

## The electronic, personalizable Rosetta system for dementia care: exploring the user-friendliness, usefulness and impact

B. J. J. Hattink, F. J. M. Meiland, T. Overmars-Marx, M. de Boer, P. W. G. Ebben, M. van Blanken, S. Verhaeghe, I. Stalpers-Croeze, A. Jedlitschka, S. E. Flick, J. v/d Leeuw, I. Karkowski & R. M. Dröes

**To cite this article:** B. J. J. Hattink, F. J. M. Meiland, T. Overmars-Marx, M. de Boer, P. W. G. Ebben, M. van Blanken, S. Verhaeghe, I. Stalpers-Croeze, A. Jedlitschka, S. E. Flick, J. v/d Leeuw, I. Karkowski & R. M. Dröes (2014): The electronic, personalizable Rosetta system for dementia care: exploring the user-friendliness, usefulness and impact, *Disability and Rehabilitation: Assistive Technology*

**To link to this article:** <http://dx.doi.org/10.3109/17483107.2014.932022>



Published online: 03 Jul 2014.



Submit your article to this journal [↗](#)



Article views: 93



View related articles [↗](#)



View Crossmark data [↗](#)

RESEARCH PAPER

## The electronic, personalizable Rosetta system for dementia care: exploring the user-friendliness, usefulness and impact

B. J. J. Hattink<sup>1</sup>, F. J. M. Meiland<sup>2</sup>, T. Overmars-Marx<sup>3</sup>, M. de Boer<sup>2</sup>, P. W. G. Ebben<sup>4</sup>, M. van Blanken<sup>5</sup>, S. Verhaeghe<sup>6</sup>, I. Stalpers-Croeze<sup>7</sup>, A. Jedlitschka<sup>8</sup>, S. E. Flick<sup>9</sup>, J. v/d Leeuw<sup>3</sup>, I. Karkowski<sup>10</sup>, and R. M. Dröes<sup>2</sup>

<sup>1</sup>Department of Psychiatry, VU University Medical Center, Amsterdam, The Netherlands, <sup>2</sup>Department of Psychiatry and Elderly Care, VU University Medical Center, Amsterdam, The Netherlands, <sup>3</sup>Vilans Centre of Expertise for Long-Term Care, Utrecht, The Netherlands, <sup>4</sup>Novay, Enschede, The Netherlands, <sup>5</sup>Zorgpalet Baarn-Soest, Soest, The Netherlands, <sup>6</sup>Christelijke Mutualiteiten, Brussels, The Netherlands, <sup>7</sup>Avics, Groningen, The Netherlands, <sup>8</sup>Fraunhofer IESE, Kaiserslautern, Germany, <sup>9</sup>Westpfalz-Klinikum GmbH, Klinik für Anästhesie, Intensiv- und Notfallmedizin, Kaiserslautern, Germany, and <sup>10</sup>TNO, The Hague, The Netherlands

### Abstract

**Purpose:** This research aimed to integrate three previously developed assistive technology (AT) systems into one modular, multifunctional system, which can support people with dementia and carers throughout the course of dementia. In an explorative evaluation study, the integrated system, called Rosetta, was tested on usefulness, user-friendliness and impact, in people with dementia, their informal carers and professional carers involved. The Rosetta system was installed in participants' homes in three countries: The Netherlands, Germany and Belgium. **Methods:** Controlled trial with pre- and post-test measures across three countries (randomized controlled trial in Germany; matched groups in the Netherlands and Belgium). Participants completed questionnaires for impact measurement and participated in semi-structured interviews regarding usefulness and user-friendliness of Rosetta. **Results:** All participants agreed that Rosetta is a very useful development. They did not rate the user-friendliness of the system highly. No significant effects were found on impact measurements. **Conclusion:** All participants found Rosetta a very useful development for future care, and would consider using it. Since Rosetta was still in development during evaluation, a discrepancy between expectations and actual functioning of Rosetta existed, which may explain the lack of findings on the impact of the system and the low appreciation of user-friendliness.

### Keywords

Assistive devices, dementia, informal care, self-help devices

### History

Received 26 November 2013

Revised 28 May 2014

Accepted 03 June 2014

Published online 3 July 2014

### ► Implications for Rehabilitation

- People with dementia and carers find assistive technology (AT) a useful future development and they are willing to use it in the future.
- People with dementia and carers have little privacy issues with AT. If they have concerns, they are willing to accept the trade-off of reduced privacy in exchange for the ability to live in their own homes for longer.
- Given that a system works flawlessly, informal carers indicate that integrated AT can reduce their burden and stress. This can in turn help informal carers to provide better care for a longer period of time.

### Introduction

Our aging society will cause a significant increase in persons with age-related physical and cognitive impairments of which dementia forms the biggest threat. This will result in a major burden on public health care. Dementia is a neurodegenerative disorder, characterized by a progressive decline in cognitive ability, with a combination of symptoms including impairment of memory, speech, action, perception and reasoning. This is often

accompanied by changes in personality and behavior. In its early stages, dementia usually begins with memory impairment and can often be misdiagnosed as normal forgetfulness. In later stages, however, people with dementia increasingly become unable to perform tasks. This begins with relatively complex tasks, like cooking, yet eventually people become unable to perform even the most basic tasks of daily life, such as maintaining personal hygiene or eating [1,2]. Dementia may be preceded by mild cognitive impairments (MCI), in which people suffer impairment in a single cognitive domain, such as memory or language, but they experience no consequences on daily activities [3]. People with MCI are at a greater risk of developing dementia: it has been estimated that annually, 6 to 15% of people with MCI develop dementia [3–5].

Address for correspondence: B. J. J. Hattink, Department of Psychiatry, VU University Medical Centre, Valeriusplein 9, 1075 BG Amsterdam, The Netherlands. Tel: +31207885622. E-mail: b.hattink@vumc.nl

When people become unable to perform tasks in their own home, they need intensive support to maintain independent living. Since professional care is limited and expensive, this support is generally provided by spouses, children or other family members. These non-professional caregivers are known as “informal carers”. An estimated 70% of community-dwelling people with dementia are cared for by informal carers [6]. Providing this care poses a great burden on them and frequently leads to conditions like depression and social isolation. Overburdening of the informal carer is the leading cause for institutionalization of the person with dementia [6].

Another major concern is the global increase of dementia prevalence: since the main risk factor for dementia is age [7] (prevalence increases from 5 to 10% at 65 years to around 45% at 95 years and older [7]) and the global population is aging rapidly, the prevalence of dementia is expected to increase dramatically [8]. Additionally, with an expected decline in workforce, the world-wide ratio of potential working people to people with dementia will decrease from 63:1 in 2000 to an estimated 27:1 in 2050. In the Netherlands, it is estimated that this ratio will change even more dramatically from 43:1 in 2010 to 16:1 in 2050 [6,7,9].

To support both informal and professional carers in their care tasks, assistive technologies are becoming increasingly important. They support persons with dementia in dealing with the disease and improving their quality of life [10–12] and allow them to stay in their own homes safely for a longer period [13]. Assistive technology (AT) can help to reduce the burden of informal caregivers [14–18] and improve their confidence [19]. Professional carers may also benefit from including AT into their daily practice, as it can give them more time for their care tasks [20], reduce staff anxiety [20], and improve work satisfaction [21]. The technologies may be very simple, like calendar clocks, to more advanced technologies like GPS-tracking systems, monitoring with sensor-based environments, and telecare services [11,12].

Four main domains of support by AT can be distinguished: (1) prompts and reminders; (2) leisure; (3) communication and (4) safety [22]. Generally, many earlier developed systems support only a single one of these domains, resulting in people being forced to purchase several systems if the need support in more than one domain. Also, many assistive technologies are developed without involvement of the target group of people with dementia [23] and are often initially designed for younger people, usually with non-progressive, traumatic injuries [24]. This makes it questionable whether they could be used by persons with dementia, and if these users would readily accept them. For categorizing AT for people with dementia, all symptoms and consequences of the disease should be taken into account. Thus, attention should not only be paid to compensations for cognitive and physical symptoms, but also to, e.g. abilities to participate in recreational activities and in society [25,26].

In the Rosetta project, a fully-integrated multifunctional modular system was developed, which, if needed, can address all previously mentioned domains to support persons with dementia, informal carers and professional carers in the subsequent stages of the disease. The integrated Rosetta-system was designed to enable the combination of three previously developed AT systems, i.e. the Cogknow Day Navigator [26–28], the EMERGE system [29] and the Unattended Autonomous Surveillance system (UAS) [30]. Though highly complex, this combination of systems was expected to offer the best possible support for the longest period of time, i.e. from the early stages of dementia (all three systems) until the more advanced stages (Emerge and UAS). Additionally, all of these systems were previously tested in European research studies, and were evaluated positively by users.

The three systems were adjusted to the needs and wishes of the target groups by means of a user-participatory design process, where people with dementia and carers, as well as dementia experts, were involved in all steps of the design process. In workshops, users could indicate both their support needs and their preferences for the ultimate lay-out and design of the system.

In the Rosetta project, the three adapted and integrated subsystems were called the Elderly Day Navigator (EDN), the Early Detection System (EDS) and the Unattended Autonomous Surveillance – Advanced Awareness and Prevention System (UAS-AAPS) (web overview: [www.aal-rosetta.eu](http://www.aal-rosetta.eu)).

These subsystems aim to help people with MCI and dementia in performing the daily activities they indicated to be of importance. Examples that were given during workshops are: reminders about activities to be done during the day; support in recreational activities and social contacts; and increasing feelings of safety by monitoring behavior patterns (thus allowing for early detection of changes in care needs) and by autonomous surveillance with sensors and smart cameras to detect potentially dangerous situations.

The integrated Rosetta system was evaluated during a field test pilot on *usefulness and user-friendliness* of the system, ethical issues in using the system, and on its *impact* on autonomy and quality of life of persons with dementia and on the feeling of competence and quality of life of their carers. Finally, among professional carers, it was rated on usefulness and user-friendliness. In this article, we will report on this evaluation study.

## Methods and materials

### Design

The study was initially set up as a randomized-controlled trial (RCT) among people with MCI and dementia and their carers in the three countries: The Netherlands, Germany and Belgium. However, many prospective participants indicated they specifically wanted to be in the experimental group, and if not they would not participate at all. This made recruitment for an RCT within the timeframe of the project not feasible in the Netherlands and Belgium. Therefore, at second instance, it was decided to change the design in those two countries into a pre-test–post-test control group design with matched groups. Matching criteria were severity of MCI/dementia and having a one or two person household. Other intended matching criteria were: relationship between caregiver–care receiver (spouse, child, etc.), age and gender of the person with dementia. In Germany, the RCT design was maintained. In the section “Population and setting”, differences between the sample which participated in the RCT and in the pre-test–post-test control group design are described.

For the evaluation of the usefulness and user friendliness of the Rosetta system among professional caregivers, a one group post-test only design was used.

### Ethical approval

The ethical boards of the participating research organizations in Germany and the Netherlands approved the study. In Belgium, external ethical approval of the study was deemed unnecessary by the Belgium partner (insurance and care) organization, as they considered the implementation of the system as part of the home care they provided.

### Population and setting

Participants in the Netherlands were recruited among clients of Zorgpalet Baarn-Soest (home care section). Belgian participants were clients of Christelijke Mutualiteiten (Belgian health insurance company and care provider). Participants in Germany were

selected through the German Red Cross and the Westpfalz Klinikum's (academic hospital in Kaiserslautern, Institute for Anaesthesiology and Emergency Medicine).

The evaluation of Rosetta was performed on a total of 42 persons with either mild cognitive impairment (MCI) or dementia (19 in the Netherlands, 11 with MCI in Germany and 12 in Belgium), and 32 of their informal carers. Among these participants, 11 persons with dementia in Germany were randomized to the experimental or the control group ( $n_e = 5$ ;  $n_c = 6$ ), while 31 persons with dementia in the Netherlands and Belgium were matched on a group level ( $n_e = 15$ ;  $n_c = 16$ ).

The low number of participants was mainly due to the restricted budget for this project and the high costs of a full Rosetta system, which did not allow for a large number of participants to get a system installed.

Six professional home-care workers (3 in the Netherlands, 1 in Germany and 2 in Belgium) who worked as care providers during the intervention period and had used the Rosetta system, participated in the evaluation of the usefulness and userfriendliness.

For the recruitment of participants the following inclusion criteria were applied.

*General inclusion criteria for all countries:* Included were participants with MCI or dementia living in the community and their informal carers. Other general inclusion characteristics included a maximum of seven rooms in a one story-house with a maximum size of 180 square meters and a maximum of five exterior doors. The house had to have the possibility for installation of wireless broad-band internet access (if not available already), since all signals of the Rosetta system were transmitted wirelessly and uploaded through an internet server.

In all countries, both one- and two-person household were recruited for the study. In two-person households, the decision to install EDS or not was based on the wishes of the informal carer.

EDN was not offered to those with more severe dementia (Global Deterioration Scale (GDS)  $> 5$ ) [31], because they would likely not be able to learn how to independently utilize this system.

*Specific inclusion criteria for the Netherlands:* Severity of dementia: mild, intermediate or severe (GDS 3 to 7). Use of Rosetta: All functionalities (EDN/EDS/UAS-AAPS) of the Rosetta system.

*Specific inclusion criteria for Belgium:* Severity of dementia: Intermediate or severe (GDS 5 to 7). Use of Rosetta: Focus was exclusively on the UAS-AAPS system, since fall- and wandering detection are most relevant in the intermediate and severe stage of dementia.

*Specific inclusion criteria for Germany:* Severity: Mild Cognitive Impairments (GDS 1 to 3). Due to German regional ethical laws regarding medical research with people, people with a diagnosis of dementia were not allowed to participate, therefore, in Germany only people with a diagnosis of MCI were included.

Use of Rosetta: All functionalities (EDN/EDS/UAS-AAPS) of the Rosetta system.

*Professionals:* All professional home-care workers who had used at least one subsystem of the Rosetta system in the houses of people they cared for, were invited to participate in an online survey. This was done through the involved care organization in each country.

## Intervention

The Rosetta system was installed in the homes of the persons with MCI or dementia in the experimental group. After installation,

participants received a training explaining how the system works. The effective usage period varied from half a month (which was the case for one participant, recruited as replacement for a drop-out) to eight months. Average use was nearly four months. This relatively short average period of usage was caused by three issues: first, some participants dropped out just before installation of the system was finalized in their homes; in their place, new participants had to be recruited. Second, it took quite some time to plan installation dates with informal carers, since the installation usually involved two full days of technicians visiting the home of the person with dementia, this shortened the intervention period. Third, technical issues often involved ordering replacement parts, which took up a large amount of time during which the system did not work. For installation of these replacement parts, it was then again necessary to plan a new installation date.

The full Rosetta system consisted of the following three subsystems designed to support people throughout the disease process, and on different need domains:

(1) The Elderly Day Navigator (EDN): This subsystem supports persons with MCIs to moderate dementia in their daily functioning in the areas of memory, social contact, recreational activities and feelings of safety. This support is provided through a video home terminal (touch screen) and/or a mobile device. To support *memory*, the touch screen provided reminders for activities (for example, "you have an appointment with the doctor at 10.00 am"). These reminders were configured remotely by informal or professional carers and were shown in an agenda containing all programmed activities and the time they were planned. Furthermore, an analogue clock and the current date were shown. To support in *social contact* there was a phone with a photo address book (Figures 1 and 2).

To support in a *recreational activity*, a person's own collection of digital photos could be viewed on the screen of the video home terminal (which could be uploaded remotely by informal carers). Finally, EDN offers several functionalities to promote *feelings of safety*. One of these functions is receiving safety warnings on the screen, such as "you left the fridge door open, please close it". Another safety feature is a Help button, which enables direct telephone contact with a relative (a list of relatives which will be contacted sequentially through this button can be set up during installation) (Figure 2). If this relative does not answer the phone, the message "Try another number?" will be displayed on the screen, allowing the user to call the next person in line to help. The final number to be called is usually a professional care organization, available 24/7. The Help button on the mobile device could also be used when persons with dementia had lost their way outside. In that case, informal caregivers could help them find their way home: through GPS technology, the informal caregivers were able to see on a webpage where the person with dementia was and which path they had followed. This information could be used to guide the person with dementia home safely. The persons with MCI/dementia and/or their informal carers could choose which functions of the EDN they wished to use in their homes.

(2) The Early Detection System (EDS) software: This subsystem records the pattern of behavior in daily living of the persons with MCI/dementia by analyzing signals from sensors in the house. In case of two-person households, the daily patterns of both persons are monitored. Within the Rosetta system, EDS analyzed the sleep-wake rhythm, mobility in- and outside the house, meal preparations, personal hygiene and the number of (emergency) alarms. The persons with dementia and/or informal carers were invited to choose which activities they wanted to have monitored.



Figure 1. Example of photo address book.



Figure 2. Screenshot of the help function on the mobile device.

In the first two weeks after installation, the EDS software established a baseline through data from the sensors. After this baseline assessment, the software:

- Automatically warned carers if there were significant changes in the day-to-day pattern of living.
- Generated graphs/indexes that offered a summary of the day-to-day pattern of living and revealed any (slowly) occurring changes in it.

These graphs allowed professional carers and informal carers to monitor the status of the person with dementia, and to decide on the need for follow-up action. To help analyzing these graphs, colored markers were displayed: green markers indicated no changes in daily patterns, yellow markers indicated mild changes in daily patterns and red markers indicated significant changes in functioning. The EDS system is designed to enable further personalization with additional sensors to register more activities and behaviors.

- (3) The Unattended Autonomous Surveillance system – Advanced Awareness and Prevention – System (UAS-AAPS): This subsystem is able to detect emergency situations and generate alarms to care organizations. By using movement sensors and cameras in the house,

emergency situations, such as fall accidents can be detected. In emergency cases, a message was displayed on the video home terminal and the person with dementia was asked to confirm whether he was safe or not. When the person was unsafe or when there was no response from the person with dementia, a message was forwarded to the professional carer, who then could assess the situation via a speak–listen unit as well as via a still image from the camera in the home of the person with dementia and decide whether help was needed. Because of privacy concerns, the camera of the system only activated when the motion detectors did not register movement for a specified time (by default set at 20 min). When activated, software analyzed the camera feed and decided if the person was motionless in a “safe zone” (e.g. sitting a chair) or in an “unsafe zone” (e.g. on the ground). If it was established that the person was in a “safe zone”, the camera would turn off again. If, however, no movement was detected and the person was in an “unsafe zone”, the alarm would be triggered and carers would be contacted. Analysis of all Rosetta data was done securely on a local server (the “Information Broker”), transmission of data through the internet was encrypted.

Persons in the control group received care and support as usual. This usual care generally consisted of home care for household chores and/or personal care and day care. Some participants received extra care, for example, help with food preparation or visits to the general practitioner.

## Measures

All countries used the same measuring instruments for the selected outcome measures. In the Netherlands and in Belgium the questionnaires were offered in the Dutch language, in Germany the questionnaires were offered in the German language.

### Primary outcome measures:

- Usefulness and user-friendliness were measured with self-developed semi-structured questionnaires for both the persons with MCI/dementia and for their informal carers, which covered all aspects of the Rosetta subsystems and included questions on ethical issues as well.
- Perceived autonomy of the person with MCI/dementia was measured with a scale which included relevant items from the Mastery scale [32] and the WHOQOL-100 [33].
- Quality of Life of the person with MCI/dementia was measured with the Quality of Life in Alzheimer’s Disease

scale (QOL-AD) [34]. )Informal caregivers filled-in two additional questions about their overall judgment of their own quality of life taken from the minimum dataset of the Dutch National Programme for Elderly Care (MDS-NPO).

- The feeling of competence of informal carers was measured with the Short Sense of Competence questionnaire (SSCQ) [35].

Secondary outcome measures:

- Delay of nursing home admission of the person with MCI/dementia was assessed by registering nursing home admissions of participants in the study.
- Care needs were measured by the Camberwell Assessment of Need for the Elderly [36].

Additionally patient and caregiver characteristics were measured to describe the study sample:

- Severity of dementia was measured by the Mini Mental State Examination (MMSE) [37]. This variable was also included as a potentially confounding variable.
- The caregiver management strategy was assessed by means of a Dutch questionnaire on ways of caring for a person with dementia. [38].
- Use of services was measured with the Use of Services questionnaire [39].

Other methods used:

- At the end of the trial, a focus group was performed with informal carers in the Netherlands to evaluate the experiences in using the Rosetta system and to discuss issues regarding future implementation of the Rosetta system. The focus group was led by an experienced researcher and was audio-taped for future analysis.

Professionals:

- At the end of the trial, an online questionnaire was filled-in by professionals of the participating care organizations to assess the usefulness and user-friendliness of the system (with a.o. items from the USE-questionnaire [40], changes in contacts with clients, bottle-necks, positive experiences and satisfaction in using the system, and the impact on job satisfaction, measured with the Leiden Quality of Work Questionnaire [41]).

## Procedure

**Recruitment:** Participants were selected through care organizations in the three countries. Health care professionals of these organizations sent letters to the potential candidates. In Germany, additionally, an information meeting was organized for potential participants. Participants who were interested to participate in the study were advised to consider participation. After a week, a care professional contacted them again. If they agreed to participate, they were invited to sign the informed consent form and an appointment for the first interview (baseline impact measurement) in their own home was made. Professional caregivers who used the Rosetta system were recruited via the participating care organizations.

**Measurement procedures:** Pretest measurement took place after signing of the informed consent form and – in the experimental group – before installation of the Rosetta system. Post-test measurement took place at the end of the trial. Measurements and interviews were performed by experienced researchers and interviewers from the respective countries.

At the end of the trial, the online questionnaire was sent out to professionals and a focus group was organized for informal carers.

## Data analysis

Descriptive analyses were performed using SPSS Statistics – version 20, to describe baseline characteristics of the study sample

and the answers to the structured questions in the semi-structured interview on usefulness and user-friendliness. The qualitative data were summarized for the total Rosetta system and for each part of the system (EDN, EDS, UAS-AAPS).

Differences between groups at baseline, and between the drop-outs and the completers of the trial, were tested with relevant tests (such as Chi-square tests, Mann–Whitney *U*-tests and *t*-tests). To test if participants in the Netherlands, Germany and Belgium could be treated as one homogeneous group in the overall analyses, we tested for differences between countries in background characteristics at baseline.

To study the effect of the Rosetta system on primary and secondary outcome measures, univariate covariance analyses (ANCOVA) were conducted on the post-test data with pre-test data included as covariates. This strategy of analysis for data with related repeated measures is recommended in small samples [42]. (With data from different clusters, multi-level analyses are generally advised. However, in small number of participants within clusters in combination with a small number of clusters, as is the case in our dataset, these analyses are discussed.) Levene's tests of homogeneity were performed to test the assumption of equality in variance among the groups. Personal characteristics that differed at baseline and were related to the outcome variable (and thus potential confounders) were included as covariates in the analysis as well. All tests were conducted two-sided with  $\alpha \leq 0.05$ .

## Results

### Characteristics of study sample at baseline and drop-outs

In total, 42 persons with MCI and/or dementia and 32 informal carers participated in the study. Characteristics of the study population are presented in Table 1.

Six professional caregivers participated in the online survey assessing usefulness and user-friendliness of the system and impact on job satisfaction. These professionals were all home care workers who visited the homes of participants.

The mean age of persons with MCI or dementia was 81 years in the experimental and 78 years in the control group. Half of the participants were male, and half were living together. The majority of the participants in the Netherlands and Germany had (very) MCIs; in Belgium all of the participants had severe dementia. This difference reflects the intended selective recruitment of different groups in the three countries. The informal carers in the experimental group had a mean age of 66 years and in the control group 69 years, and those in the experimental group were slightly more often female. Most carers were either partners or children of the person with dementia, 22% had another relationship with the person with dementia. From the persons with MCI or dementia who participated at baseline, 18 dropped out during the field trial. A flow chart of the participants with dementia and reasons for dropout is presented in Figure 3.

The professional carers were all female and varied in age from 26 to 54. They had intermediate or higher professional education (e.g. nursing), sometimes followed by special courses. Most of them gained little or no experience in using the Rosetta system during the pilot, only in Germany the professional carer gained much experience with the EDN part of Rosetta.

For 24 participants with memory problems (MCI or dementia) pre- and post-test assessments of outcome measures were available. Tests were performed to check whether (1) the participants from the experimental and control group who completed the trial were comparable or differed at baseline, and (2) the participants from different countries could be treated as one homogeneous group or that variables, such as certain

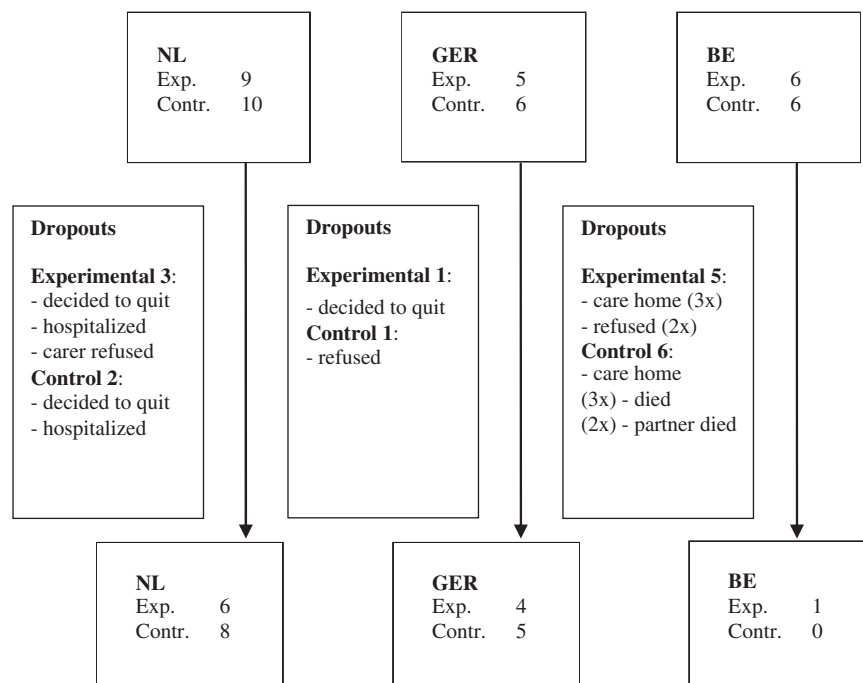
Table 1. Baseline characteristics of the study population.

	The Netherlands ( <i>n</i> = 19)		Germany ( <i>n</i> = 11)		Belgium ( <i>n</i> = 12)		Total ( <i>n</i> = 42)	
Persons with MCI/ dementia	Exp ( <i>n</i> = 9)	Control ( <i>n</i> = 10)	Exp ( <i>n</i> = 5)	Control ( <i>n</i> = 6)	Exp ( <i>n</i> = 6)	Control ( <i>n</i> = 6)	Exp ( <i>n</i> = 20)	Control ( <i>n</i> = 22)
Age								
Mean (SD)	82.7 (9.4)	78.6 (4.2)	76.2 (5.3)	72.2 (6.5)	81.3 (3.0)	76.0 (6.5)	80.6 (7.6)	78.2 (7.0)
Range	62–96	73–87	71–82	64–81	78–85	68–83	62–96	64–87
Sex								
Male	1	5	2	4	1	1	11	10
Female	8	5	3	2	5	5	9	12
Living, together	1	4	2	5	3	4	6	13
Alone	8	6	3	1	3	2	14	9
MMSE, Mean (SD)	20.4 (2.4)	21.8 (4.7)	24.4 (1.7)	22.8 (2.6)	6.6 (4.2)	8.3 (6.1)	17.8 (7.6)	18.9 (7.1)
QOL-AD	39.7 (6.5)	33.6 (7.1)	35.6 (3.5)	32.3 (5.9)	40.5 (8.35)	32.3 (4.0)	38.7 (6.3)	33.0 (6.0)
Carers	<i>n</i> = 9	<i>n</i> = 10	<i>n</i> = 2	<i>n</i> = 1	<i>n</i> = 6	<i>n</i> = 4	<i>n</i> = 17	<i>n</i> = 15
Age								
Mean (SD)	53.1 (2.2)	60.8 (19.6)	66.5 (26.2)	39	66.0 (15.9)	69.3 (11.3)	57.8 (3.1)	61.7 (5.0)
Range	48–55	29–80	48–85	-	66–72	48–81	48–85	29–81
Sex								
Male	2	2	1	1	4	3	7	6
Female	7	6	1	1	2	1	10	8
Relation PwM <sup>a</sup> /IC:								
Partner	1	4	1	0	3	3	5	7
Child	5	3	1	0	3	1	9	4
Other	3	3	0	1	0	0	3	4
QOL-AD <sup>b</sup> , Mean (SD)	29.7 (5.6)	29.0 (2.4)	35.0 (7.1)	29.5 (5.0)	29.3 (6.3)	31.3 (2.6)	30.2 (5.9)	29.6 (2.7)
Own QoL, Mean (SD)	8.1 (0.9)	8.0 (0.8)	7.5 (0.7)	6.5 (2.1)	7.4 (1.5)	5.5 (1.7)	7.81 (0.27)	7.07 (0.44)
Feeling of competence Mean (SD)	27.6 (4.3)	26.8 (3.0)	24.0 (5.7)	21.5 (3.5)	29.0 (0.9)	30.3 (0.5)	27.7 (3.7)	27.4 (3.2)

<sup>a</sup>PwM = person with memory problems (MCI/dementia); IC: Informal Carer.

<sup>b</sup>QoL of person with memory problem's QoL, as answered by carer.

Figure 3. Flowchart of dropouts of persons with MCI/dementia.



background characteristics, had to be included in the effect analyses as potential confounders.

Participants from the experimental and control group only differed in gender, it turned out that there were significantly more males in the control group than in the experimental group (Table 2). Between the Netherlands and Germany, participants differed on age and MMSE score, for which was corrected in the analysis by including these variables as covariates.

### Use of the system during the trial

At baseline, the persons in the experimental group were offered all parts of the Rosetta system (UAS-AAPS, EDS, EDN), except for Belgium where persons only received the UAS-AAPS system.

Not all subsystems were fully working at the moment of installation of the system. Systems could be temporarily switched off, or turned in idle mode in case of multiple false alarms, maintenance or lacking functionality. For participants who used

Table 2. Comparison of experimental and control group at baseline (completers only).

	Experimental	Control	Test statistic	<i>p</i>
Age carer, M (SD)	59.22 (12.93)	58.33 (19.68)	$t = 0.11$	0.91
Age PwM, M (SD)	81.00 (6.00)	76.38 (5.24)	$t = 2.01$	0.06
MMSE, M (SD)	21.36 (5.78)	21.77 (3.78)	$t = -0.0206$	-0.41
Living situation			$\chi^2 = 3.55$	0.17
PwM, <i>n</i> (%)				
Alone	8 (72%)	5 (38%)		
with partner	3 (28%)	6 (46%)		
with others	0	2 (15%)		
Carer sex, <i>n</i> (%)			$\chi^2 = 0.00$	1.00
Male	2 (22%)	2 (22%)		
Female	7 (78%)	7 (78%)		
PwM sex, <i>n</i> (%)			$\chi^2 = 7.24$	0.01*
Male	1 (22%)	9 (22%)		
Female	8 (78%)	4 (78%)		
Caregiving style, <i>n</i> (%)			$\chi^2 = 2.81$	0.42
Nurturing	2 (22%)	4 (44%)		
Supporting	4 (44%)	3 (33%)		
Confronting	0 (0%)	1 (11%)		
None	3 (33%)	1 (11%)		

PwM = person with memory problems (MCI/ dementia).

the Rosetta system, the usage varied from half a month to 8 months. EDN support was available for the full period after installation. EDS was disabled for the majority of the installation time in most houses, though at the end of the field trial it worked well. Due to technical issues with the sensors and camera, the UAS-AAPS system was also not always available. In some participants' homes this system was not activated or it was removed, because some participants did not want the sensors installed. Another participant, for example, decided it took too long before the system was working properly, and removed all technology himself.

### Usefulness and user-friendliness

Participants were questioned about their opinions on the usefulness and user-friendliness of the Rosetta system and its specific subsystems. It should be noted, however, that participants varied in use of specific systems and duration of usage. Furthermore, participants with dementia were only actively interacting with the EDN subsystem and not with the EDS and UAS-AAPS system as these work automatically without user involvement. As a result of this, it was not always clear to participants which functionalities belonged to which subsystems (EDN, EDS, UAS-AAPS). With the EDS and UAS-AAPS, the carers were involved when using the EDS web interface and in case of alarms, respectively.

Both people with MCI/dementia ( $n = 10$ ) and informal carer ( $n = 9$ ) judged the overall Rosetta system to be a very *useful* development and agreed that systems like this would very likely be necessary to properly support people with dementia in the future. Despite technical difficulties, participants indicated that the system is very useful and that they were happy with it. They were very satisfied with the technical support provided in cases of problems with the system. Three informal caregivers described the system to have had a noticeable impact on the life of their family member with dementia: They indicated that it was "more comforting", and that it offered "a safer feeling, [like] an extra pair of eyes watching her" and "[feelings of] more security and confidence". Carers indicated they felt "safer, [they got] more rest at night", and they experienced "a little less burden".

Professional carers were ambivalent in their opinions on the system. One carer indicated that she was "convinced this system kept the person with dementia at home longer", whereas one other indicated that the system "did nothing". Other remarks about the usefulness of the system as a whole focused on technical issues encountered during the trial, like "[It gives me] more security and confidence, but [there are] so many problems that one can't rely on it now" or "A good idea, it would have worked if the system didn't have this many faults". This was confirmed during in-between interviews, in which it was indicated that participants thought the system is very useful, but that they could not depend on it and therefore hardly felt safer.

Partly because of the technical issues, the *user friendliness* of the overall Rosetta system was not rated very high by informal caregivers or by persons with dementia; the system was experienced as complex and hard to work with.

Half of the 10 persons with MCI/dementia indicated at post-test that at some point during the trial, they had doubts about their participation in the study. Reasons for persons with MCI/dementia to doubt were for example, that "the system is too hard to understand". Informal carers had fewer doubts about their participation, only one expressed doubts because were concerned what the "technical people" would install in their house. Concerns about privacy or whether or not their family member would cognitively be "too good for this" were mentioned occasionally. During in-between interviews people also indicated that they recognized the importance and usefulness of the system, but had not realized at the start of participation in the study that the development of the system was still ongoing.

### Elderly day navigator

**Usefulness:** Both the EDN homescreen and mobile device were considered *useful* by the three carers who actively used them. One of these carers indicated they thought that the EDN was the only thing still keeping their family member at home. Without the EDN, they indicated, their family member would likely be staying in a care home now. Three of the persons with dementia, as well as three carers indicated that the agenda on the EDN screen was the most useful function of Rosetta. Two persons with dementia and three carers, however, indicated that the EDN was the least useful part of the whole Rosetta system, and that they did not use it.

**User-friendliness:** Regardless of how useful participants considered the EDN, they were generally not positive about its *user-friendliness*. Especially the caregivers expressed difficulties with the system. For example, regarding remote configuration for the agenda and reminders, carers in the focus group said that they had trouble logging into the portal website, and that they had to save three to four times before a single message or reminder in EDN was actually saved. One of the carers in the focus group indicated he had given up trying to access this portal due to technical difficulties, despite being highly motivated to access the system at first. Informal caregivers also did not like the look of the portal; they felt it looked very outdated and complicated. It was experienced as especially frustrating that downtime of the portal website could happen without communication on the reasons for this, or how long it would take before the site was operational again. Informal carers of the participants really wanted to use the GPS navigation features to locate their family members, yet this functionality was most of the time unavailable, either due to technical difficulties, battery problems or reception issues of the mobile device. Informal carers were disappointed this did not work; they indicated it would have given them a great feeling of safety if it had worked since some of the participating people with dementia were known to get lost.



Of those people with dementia who had used the EDN touch screen for some time, three out of seven indicated they had learned how to use it without help. Another three out of seven could use it, but needed help. A major complaint about the home terminal was that the touch screen was both un-intuitive to use for older people who had never used a touch screen before, and that the responsiveness of the screen was bad as well. This was mainly because the touch screen used an older form of touch-screen technology (resistive instead of capacitive) because of economic considerations. Both informal carers and persons with dementia indicated this.

### Early detection system

**Usefulness:** Very few opinions on the *usefulness* of the sensor-based EDS were collected. This is partly due to restricted usage of the system during the trial period because of technical problems, but also due to persons with dementia not realizing that (the sensor based) EDS was installed in their home (as the system does not require interaction with users). Most people with dementia were in fact confused as to what exactly EDS registered in their home. The fact that people were not aware of the system confirms that the EDS is indeed unobtrusive. Since EDS did not function fully during the trial period, informal carers had very little opportunity to experience the full usefulness of the information generated by EDS. This was confirmed during in-between interviews by three participants, who indicated that they “would look [on the web page with sensor data], but [it] hasn’t worked yet”. Most informal carers considered it especially useful to be able to see the sleeping and eating patterns of their family members – especially to check up if they actually did eat or sleep like they said they did: “Saying they’re doing something is different from actually doing it”.

**User-friendliness:** Most of the *user-friendliness*-related remarks concerning EDS are again related to the Rosetta-portal site which was judged very user-unfriendly, since it often did not work during the trial, gave errors and required persons to try and log-in multiple times. Persons with dementia judged the user-friendliness of this EDS system differently than carers, since participants were hardly aware of the system. Most of them noticed the sensors and the camera, but did not mind them, and had no opinion on them.

### Unattended autonomous surveillance-advanced awareness prevention system

**Usefulness:** Most informal carers felt UAS-AAPS is a very *useful system*. One of them indicated that since the installation of the UAS-AAPS system, she turned off her cell phone at night, allowing her quieter nights and better sleep. Besides feeling more pleasant and at ease, persons with MCI/dementia also indicated at the end of the trial period that UAS-AAPS is “useful” ( $n = 7$ ) or “very useful” ( $n = 3$ ) to feel more safe and self-sufficient. During the trial with the UAS-AAPS system, five persons clearly had felt safer in their homes, three sometimes felt safer and two did not feel any safer with the support of the system.

Professional carers agree that the UAS-AAPS system is very useful to help persons live in their own homes for a longer time.

**User-friendliness:** False alarms were experienced as bothersome, though informal caregivers in the focus group indicated they would “rather get 100 false alarms and 1 actual alarm, than risking missing out on getting the actual alarm.” For persons with MCI/dementia, these false alarms were bothersome as well; people disliked getting phone calls (sometimes at inconvenient times) asking if something had happened while nothing was wrong and they had not even noticed that the system had triggered in the first place.

There were some incidents in relation to detection of falls. On three occasions, twice in the Netherlands and once in Germany, the participant had fallen but the system had not detected these falls. For one of these cases, this was likely because the person continued moving while on the ground, thus triggering the motion sensors and preventing an alarm. Though this (assessing non-movement instead of detecting a fall) reflects correct functioning of the system, this limitation of the system was not fully understood by the carer who therefore had higher expectations of the system.

### Ethical issues

**EDS:** EDS did not raise any privacy concerns for persons with MCI/dementia, most of who indicated that they never noticed the system. All 10 participants with MCI/dementia who answered this question indicated that the presence of the sensors was “not uncomfortable or stressful at all”; nor did it bother anybody if other people would see the presence of the sensors, all 10 indicated this was “not bothersome at all”. This matched with the expectations of people about the system in the first place. The same was true for informal carers: None of the nine informal carers interviewed at post-test indicated that EDS had been an issue, neither for themselves nor for their family members.

**UAS-AAPS:** There were minor issues regarding the privacy concerns raised by the UAS-AAPS supervision; most of the participants (both persons with dementia and carers) indicated that they were not uncomfortable at all ( $n = 9$ ) or only somewhat ( $n = 1$ ) uncomfortable with the system in the house. Also during the semi-structured interview persons with dementia indicated they had no privacy concerns regarding the system. On the other hand, most people did seem to have some negative feelings about the camera, more specifically about the red light on it. In most homes, this small light turned on occasionally when assessing suspected cases, which was experienced as somewhat uncomfortable (“Is it filming me now? Can it see me?”). One informal carer who participated in the focus group commented she had noticed that her aunt – who had indicated she had no privacy concerns – had recently started sitting in another chair; the one the camera was not facing (focus group). In the semi-structured interview, more persons with dementia commented specifically on this light: “[it bothers me] only when that light turns on” and “[it] feels strange when the camera suddenly switches on”. Despite this, however, only one participant indicated that the camera’s ability to see him was “somewhat bothersome”, all other nine participants indicated that the presence of the camera was “not bothersome at all”.

### Impact of (sub) systems on main and secondary outcomes (PwM, carers)

The results show that overall there were no significant differences in background characteristics between the experimental and control group at baseline, except for the gender of the person with memory problems. There was a trend that persons in the control group were younger ( $t = 2.01$ ,  $p = 0.06$ ). There were differences between the countries: participants from the Netherlands and Germany differed significantly on mean age and MMSE score at baseline, with the German group being significantly younger and less cognitively impaired (higher MMSE scores). Informal carers’ age and gender did not differ significantly between the countries.

The ANCOVAs, using baseline scores together with age and MMSE as covariates, show that there were no significant differences on primary and secondary outcome measures between participants who used the Rosetta system and those who received usual care (the control group), see Tables 3 and 4.

Table 3. Analysis of covariance on primary outcome measures.

Test	Baseline <i>Experimental</i>	<i>Control</i>	Post-test <i>Experimental</i>	<i>Control</i>	Statistic
QoL-AD (PwM) total (SD)	38.10 (1.90)	33.67 (1.56)	36.10 (6.86)	34.42 (3.42)	$F = 0.25$ $p = 0.62$
QoL-AD (Carer) total (SD)	31.89 (2.05)	29.00 (0.96)	30.25 (6.74)	30.13 (3.87)	$F = 0.87$ $p = 0.37$
Perceived autonomy (PwM) (SD)	39.10 (2.37)	38.83 (1.62)	35.80 (8.97)	36.33 (8.75)	$F = 0.02$ $p = 0.88$
Grade for QoL (Carer) mean (SD)	7.89 (0.40)	8.00 (0.27)	7.06 (0.69)	7.00 (0.74)	$F = 1.32$ $p = 0.28$
Feeling of competence (Carer) (sd)	4.13 (0.40)	5.30 (0.37)	4.13 (1.45)	5.13 (0.83)	$F = 3.03$ $p = 0.11$

PwM = person with problems (MCI/dementia).

Table 4. Analysis of covariance on secondary outcome measures.

Test	Baseline <i>Experimental</i>	<i>Control</i>	Post-test <i>Experimental</i>	<i>Control</i>	Statistic
MMSE (PwM) total	21.36 (1.74)	21.73 (1.24)	21.40 (3.40)	19.45 (4.93)	$F = 0.71$ $p = 0.41$
CANE (PwM) number of <i>unmet</i> needs (SD)	1.00 (0.38)	0.31 (0.18)	2.10 (2.23)	1.23 (1.64)	$F = 0.05$ $p = 0.83$
CANE (Carer) number of <i>un-met</i> needs (SD)	3.09 (0.70)	0.62 (0.29)	2.18 (0.64)	1.23 (0.46)	$F = 0.07$ $p = 0.79$
CANE (PwM) number of <i>met</i> needs (SD)	5.45 (1.02)	5.92 (0.74)	7.10 (3.45)	6.85 (3.53)	$F = 0.217$ $p = 0.65$
CANE (carer) number of <i>met</i> needs (SD)	1.00 (0.38)	0.31 (0.18)	8.30 (5.08)	6.00 (5.37)	$F = 0.70$ $p = 0.42$
Total number of services used (SD)	3.73 (0.72)	4.38 (0.99)	3.80 (2.39)	3.69 (3.30)	$F = 0.14$ $p = 0.71$
Delay of nursing home admittance			Three participants admitted to nursing home	Three participants admitted to nursing home	

PwM = person with memory problems (MCI/dementia).

## Discussion

Overall, users indicate that they find the Rosetta system a very useful device, one which they think to be likely necessary in the future to provide good care to people with dementia. Some users indicated in the interviews and focus groups that the system had an impact on their lives and their feelings of safety and comfort. Especially the fall detection function of UAS-AAPS and the memory support through the EDN touch screen and mobile device were experienced as supportive. In its current form, the users of the system rated its user-friendliness low. It was considered especially bothersome that the system was hard and unintuitive to use.

No significant impact was measured on the selected quantitative outcome measures (perceived autonomy, care needs, quality of life or performance of daily activities, and sense of competence of informal carers), which is most likely explained by the relatively short period of time that the system had successfully worked during the intervention period.

Both people with dementia and their informal carers considered a system like EDN is useful to help maintain independence by reminding people with dementia of appointments, which informal carers can remotely set. Earlier research by Cahill et al. [43] confirms that AT like this can help people with dementia maintain independent living and can promote their time orientation. Many people also appreciated the ability of the UAS/AAPS subsystem to enhance feelings of safety. Research also points out that, since accidental falls are one of the leading causes of death in older adults [44], technology that can monitor fall situations is a highly relevant research topic [45,46]. Rialle et al. [47], for

example, also note that technologies aimed at increasing safety for people with dementia and lowering anxiety of informal carers, are among the most appreciated technological developments.

This research also confirms earlier research with regard to the overall positive attitude of people with dementia and informal carers towards AT, and the expectation that most will readily accept the use of AT [48,49] if it can enhance safety and assist in self-management and independent living. Moreover, people with dementia and carers who participated in this study also had no ethical or privacy concerns regarding the provided technology. They indicated that, as long as they can rely on the support of the system, AT may help to promote feelings of safety and reduce feelings of burden and stress. This gives hope for future development of technological systems, and adds to a growing body of research evaluating the use of AT, specifically in people with dementia [50,51].

The Rosetta study had several limitations, which may have influenced the study results. Firstly, this project was a *research and development* project in which the development took more time than expected. Therefore, the reliability of the system was not yet entirely consistent during the explorative evaluation research and nearly all users had to deal with unstable or malfunctioning systems, which has affected the results of the evaluation study. It also caused a discrepancy between user expectations and ultimate functioning of the system, which in turn may have caused a more negative assessment of the system: with participants expecting a fully-developed and (near-) 100% functioning system, the level of development of the system could not match expectations, and may have caused participants to rate the

system markedly lower than they would have if the system had been already more stable.

Secondly, the sample size of the study was small, due to the expensive equipment needed for each participant in the experimental group and the limited budget. Due to the fixed project time and the extended development period, it was not feasible to have persons use the equipment sequentially, which could have allowed for including more participants. Thirdly, it seemed not feasible to maintain the RCT design in the Netherlands and Belgium, what may have caused some selection bias in these countries. To limit bias, we used a matched control group. Finally, since participants could choose which Rosetta subsystem they wanted to use, this may have biased the results, since those that chose specific systems (e.g. using EDS or not) may have been biased towards use of such systems (e.g. those uncomfortable with touch screens may have chosen not to use the EDN).

This evaluation study showed that the Rosetta system was anticipated very useful by the participants, especially when the major technical problems would be resolved. At the end of the project, the Rosetta system worked well and some parts of it are currently being brought on the market. It would be therefore recommendable to repeat the impact evaluation study, with the improved version of the Rosetta system. For future research, it is recommended that end-users with dementia are involved in the design of a new AT device and in the evaluation of its user-friendliness and usefulness. Evaluation of the impact of devices on daily life should only be performed when the system meets an acceptable standard of stability and reliability. Unfortunately it happens still too often that impact evaluations perforce start too soon in ICT development projects (see e.g. Jones [52] and Meiland [27]).

The Rosetta system was developed for people with mild dementia as well as for people with *moderate* dementia and their carers. Earlier research focused mainly on people with mild dementia, since these are generally more able to learn using new devices [51]. It is encouraging that people with more severe dementia can also be served by assistive technologies and may also benefit from it.

## Acknowledgements

We would like to thank all people with dementia and their carers that participated in the workshops, focus groups and the evaluation trial as well as their professional carers who participated in this study.

## Declaration of interest

The authors declare that there is no conflict of interest.

The Rosetta project was funded by the EU [AAL-2008-1-143] and national (governmental funding) institutes of the participating countries. Additional funding was received from Foundation Vita Valley.

## References

- Hope T, Keene J, Fairburn CG, et al. Natural history of behavioural changes and psychiatric symptoms in Alzheimer's disease. A longitudinal study. *Br J Psychiatry* 1999;174:39–44.
- Lyketsos CG, Steinberg M, Tschanz JT, et al. Mental and behavioral disturbances in dementia: findings from the Cache County Study on Memory in Aging. *Am J Psychiatry* 2000;157:708–14.
- Petersen RC, Smith GE, Waring SC, et al. Mild cognitive impairment: clinical characterization and outcome. *Arch Neurol* 1999;56:303–8.
- Gauthier S, Reisberg B, Zaudig M, et al. Mild cognitive impairment. *Lancet* 2006;367:1262–70.
- Geda Y. Mild cognitive impairment in older adults. *Curr Psychiatry Rep* 2012;14:320–7.
- World Alzheimer Day report. The Netherlands: Alzheimer Nederland; 2011.
- Health Council of the Netherlands, Dementia. Report for The Health Council of the Netherlands. The Netherlands: The Hague; 2004.
- Prince M, Jackson J. Alzheimer's Disease International World Alzheimer Report 2009. Report for Alzheimer's Society, 2009.
- Wancata J, Musalek M, Alexandrowicz R, Krautgartner M. Number of dementia sufferers in Europe between the years 2000 and 2050. *Eur Psychiatr* 2003;18:306–13.
- Nugent CD. ICT in the elderly and dementia. *Aging Ment Health* 2007;11:473–6.
- Lauriks S, Osté J, Hertogh CMPM, Dröes RM. Meer levenskwaliteit met domotica. Effectonderzoek naar de toepassing van domotica in kleinschalige groepswoningen voor mensen met dementie (A better Quality of Life with home technology. Effect study into the appliance of home technology in small scale living arrangements for people with dementia). Report for Department of Psychiatry, VU University Medical Center/GGD Amsterdam, 2008.
- Topo P. Technology studies to meet the needs of people with dementia and their caregivers: a literature review. *J Appl Gerontol* 2009;28:5–37.
- Sixsmith A, Orpwood R, Torrington J. Quality of life technologies for people with dementia. *Top Geriatr Rehabil* 2007;23:85–93.
- Kinney J, Kart CS, Murdoch L, Conley C. Striving to provide safety assistance for families of elders: The SAFE House project. *Dementia* 2004;3:351–70.
- Gilliard J, Hagen I. Enabling technologies for people with dementia. Cross-national analysis report, 2004 (D4.4.1. QLK-CT-2000-00653, pp. 1–69).
- Beauchamp N, Irvine AB, Seeley J, Johnson B. Worksite-based Internet multimedia program for family caregivers of persons with dementia. *Gerontologist* 2005;45:793–801.
- Smith TL, Toseland RW. The effectiveness of a telephone support program for caregivers of frail older adults. *Gerontologist* 2006;46: 620–9.
- Van Mierlo LD, Meiland FJM, Dröes RM. Dementelcoach: effect of telephone coaching on carers of community dwelling people with dementia. *Int Psychogeriatr* 2012;24:212–22.
- Lewis ML, Hobday JV, Hepburn KW. Internet-based program for dementia caregivers. *Am J Alzheimer's Dis Other Dementias* 2010; 25:674–9.
- Blackburn P. Freedom to wander. *Nurs Times* 1988;84:54–5.
- Engström M, Ljunggren B, Lindqvist R, Carlsson M. Staff perceptions of job satisfaction and life situation before and 6 and 12 months after increased information technology support in dementia care. *J Telemed Telecare* 2005;11:304–9.
- Savitch N, Brooks D, Wey S. AT Guide: developing a new way to help people with dementia and their carers find information about assistive technology. *J Assist Technol* 2012;6:76–80.
- Span M, Hettinga M, Vernooij-Dassen M, et al. Involving people with dementia in the development of supportive IT applications: a systematic review. *Ageing Res Rev* 2013;12:535–51.
- Bharucha AJ, Anand V, Forlizzi J, et al. Intelligent assistive technology applications to dementia care: current capabilities, limitations and future challenges. *Am J Geriatr Psychiat* 2009;17: 88–104.
- Scherer MJ, Federici S, Tiberio L, et al. ICF core set for matching older adults with dementia and technology. *Ageing Int* 2012;37: 414–40.
- O'Keeffe J, Maier J, Freiman MP. Assistive technology for people with dementia and their caregivers at home: what might help. Research Triangle Park (NC): RTI International; 2010.
- Meiland FJM, Reinersmann A, Sävenstedt S, et al. User-participatory development of assistive technology for people with dementia – from needs to functional requirements. First results of the COGKNOW project. *Nonpharmacol Ther Dementia* 2010;1: 71–91.
- Meiland FJM, Bouman AIE, Sävenstedt S, et al. Usability of a new electronic cognitive device for community-dwelling people with mild dementia. *Aging Ment Health* 2012;16:584–91.
- Storf H, Kleinberger T, Becker M, et al. An event-driven approach to activity recognition in ambient assisted living. *Ambient Intelligence*. Berlin–Heidelberg: Springer; 2009.

30. Jans A, Overmars-Marx T, Van Hoof J, Kort HSM. Evaluatieonderzoek van het UAS-project van Zorgpalet Baarn-Soest, Zorg aan huis. Report for Vilans, Utrecht; 2009.
31. Reisberg B, Ferris SH, de Leon MJ, Crook T. The global deterioration scale for assessment of primary degenerative dementia. *Am J Psychiatr* 1982;139:1136–9.
32. Pearlin LI, Schooler C. The structure of coping. *J Health Soc Behav* 1978;19:2–21.
33. The WHO Quality of Life group. WHOQOL-100. World Health Organisation Quality of Life instrument. Report for The WHO Quality of Life group, Division of Mental Health; 1998.
34. Logsdon RG, Gibbons LE, McCurry SM, Teri L. Assessing quality of life in older adults with cognitive impairment. *Psychosom Med* 2002;64:510–19.
35. Vernooij-Dassen MJ, Felling AJ, Brummelkamp E, et al. Assessment of caregiver's competence in dealing with the burden of caregiving for a dementia patient: a Short Sense of Competence Questionnaire (SSCQ) suitable for clinical practice. *J Am Geriatr Soc* 1999;47:256–7.
36. Reynolds T, Thornicroft G, Abas M, et al. Camberwell Assessment of Need for the Elderly (CANE). Development, validity and reliability. *Br J Psychiatry* 2000;176:444–52.
37. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975;12:189–98.
38. De Vugt ME, Stevens F, Aalten P, et al. Do caregiver management strategies influence patient behaviour in dementia? *Int J Geriatr Psychiatr* 2004;19:85–92.
39. Dröes RM, Meiland FJM. Lijst van gebruik van Instellingen [Use of services list]. In: Dröes RM, Meiland FJM, Schmitz MJ, et al., eds. Implementatie Model Ontmoetingscentra; een onderzoek naar de voorwaarden voor succesvolle landelijke implementatie van ontmoetingscentra voor mensen met dementie en hun verzorgers, Eindrapport. Amsterdam: Afdeling Psychiatrie/EMGO, VU medisch centrum; October 2003.
40. Lund A. Measuring usability with the USE questionnaire. *Usability Interface* 2001;8:3–6.
41. Van der Doef M, Maes S. The Leiden Quality of Work Questionnaire: it's construction, factor structure, and psychometric qualities. *Psychol Rep* 1999;85:963–70.
42. Cole DA. Statistics for small groups: the power of the pretest. *J Assoc Pers Sev Handicaps* 1998;13:142–6.
43. Cahill S, Begley E, Faulkner JP, Hagen I. "It gives me a sense of independence" – findings from Ireland on the use and usefulness of assistive technology for people with dementia. *Technol Disabil* 2007;19:133–42.
44. Bradley C, Harrison JE. Hospitalisations due to falls in older people, Australia, 2003–04. Report for Australian Institute of Health and Welfare; 2007.
45. Abbate S, Avvenuti M, Corsini P, et al. Monitoring of human movements for fall detection and activities recognition in elderly care using wireless sensor network: a survey. In: Tan YK, ed. *Wireless sensor networks: application-centric design*. Rijeka, Croatia: InTech; 2010.
46. Mubashir M, Shao L, Seed L. A survey on fall detection: principles and approaches. *Neurocomputing* 2013;100:144–52.
47. Rialle V, Ollivet C, Guigui C, Hervé C. What do family caregivers of Alzheimer's disease patients desire in smart home technologies? Contrasted results of a wide survey. *Methods Inf Med* 2008;47:63–9.
48. Demiris G, Rantz MJ, Aud MA, et al. Older adults' attitudes towards and perceptions of "smart home" technologies: a pilot study. *Inf Health Soc Care* 2004;29:87–94.
49. Rosenberg L, Kottorp A, Nygård L. Readiness for technology use with people with dementia: the perspectives of significant others. *J Appl Gerontol* 2012;31:510–30.
50. Nijhof N, Van Gemert-Pijnen JWC, Dohmen DAJ, Seydel ER. Dementia and technology. A study of technology interventions in the healthcare for dementia patients and their caregivers. *Tijdschrift voor Gerontologie en Geriatrie* 2009;40:113–32.
51. Clare L, Wilson BA, Carter G, et al. Intervening with everyday memory problems in dementia of Alzheimer type: an errorless learning approach. *J Clin Exp Neuropsychol* 2000;22:132–46.
52. Jones K. Enabling technologies for people with dementia. Report of the assessment study in England; 2004 (Rep. No. D.4.1.1.).