Smart nursing: the use of technology to support homecare nurses with their care of the elderly

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Abstract. The demand for homecare services is on the rise, while simultaneously there is a shortage of homecare nurses who are burdened with increasingly heavier workloads. The introduction of assistive technologies has the potential to assist elderly individuals as well as (informal) caregivers. This study aims to facilitate nursing care with technology, within the framework of a proper daily structure for elderly people. Initially, a needs assessment was performed with homecare nurses to identify the most relevant daily structure patterns. Subsequently, a prototype comprising of a test setup and a mobile application was developed, followed by a case study involving participation from homecare nurses, informal caregivers, and patients. Both subjective experiences and standardized outcome measures (System Usability Scale, Usefulness Satisfaction and Ease of Use Scale and User Experience Questionnaire) revealed highly positive attitudes towards the test setup and application. Future research endeavours should focus on scaling up the technology and expanding its availability to other caregivers.

Keywords. Assistive technology, sensors, elderly, homecare nursing, daily structure.

1. Introduction

The aging population continues to increase significantly. In the European Union, the number of people aged 75-84 years is projected to expand by 56.1%, while the number aged 65-74 years is projected to increase by 16.6% between 2019 and 2050 [1]. The demand for home care is increasing while at the same time high-quality care is still the main goal of caregivers. Homecare nurses experience very high workloads and stress levels [2, 3]. Furthermore, homecare nurses encounter many difficulties when providing

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services at home, for instance objective measurements are important for clinical reasoning, but it is often a challenge to gather such data about patients [4].

Lack of daily structure is a widespread problem for elderly people for whom home care is needed. The implementation of technology in healthcare can support the elderly as well as (informal) care providers. A lot is possible today; technological evolutions are happening at a quick pace [5]. Electronic sensors are becoming more accurate, and processors are becoming faster at a steady rate. This creates opportunities for new applications around IoT-devices (Internet of Things) such as using a smartphone to control lights, keeping track of the contents of the fridge, controlling the thermostat or even operate and manage washing machines remotely. Each of these are technologies that make life easier for people, not only at the level of providing information, but also at the level of assisting. Smart algorithms using artificial intelligence can consequently offer many solutions in healthcare using the data collected by these sensors [6]. Benefits from technology including smart homes have been demonstrated in literature [7], showing improvements in safety and insight in the risk of falling [8] and indoor mobility [9] etc. Assistive technology can lead to more comfort, new healthcare opportunities and more efficiency and quality of care [10, 11].

In general, nurses are positive about new technologies in care. They consider it important that technology contributes to better quality of care. When nurses are involved in the selection and introduction of new technologies, it increases the likelihood that technology will actually be used. Nurses mainly expect these technologies to increase the quality of life and self-reliance of the client, they do not expect an effect on physical strain, workload and attractiveness of the profession. In contrast, nurses do show a fear of losing their jobs due to increased use of technology [12]. However, clinical reasoning by nurses will always remain crucial in care and cannot easily be replaced by technology.

The aim of this study is to facilitate nursing care through the use of technology within the framework of a proper daily structure for elderly people. To achieve this goal, the following questions were formulated:

1) Which are the most relevant daily structure patterns that require monitoring?
2) How can a prototype for stimulating day structure be developed which integrates the most relevant nursing problems and linked interventions? How can nurses access recorded data in a simple and intuitive manner?
3) How do homecare nurses, patients and informal caregivers experience the feasibility of the developed test setup to monitor patients and support them during their daily care?

2. Methods

This study can be divided into three phases. Firstly, in order to acquire a comprehensive understanding of the most significant daily structure patterns, a needs assessment was executed. Secondly, drawing from the findings of the needs assessment, an iterative design process was implemented, leading to the development of a prototype for monitoring daily patterns and an application for straightforward and user-friendly access to recorded data. Finally, a pilot case study was conducted to investigate the feasibility of using the prototype and application in a real-world setting.

2.1. Needs assessment

In a previous study conducted by our research team, a needs assessment was performed among elderly individuals displaying potential signs of dementia and their informal caregivers. The aim was to identify the daily activities that posed the greatest challenges for them. The current study turns its attention to home care nurses, as they play a critical role in supporting these challenging daily activities and hence can offer valuable insights into improving elderly care. One of the goals of this assessment was to investigate the specific needs of homecare nurses in relation to their care for the patients and regarding the visualisation of patient data. However, the patient and informal caregivers remained central throughout all considerations during the project. The needs assessment itself consisted of two parts: an online questionnaire and in-depth interviews.

2.1.1. Participants

Home care nurses were recruited via multiple homecare organisations in the Limburg region of Belgium as well as through a call on social media. The inclusion criterion was to be employed as a nurse in the home care sector working with elderly people. Nurses who indicated in the questionnaire they would like to participate in an in-depth interview were contacted for the interview. The questionnaire was administered between January 2021 and March 2021 after which the interviews were conducted between March 2021 and April 2021. Within these periods the data collection for both the questionnaire and interviews continued until data saturation was reached.

2.1.2. Survey and semi-structured interviews

An online questionnaire was developed containing 33 questions in the following domains: demographic (3 questions), workload (3 questions), technology use (11 questions), patterns of daily structure (13 questions), information processing (3 questions). For the in-depth interviews, an interview guideline was prepared to further investigate the most important patterns related to daily structure. For each pattern it was explored which parameters should be measured, which nursing problems and interventions are related to the pattern and how technology can support them. Furthermore, it was investigated how homecare nurses should receive the information provided by the technology.

2.2. Test setup and application

Following the needs assessment and an analysis of critical patterns and parameters, a comprehensive selection of sensors and technologies was made. Factors of particular importance included: interoperability, affordability (open-source whenever possible) and privacy. The input and feedback from nurses were taken into account to ensure alignment with their requirements and preferences.

To ensure the application in which nurses viewed the patient data was sufficiently user-friendly, an iterative design process was followed in which nurses were closely involved through focus groups. Home care nurses were recruited via the researchers' network and through healthcare organizations. Guidelines were developed to be used during the focus groups in which the first prototype of the test setup and application were shown and discussed. There were two rounds of focus groups, in between which the

application prototype was incrementally improved. The focus groups were conducted between March 2022 and May 2022 and continued until data saturation was achieved.

2.3. Case study

For the case study, a close collaboration with the healthcare organization Wit-Gele Kruis Limburg was established. Two patients receiving care from their organization were recruited together with their regular nurses. Inclusion criteria for the patients were: living alone, at home or in an assisted living facility, being over 65 years of age, being able-minded, having an informal caregiver and the presence of one or more potential/current nursing problems according to Gordon's patterns or the Omaha system. To create a simpler and more easily controlled environment, the exclusion criteria were living together or the presence of large pets. For the home care nurses the inclusion criterion was to take care of the included patient and willing to participate in this study.

The test setup was installed and used for 3 consecutive months. Both standardized assessments and semi-structured interviews were performed. For the standardized assessments, the System Usability Scale (SUS), the Usefulness, Satisfaction and Ease of Use scale (USE) and the User Experience Questionnaire (UEQ) were used (filled in by the nurses). The semi-structured interview was conducted with the patient (n=2), informal caregiver and homecare nurses. Interviews were conducted at the start and end of the 3-month period. The SUS, USE and UEQ were taken at the end of the 3-month period. Every week, the nurses and informal caregivers were contacted by telephone to ask about their experiences and answer questions.

2.4. Ethical considerations

This study was approved by the Medical Ethical committee of Hasselt University. All participants have been informed both orally and in writing and have signed an informed consent document.

3. Results

3.1. Needs assessment

For the needs assessment the online questionnaire was completed by 143 homecare nurses, of which 6 homecare nurses participated in the in depth-interview. The mean age was 49.5 years with 66% having over 10 years of working experience. The homecare nurses' workload can be considered fairly high as on average (across 140 nurses) a score of 7 out of 10 was given (with 10 being the highest conceivable workload). Attitudes towards technology were positive in 60%, and negative in 8% of the homecare nurses. Out of several metrics of interest, the sleep and rest pattern was perceived to be the most important, followed by diet and metabolism, activity, health perceptions/maintenance, and cognition/perception. Over 86% of the homecare nurses indicated that the electronic patient file is the preferred channel for receiving information from technology, while 37% also consider an application on a smartphone or tablet to be a good way.

3.2. Test setup and application

3.2.1. Test setup

Based on the needs assessment, the sleep and resting and activity pattern were selected as focus for the test setup. A diverse mix of moderately affordable sensors were selected that were for the most part easily available on the commercial market. Clients and their living quarters were equipped with the following technologies: a smart watch (measuring steps, heart rate and sleeping pattern), a sleeping mat (measuring sleep and breathing pattern), a smart scale, movement sensors, door sensors (front door, refrigerator door), a seating mat and a tablet. A smartphone and internet connection were provided in case they were not already present.

With privacy and security in mind, the data these sensors provided was collected and aggregated on a network storage device that was located on premise. Home care nurses could consult this data for the patients in their care, using a tailor-made mobile application. Restricted access to the patient data was ensured via a login system and a secure encrypted connection. An additional tablet device was provided for the patient and their informal caregiver.

Information provided to the nurses consisted of (detailed) sleep information, periods of activity and inactivity, weight and heart rate information, and information about living habits in general (movement between and presence in rooms, and number of times the fridge was opened). Figure 1 schematically demonstrates the test setup.

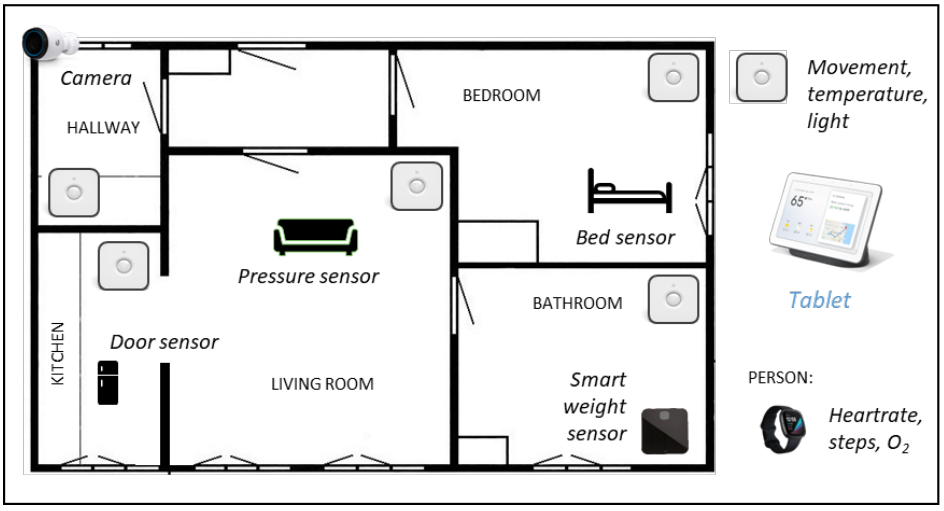

Figure 1. Overview of the test setup.

3.2.2. Application

Initially, a non-functional design of the application including several screens and dummy data was made. This first version was presented to 13 nurses in total during 3 focus groups. Feedback for each screen was collected, consisting of good elements, things that

could be improved, items which were redundant and missing elements. Based on these insights a second version of the design was created and presented to another group of 9 nurses total in a second round of 2 focus groups.
Starting from this design, a working prototype was produced that could display the collected data. During the pilot cases more data and visualizations were added to the application, and several changes were implemented based on user feedback. Figure 2 gives an overview of the process and some screenshots of the application.

Figure 2. Iterative design process of the application, including some screenshots.

3.3. Case study

The test setup was installed in 2 patients' homes and the experiences of 5 nurses and 2 informal caregivers were mapped. The information from the sensors (on top of the usual information obtained while conversing with the patients) often became a useful starting point for more detailed enquiries, and more evidence-based decisions during home care. Several participating nurses indicated they gained a clearer understanding of the patients' general physical health and well-being. Patients reported that the test set up had no noticeable impact on their daily life. The sensors were inobtrusive except for the smart watch. They were also curious about the results regarding their sleep, resting and activity pattern. The information provided by the nurses gave them a more accurate insight into these patterns. Informal caregivers reflected that when abnormalities were observed by the nurses, they were contacted. Overall, the informal caregivers experienced no perceptible disadvantages from the test setup.

The mean SUS score was 87.5 (stdev 15) and the scores ranged between 70 and 100. The UEQ uses 6 scales: attractiveness, perspicuity, efficiency, dependability, stimulation and novelty. On all of these, the test setup and application had a positive evaluation (figure 3A). Compared to the benchmark dataset of the UEQ (containing data on 21.175

individuals from 468 studies concerning different products, the test setup and application scored ‘good’ on dependability and ‘excellent’ on the other 5 scales. Regarding the USE questionnaire, the mean scores on a seven-point scale were 5.1 for usefulness, 5.6 for ease of use, 6.2 for ease of learning and 5.7 for satisfaction (figure 3B).

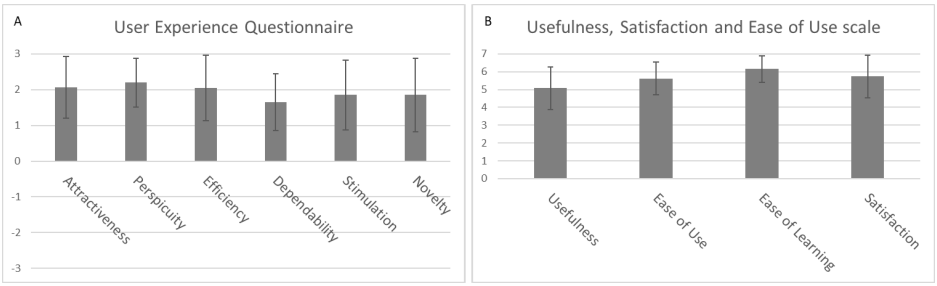

Figure 3. Results of A) the User Experience Questionnaire (UEQ) and B) the Usefulness, satisfaction, and ease of use (USE) scale.

The application of data analysis techniques and artificial intelligence can be a valuable asset for homecare nurses. Various unsupervised learning approaches (Isolation Forest, kNN, PCA analysis, and others) enable the detection and flagging of potential anomalies, which may not be immediately apparent when homecare nurses interact with the visualized data in the application. They can then perform a more in-depth inspection of the potentially anomalous events.

4. Discussion, future work, and conclusion

The main aim of this project was to facilitate nursing care using technology within the framework of a proper daily structure for elderly people. With a focus on the sleep, rest and activity pattern, a test setup and application were developed in collaboration with homecare nurses. The relevance of the two selected patterns has also been demonstrated in literature [13]. Homecare nurses as well as patients and informal caregivers were all positive about the test setup and application as demonstrated by the questionnaires and interviews. During the study, several other healthcare providers were interested in the data, including the physiotherapist, GP and informal caregiver. In the future we should look at how the test setup can be made available to multiple additional disciplines and what information should be made available to each.

Based on our interviews with home care professionals, it turned out the parameters of importance for monitoring patients can be quite diverse and differ significantly on a case-by-case basis. While collecting requirements from home care nurses, some other parameters of interest were discussed, for which we could not obtain proper sensors or platforms in time. A non-exhaustive list of “smart” products that may create added value in specific cases are: a smart medication dispenser, a smart blood pressure sensor, a smart cup or pitcher that measures liquid intake and a smart toilet that measures quantity and/or quality of excreta. Note that all these products should have an API accessible to third

parties to be able to be integrated with our platform; some of these products were available, but only within a closed software ecosystem that could not be integrated.

An interesting avenue in which to continue this project in the future is scaling it up to accommodate a (significantly) higher number of patients, home care nurses and informal caregivers and increase the test period duration. We are currently outlining a follow-up project in which we want to address potential upscaling challenges such as cost per patient, cost for the operator of the platform, simplicity of installation, ease of use, data storage, privacy, security, and data analysis.

In summary it can be stated that a system to give home nurses a more detailed insight about patients' daily structure is very valuable in supporting them in the context of patient care.

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