementia. The aim of this larger 'Eeva' project was to build an individual safety net for people with dementia living in rural areas and their family caregivers. This safety net is woven from family members, relatives, friends, neighbours, villagers, municipal home help service, service enterprises, church assisted social work, volunteers etc. This net is supported by technology. In this way the persons and organizations supporting the everyday life of people with dementia are connected to cooperate according to a common timetable. In this model safety and communication technologies are adapted as a part of the complete safety net. It has been previously found that since technology operates as part of a social network, the technological solutions chosen must also be individually appropriate[19].

As a part of the 'Eeva' study, different technologies were installed in homes of people with dementia. Some devices were for the use of the person him/herself, whilst other devices were installed for use by the family caregivers or professional health care workers. Previous researchers have focused on different needs of different user groups and their ability to use different types of devices[8,17,20].

The aim of this study was to determine the following:
(i) Which technological solutions are the most appropriate for use to support home care for people with dementia, from the point of view of people with dementia and family caregivers?
(ii) What is the impact of the home care technologies chosen on the ability of people with dementia to continue living at home?
(iii) What financial outcomes can be extrapolated from the use of technology on the overall costs of care?

## Materials and Methods

### Participants

The target group consisted of 25 people with dementia and their family caregivers in six communities in the Finnish Health District of South Ostrobothnia. The total population of the district is about 195,000.

The criteria for selection were that all the subjects were living at home, had Alzheimer's disease and were patients of the South-Ostrobothnia Health Care District. The region in question is predominantly rural; therefore the patients were living in a rural or semi-rural setting. The participants were chosen based on consensual consent and prioritization by the regional health care organizations responsible for individual care.

The study group consisted of 5 male and 20 female subjects. At the beginning of the intervention, a mild stage of Alzheimer's disease was diagnosed in 12 patients, a medium stage in ten, and a severe stage in three patients. The age group of the people with dementia ranged from 54-90 years, the average age was 79 years. The family caregivers consisted of 8 sons, 11 daughters, 2 wives, one husband, 2 brothers, one son in law and one niece. The ages of the family care givers were under 65 in 20 cases and over 65 in five cases (*Table 1*).

Ethnographic methods were used for data gathering, which was carried out on four occasions during 2004-2006. Written permission for the project was obtained; the ethical board of the regional Health Care district approved this research. The technologies installed in a particular person's home were chosen according to an evaluation of individual abilities and needs. Four clinically approved appraisal tools were used to evaluate comprehensively the patients' status and family caregivers' current workload previous to the installation of technology.

*Table 1. Summary of devices used by each individual person with dementia; F=female; M=male; MMSE=Mini Mental State Examination 30-0; CDR = Clinical Dementia Rating: 3-0; GDS-fast = Global Deterioration Scale functional assessment: 7-0; NPI = Neuropsychiatric Inventory: 120-0; *:1 = Solitude, loss of stimuli, 2 = Problems with taking medicine, 3 = Wandering, getting lost, 4 = Inability to open the door from outside, 5 = Has to be locked in to prevent wandering; 6 = Falling, loss of balance, 7 = Danger from fire, danger from carbon monoxide poisoning; 8 = Unwanted salesman, thieves, 9 = Hearing problems; 10 = Difficulties in using the phone; **: A = Automatic, C = Caregiver, D = Person with dementia, H = Home care; ***= Couples who used the same devices; ****= Technology use continued after the project, unless stated here*

| Subject #, Caregiver | Age, Sex | MMSE | CDR, GDS-fast | NPI | Problems* | Technologies (Users**) | Period of project | End of use**** |
|---|---|---|---|---|---|---|---|---|
| 1, Son | 75, M | 16 | 2,4 | 5 | 2,3,4,5,6 | Safety telephone for transmitting alarm (A)<br>Door alarm in alarm phone (C)<br>Shower stool (A)<br>Mat in the shower room (A)<br>Electronic medication dispenser (D,C,H)<br>Bed with raise/fall pump (A) | 9.12.04-28.2.06 | |
| 2, Brother | 85, F | 23 | 2,4 | 13 | 2,3,6, | Safety alarm telephone (D)<br>Electronic medication dispenser (D, C, H)<br>Slip prevention heel spikes (C)<br>Motion sensitive light (C) | 5.12.06-28-6.06 | Medication dispenser after 1 month; it caused anxiety |
| 3, Son-in-law | 82, F | 12 | 2,5 | 13 | 1,3,6,7 | Floor monitoring system: alarm mat (C)<br>Motion sensitive light (C)<br>Cooker alarm (A)<br>Slip prevention shoes (D) | 19.12.05-28.2.06 | |
| 4, Son | 71, F | 8 | 2,4 | 28 | 1,3,6,7 | Safety alarm telephone for transmitting alarm (A)<br>Door alarm in the alarm phone (C)<br>Motion sensitive light (C)<br>Cooker alarm (A)<br>Support handles (A) | 6.4.05-28.2.06 | |
| 5, Son | 79, F | 13 | 2,5 | 15 | 4,6,7,9 | Cooker alarm (A)<br>Carbon monoxide alarm (A)<br>GSM camera (C )<br>Motion sensitive light x2 (C)<br>Call amplifier in the phone (C) | 21.6.05-28.2.06 | |

*Table 1 continued: Summary of devices used by each individual person with dementia*

| Subject #, Caregiver | Age, Sex | MMSE | CDR, GDS-fast | NPI | Problems* | Technologies (Users**) | Period of project | End of use**** |
|---|---|---|---|---|---|---|---|---|
| 6***, Daughter | 86, M | 17 | 2,5 | 17 | 3,6,7,8,10 | Floor monitoring system: alarm mat (C)<br>Motion sensitive light x2 (C)<br>Cooker alarm (A)<br>GSM camera (C)<br>Easy to use desk phone (D)<br>Fire alarm in the phone (A) | 17.6.05-28.2.06 | |
| 7***, Daughter | 85, F | 21 | 2,4 | 11 | 7,8,10 | Floor monitoring system: alarm mat (C)<br>Motion sensitive light x2 (C)<br>Cooker alarm (A)<br>GSM camera (C)<br>Easy to use desk phone (D)<br>Fire alarm in the phone (A) | 17.6.05-28.2.06 | |
| 8, Husband | 74, F | 22 | 2,4 | 9 | 6,7,10 | Cooker alarm (A)<br>Easy to use desk phone (D)<br>Motion sensitive light (C)<br>Radio phones (C,D) | 25.6.05-28.2.06 | |
| 9, Wife | 78, M | 26 | 2,5 | 17 | 2 | Dosage medication reminder (D, C)<br>Safety Alarm telephone (C) | 28.3.05-28.2.06 | |
| 10, Son | 54, F | 8 | 3,5 | 14 | 1,2,3,7 | Electronic medication dispenser (C)<br>Easy to use desk phone (D) | 27.12.05-28.2.06 | |
| 11, Wife | 75, M | 18 | 1,4 | 5 | 3,6,7 | Safety Alarm telephone (C)<br>Domino district control (C)<br>Fire alarm in the phone (A)<br>Radio phones (C,D)<br>Slip prevention shoes (D) | 20.12.05-28.2.06 | Radio phones after 1 month; outside disruption |
| 12, Daughter | 81, F | 17 | 1,4 | 25 | 6,8,10 | Radio phones (C,D)<br>Easy to use desk phone (D)<br>Motion sensitive light (C)<br>GSM camera (C)<br>Slip prevention shoes (D) | 21.11.05-28.2.06 | |
| 13, Son | 90, F | 15 | 3,5 | 25 | 1,3,4,5,6,7 | Cooker alarm (A)<br>Door alarm with a bell (A)<br>Motion sensitive light x2 (C) | 24.11.05-28.2.06 | |

*Table 1 continued: Summary of devices used by each individual person with dementia*

| Subject #, Caregiver | Age, Sex | MMSE | CDR, GDS-fast | NPI | Problems* | Technologies (Users**) | Period of project | End of use**** |
|---|---|---|---|---|---|---|---|---|
| 14, Daughter | 77, F | 23 | 1,4 | 31 | 1,6,7,10 | Safety Alarm telephone (D)<br>Fire alarm in the phone (A)<br>Easy to use desk phone (D)<br>Motion sensitive light x2 (C)<br>Slip prevention galoshes (D) | 20.11.05-28.2.06 | |
| 15, Daughter | 73, F | 21 | 2,5 | 9 | 1,2,6,7,10 | Easy to use desk phone (D)<br>Dosage medication reminder (D, C, H)<br>Electronic medication dispenser (D,C,H)<br>Motion sensitive light (C) | 28.3.05-28.2.06 | After 8 months dosage medication reminder changed to electronic medication dispenser |
| 16, Son | 81, F | 18 | 2,5 | 7 | 6,7 | Safety Alarm telephone for transmitting alarm (A)<br>Fall alarm in the alarm phone (D,C) | 24.5.06-30.7.06 | Subject moved to residential care |
| 17, Daughter | 81, F | 10 | 2,5 | 9 | 1,3,4,7,10 | Safety Alarm telephone for transmitting alarm (A)<br>Tracker positioning system (C,H)<br>Domino district control (C)<br>Easy to use desk phone (D)<br>Fire alarm in the phone (A)<br>Cooker alarm (A) | 18.5.05-28.2.06 | After 7 months tracker position system changed to Domino district control |
| 18, Son | 90, F | 16 | 2,5 | 0 | 3,6,7 | Saver location device (C)<br>Cooker alarm (A)<br>Safety Alarm telephone for transmitting alarm (A)<br>Bed monitoring system (C)<br>Speech volume amplifier (A) | 18.8.05-28.2.06 | |
| 19, Son | 80, F | 19 | 2,5 | 19 | 1,2,3,6,7,10 | Safety Alarm telephone (D)<br>Electronic medication dispenser (D,C)<br>Easy to use desk phone (D)<br>Cooker alarm (A)<br>Motion sensitive light (C)<br>Saver location device (C) | 1.5.05-28.2.06 | |

*Table 1 continued: Summary of devices used by each individual person with dementia*

| Subject #, Caregiver | Age, Sex | MMSE | CDR, GDS-fast | NPI | Problems* | Technologies (Users**) | Period of project | End of use**** |
|---|---|---|---|---|---|---|---|---|
| 20, Daughter | 85, F | 15 | 2,2 | 4 | 1,6,7,10 | Easy to use desk phone (D)<br>Cooker alarm (A)<br>Safety Alarm telephone (D)<br>Fire alarm in the phone (A)<br>Mat in the shower room (A)<br>Support handles (A) | 22.5.05-<br>28.2.06 | |
| 21, Daughter | 78, F | 22 | 2,6 | 22 | 1,6,7 | Safety Alarm telephone (D)<br>Motion sensitive light (C)<br>Cooker alarm (A)<br>Support handles (A) | 26.3.05-<br>28.2.06 | Motion sensitive light; it caused anxiety |
| 22, Niece | 88, F | 22 | 1,4 | 0 | 1,6,7,10 | Safety Alarm telephone (D)<br>Cooker alarm (A)<br>Fire alarm in the phone (A)<br>Easy to use desk phone (D) | 4.11.05-<br>28.2.06 | Motion sensitive light after 1 month; it caused anxiety |
| 23, Brother | 81, F | 14 | 2,4 | 4 | 1,7,9,10 | Easy to use desk phone (D)<br>Call volume amplifier (A)<br>Slip prevention mat outdoors (A)<br>GSM camera (C)<br>Motion sensitive light x2 (C) | 18.10.05-<br>28.2.06 | |
| 24, Daughter | 79, F | 23 | 1,3 | 3 | 6,7,8 | Fire alarm in the phone (A)<br>Safety Alarm telephone for transmitting alarm (A)<br>Draw cord alarm in the shower (D)<br>Shower stool (A)<br>GSM camera (C ) | 1.3.05-<br>28.2.06 | |
| 25, Daughter | 81, M | 20 | 2,5 | 16 | 2,3,7,9 | Saver location device (C)<br>Electronic medication dispenser (D,C)<br>Cooker alarm (A) | 30.6.05-<br>21.10.05 | Subject died |

The tests used were the Mini-Mental State Examination (MMSE)[21], Clinical Dementia Rating (CDR)[22], GDS-FAST- classification[23] and Neuropsychiatric Inventory(NPI)[24].

A more detailed user need appraisal was conducted during fall-spring of 2004-2005. It was carried out during home visits by interviewing the person with dementia and his or her family caregiver. A semi-structured interview form was used to map out the overall status and the life situation of the person in question.

This evaluation was based on the examination of the person's physical, social and emotional status and the evaluation of personal needs. The evaluation was based on interviews and observations. The situation was followed throughout the intervention until spring 2006. The initial and final assessment was conducted by a health care professional who had training in the assessment of memory impairment; the interviews were carried out by a researcher aided by a trained nurse or a teacher in nursing (RN, MSc).

Two of the 25 people in the study dropped out of the intervention: One moved to residential care after five months. One died before three and a half months had elapsed. The intervention was completed in February 2006, a follow-up evaluation study was carried out during March-April 2006 and the second assessment directed to the community health care personnel responsible for that particular person's care was carried out in May 2007. The installed devices remained in use with the study group participants as long as they were needed. The community health care personnel were asked to assess the impact of the installed technology and to give an estimate of the effect of the installed technology on the ability of the person to continue living at home. The criteria for transferring a person to institutional care consisted of feedback from the family caregiver, and a group opinion of the community health care personnel.

**Technologies**

The home care technologies that were actually installed were chosen after completion of the evaluations, in consultation with the person with dementia and their family caregivers and relatives, and based on recommendations from home care technology specialists.

A technology specialist provided training for the use of the devices to caregivers of the person with dementia or to relatives and members of home care organizations and if necessary also to the person with dementia.

**Training**

Of the 29 different devices, ten required simple interaction by the device user. These devices were a safety alarm phone, an easy to use desk phone, an electronic medication dispenser, a dosage medication reminder, a radio phone, a draw cord alarm in the shower, slip prevention shoes and galoshes, a speech volume amplifier and a fall alarm. A technology specialist and a project researcher gave training for the use of these devices as a part of the intervention during the installation of the device. All persons in charge of the care of the person with dementia were told the purpose and operating principles of the devices installed. The rest of the devices did not require interactions by the device user, but training on their purpose and maintenance, if required, was given to the family caregivers and professional care givers.

Of the installed devices, 16 technologies did not require a monitoring service, 14 on the other hand required someone to act as a recipient of an alarm. The alarms were routed to relatives or care organizations run by the community in question. The devices were chosen from a potential pool of 50 technologies that were available and marketed in Finland. The purchasing costs of individual devices did not significantly impact on the purchasing decision by the community, as the costs were generally modest and the participating communities had made a commitment to participate in the project.

During the project, the maintenance of the devices was the responsibility of the project researchers. After the termination of the research project, this responsibility fell on relatives of the people with dementia or the community health care personnel.

The purchasing and installation costs of the devices were generally covered by the community participating in the project. In some cases, the community involved was unable or unwilling to purchase particular devices. In these cases the costs were covered by the relatives of the patient in question.

The impact of the technology was evaluated at the end of the study period in 2006 and 2007 by a structured questionnaire sent to the home care professionals in charge of the person with dementia in each of the six communities. The utility and acceptance of the technologies was evaluated by two consecutive interviews with the person with dementia and their family caregivers, as well as community health care personnel in charge of the person with dementia.

During the evaluation process, community health care personnel were asked whether the individual devices had prolonged the duration the person with dementia was able to live at home, and if the devices were still in use.

## Results

Twenty-nine different and individual technological solutions were used in this study; twenty-six were commercially available products and three had been adapted from available commercial solutions. The adapted devices included a draw-cord for activating an alarm in the shower, a door chime to indicate exit of the person outdoors during the night (notification to family caregiver by audio signal) and the third device consisted of a hand-held radiophone that had an alarm button installed.

In total 112 individual devices were installed (*Table 2*). Individual devices were in use during the study for an average of 7.5 months. This was measured from the date of installation to the date when the device was either removed, or the intervention was terminated. In the latter case, the devices in some instances were retained in use, but the additional user time period was not included in the research results as it was not known.

The technologies used in this research project could be divided into three categories: risk preventive technology, assistive technology and emergency technology. Risk preventive devices included cooker alarms and smoke detectors with alarms routed through a safety alarm telephone. Assistive technology devices included memory aids and medication dispensers with reminder or alarm functions. In general these devices aided in everyday coping. Emergency technology included fall detector alarms, and systems that primarily summoned help automatically in emergency situations or that could be used to assist in locating a person that might have become lost outdoors.

The most common installations were a motion sensitive light, a cooker alarm, a safety alarm telephone and an easy to use desk phone. It should be noted that of those people with dementia that had a safety alarm telephone installed, only six out of fourteen had a bracelet alarm in use. All of these people had a mild or moderate stage of dementia. For the rest, the alarm was triggered by attaching the alarm phone to various other devices, such as movement detectors and floor pressure (movement) sensors or it was in the use of the family caregivers. Alarm bracelets are not very useful for patients with more advanced stages of dementia. This finding has been noted also previously[19,25,26].

In general, the most readily accepted, and most useful, were passive devices that did not require active control or activation by the user. These included the cooker (stove) alarm and door alarm connected through the alarm phone. On the other hand, devices that were based on technology familiar

*Table 2. The 122 technologies installed in the homes of 25 persons with dementia, and their aims; x=aim; -=not relevant; *= devices modified according to personal needs*

| Technology | | Number installed | Technology type | | | |
|---|---|---|---|---|---|---|
| | | | Risk prevention | Assistive | Emergency | Alarm recipient |
| Bed | Monitoring system | 1 | x | - | x | Relative |
| | Raise/fall pump | 1 | - | x | - | - |
| Call amplifier in the phone | | 2 | - | x | - | - |
| Cooker alarm | | 14 | x | - | - | - |
| Carbon monoxide alarm | | 1 | x | - | - | - |
| Door alarm | In the alarm phone | 2 | x | - | x | Community, relative |
| | With a bell* | 1 | x | - | - | Relative |
| Draw cord alarm in the shower* | | 1 | - | - | x | Community |
| Easy to use desk phone | | 11 | - | x | x | - |
| Fall alarm | Alarm mat | 2 | x | - | x | Relative |
| | Alarm in phone | 1 | - | - | x | Relative |
| Fire alarm in the phone | | 7 | x | - | - | Community |
| GSM camera | | 5 | x | - | x | Relative |
| Medication | Electronic dispenser | 6 | - | x | - | Relative |
| | Dosage reminder | 2 | - | x | - | - |
| Motion sensitive light | | 18 | x | - | - | - |
| Radio phones (pair)* | | 3 | - | - | x | Relative |
| Safety Alarm telephone | | 14 | x | - | x | Community |
| Saver location device | | 3 | - | - | x | Relative |
| Shower stool | | 2 | x | - | - | - |
| Slip prevention | Galoshes (pair) | 1 | x | - | - | - |
| | Heel spikes (pair) | 1 | x | - | - | - |
| | Mat outdoors | 1 | x | - | - | - |
| | Shoes (pair) | 3 | x | - | x | - |
| | Shower room mat | 2 | x | - | - | - |
| Speech volume amplifier | | 1 | - | x | - | - |
| Support handles | | 3 | x | - | x | - |
| Tracking | Domino district control | 2 | x | - | x | Relative |
| | Tracker positioning | 1 | x | - | x | Community |

to the patients, such as the easy to use desk phone, were well accepted. Others, such as the motion sensitive light did not prove to be effective in real life situations, because they caused too much confusion for the person with dementia and thus were not useful. As the light turned on automatically, people with diminished memory capabilities were unable to remember that the light would switch off automatically when they stopped moving. This caused unnecessary anxiety and aggravation.

**Impact of the technology**

The impact of the technology was assessed by estimating the possible positive influence of the technology on increasing the ability of the subjects to keep living at home during the intervention, the 'at home time'. This was estimated by conducting interviews with the family caregivers during the intervention, a structured survey with the family caregivers and professionals responsible for the person´s care, and by performing a Neuropsychiatric Inventory (NPI) assessment at the end of the intervention. This assesses also the stress and workload of the family caregiver.

On average, the technology installed was evaluated to have increased the 'at home time' of the people with dementia by about 8 months (range 0 to 12 months or over). Since this was extremely difficult to determine, the time periods reported can be considered indicative only.

However, the results do give support to the idea that the technology installed resulted in postponement of moving these people to institutional care. In two cases the physical condition of the person with dementia deteriorated so rapidly that there was no time for the technologies to have any impact. On the other hand nine patients were still living at home at the end of the study, at least partly because of the technologies installed. As a conclusion of the study the final impact of the technology installed could be greater than these initial results indicate. The technology in effect formed a part of the social care giving network around the patient, thus improving the efficiency of this care by giving a network and in some cases significantly reducing the mental stress of relatives and family caregivers.

**Cost issues**

The cost of the devices installed was ranged between €30 and €2,100. The average price of the devices per person was €600. When the installation and training costs are included, the total expenses were approximately €700 per client. This was the cost incurred to the community where the person was residing. This cost was calculated by averaging the total cost of all purchased equipment including also the training and installation costs per person. Since the average expenses of a person with dementia in institutional care are approximately €3,000/month[5], technology taken to homes can be considered to be profitable in the long run.

The cost of the installation, maintenance and support of the technological devices depended on the device itself. The devices can be roughly divided into three cost categories:

*1st category costs*

Simple devices which function autonomously and which have a simple operating principle require a single visit for their installation and training of the users (elderly/relative). The installation and user training required 4-8 hours and the expenses, excluding the device itself, were €280–€560.

*2nd category costs*

As for category one above but in addition the devices required continuous maintenance and testing. Regular maintenance, such as the renewal of batteries or software updates, need to be performed by those responsible for technical support. Each maintenance visit was repeated every 2-4 months at a cost of €140-€280 per visit.

*3rd category costs*

Devices that require monitoring or alarm service or a recipient were most costly. These costs were paid by the health provider organizations or by the relative. The maintenance of constant monitoring resulted in costs of €10 to €70 per month, depending on the device in question. The installation and user training required 4-8 hours and the expenses, excluding the device itself, were €280–€560. The monitoring costs were not covered by the participating communities, but were covered by the relatives because in most cases the alarm was routed directly to them, instead of a community organization.

## Discussion

It was found that people with dementia approved devices more readily if the devices were easy enough to use, not noticeable and functioned passively in the background. A person with dementia can easily become disturbed if even a single new 'foreign' object is introduced to his/her home. In some instances a new wire or a signal light shining in the dark was sufficient to cause anxiety.

No single ready made solution will fit all[27,28]. The stage of disease can change rapidly, therefore the choice and use of technology needs to be constantly assessed and changed when appropriate. This is one reason why the individual devices were in use during the study for an average of only 7.5 months, since the individual needs of the people with dementia were constantly changing. Due to these individual needs, some of the devices also required individual adjustments or modifications.

In general, the best results were obtained from devices that monitored movements either within the home, or when leaving the home. Disorientation and a decrease in ability to distinguish physical space and orientation can often cause people with dementia anxiety attacks and an impulse to 'return home' even if they already are at home. This impulse combined with general anxiety and disorientation can lead to potential life-threatening situations, for instance if they decide to go outdoors in the middle of the night at wintertime.

Security and the reduction of the risk in getting lost outside the home are significant issues in prolonging the ability of people with dementia to be able to cope at home and postpone the need for institutional care[29,30]. In this study, tracking and location sensors were the most concrete technologies that enabled prolonged living at home. During the study there were incidents in which the existence and use of the technology potentially saved lives by preventing fires (by alarms routed through the safety alarm telephone). In particular, devices that monitored movements, such as door alarms and motion alarms significantly improved the safety of the people with dementia, thus prolonging the duration of the period when they were able to cope at home, thus delaying the need to move to a care institution.

## Conclusions

Many home care devices are actually intended for family members and professionals in elderly care. For people with dementia themselves, close human relationships are the most important thing. Technology can be useful, even if it is principally aimed at the family members of a person with dementia. It is easy for health care professionals to get lost in the 'technological jungle', thus professionals need more information on technologies available and also information on criteria for their use. The choice of technology utilised also needs to be more rigorously assessed and based on more clearly defined guidelines than what is presently available. The price of home care technology need not be great, but the subjective impact on relatives and elderly persons can be significant.

The devices installed have been predominantly taken into routine use by the municipalities participating in the project. The safety net model is in use in all six participating municipalities. In four of the municipalities, the devices have been re-used by new people with dementia, when needed. The most significant problems in the use of the technology and safety net approach were a lack of human resources of the community health care personnel, mostly due to problems in the organization of tasks in the community.

Since the study population group is too small to yield statistically significant results, the reported results are only indicative. However, the study included a rigorous assessment tool for the assessing of the mental and physical well-being of both the people with dementia and their family caregivers. Therefore, as some significant findings can be

reported, a good conclusion can be made that the technological solutions installed did prolong the ability of the people with dementia to continue living at home. If used appropriately, therefore, home care technology can have a significant positive impact on the home care of people with dementia.

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