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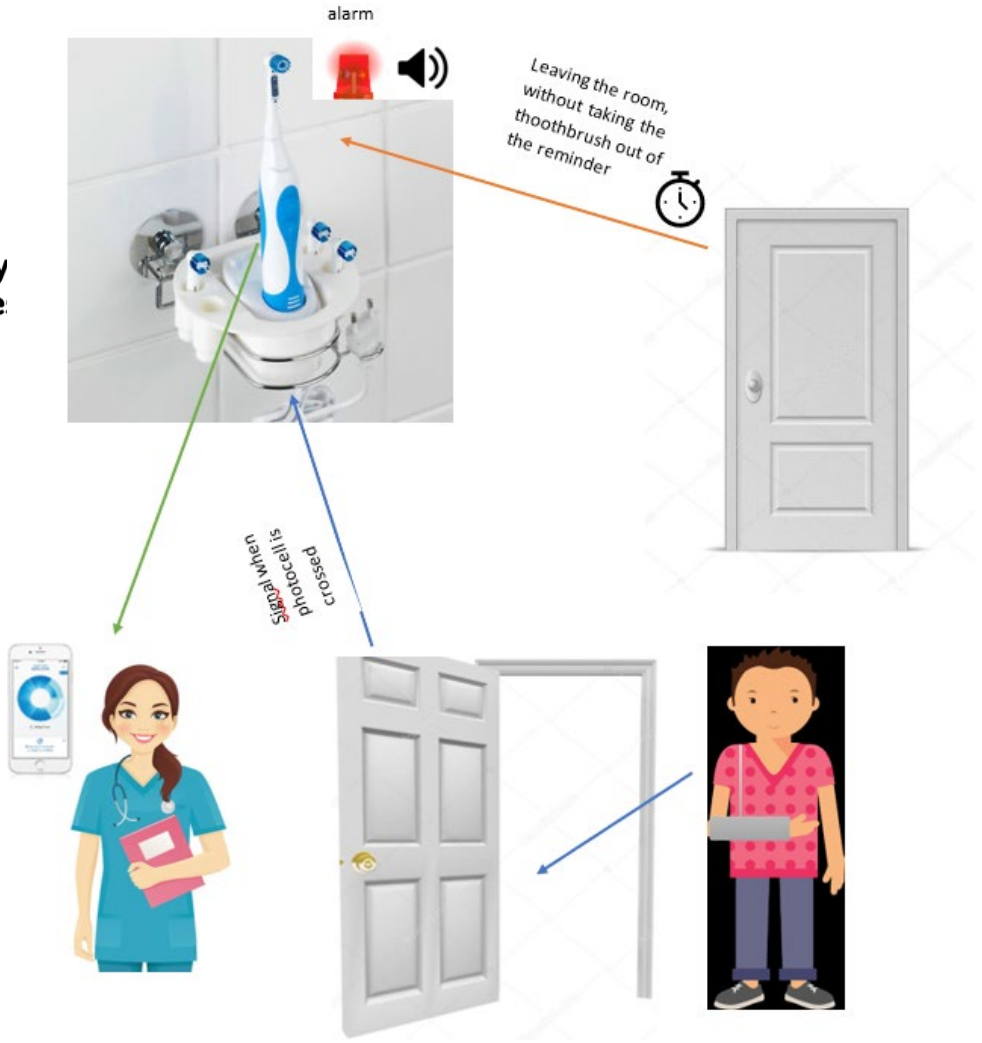

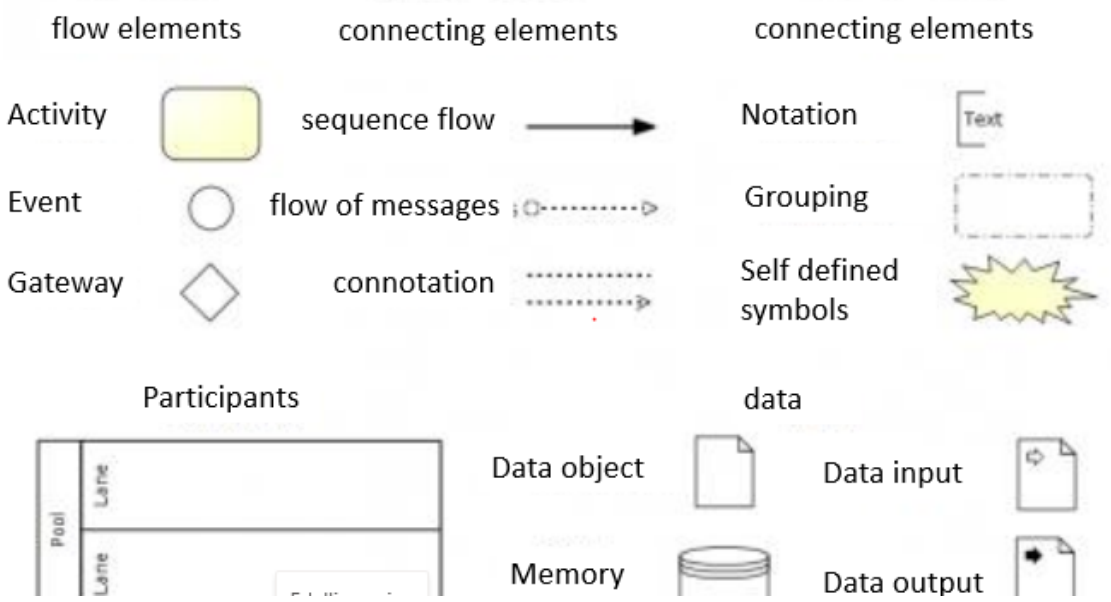

Smart Solutions for Wellbeing Service Development and Management – developing health care innovations in multidisciplinary student teams 2.0

Härkönen Jaana (ed.)

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Kajaani University of Applied Sciences publication series B

Reports and surveys 103

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Kajaani University of Applied Sciences publication series B 103 / 2020

ISBN 978-952-7219-55-3

ISSN 1458-915X

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1 Preface

The vision of Kajaani University of Applied Sciences (KAMK), as described in its strategy, aims to be the smartest university in Finland by 2024 and profiles in promoting regional development through internationalization. Activities are steered by one profile – smart solutions – which cuts through all KAMK activities. In addition to technological solutions, smart solutions refer to the ability to do correct things correctly. Enhancing competence and effectiveness as well as renewing cooperation and division of work are strategic objectives of KAMK.

The Smart Solutions for Wellbeing Service Development and Management course promotes the strategic objectives of the university. The network approach and renewed multiprofessional and multidisciplinary collaboration have been applied to developing this course the concept of which is described in the first article of this publication. Both teachers and students' competence has been enhanced to meet the requirements set for an internationalized institution of higher education. Digitalization is embedded in the course content and implementation as well as in the communication between students. Cooperation in innovating smart solutions has also advanced effectiveness as described in the KAMK profile, which is reflected in the quality of education and innovations that reform the working life.

Multidisciplinary development and problem setting always require building multidisciplinary student groups and combining the approaches and teacher competences of different disciplines. The multidisciplinary approach facilitates the creation of something completely new as innovations can be viewed from different perspectives and as traditional boundaries between disciplines can be crossed. Problematization of innovation objects from multidisciplinary perspectives leads solutions that are based on a new way to understand practical problems and solve them.

Sharing students and teachers' competence in multidisciplinary innovation teams creates synenergy benefits that are described in the articles. Collaboration among student teams and teachers has resulted in innovations that embody the multidisciplinary approach. Applying competence in the development of the innovations facilitates new and interesting perspectives which we hope will also interest a wider readership outside the applied universities in Kajaani and Neu-Ulm.

It is challenging to write and publish descriptions of multidisciplinary innovations. Student who participate in the work of a multidisciplinary student team certainly learn something new, but they may also have to step out of their comfort zone. They have to learn ideas and perspectives that do not belong to their own competence in a foreign language. Institutions of higher education usually plan and implement multidisciplinary teaching within the context of one field of education only. Multidisciplinarism may be named as an approach in strategies; yet at the same time it may not be implemented in practice. Many everyday practices at universities of applied sciences have been planned to promote the development of one field of education. The innovations described in this publication demonstrate that a multidisciplinary approach and collaboration between different fields of education promote effectiveness and competence development of those who participate in the planning of innovations.

Kajaani 7.11.2019

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2 Smart Solutions from an Multidisciplinary Perspective

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2.1 Background

Digitization will significantly change the health care system in the next few years. Established processes will experience digital support, change or become obsolete. New supply scenarios are emerging that present challenges for actors involved – both service providers and patients.

When it comes to digitization in social and health care, it is worth looking at developments in eBusiness. In the beginning it quickly became clear that the use of new information and communication technologies alone would not guarantee a higher productivity (Picot, Reichwald & Wigand 1998). Only if established processes are adapted to new technologies can they be used effectively (Jaeckel, Roevekamp & Wuerfel 2004). Furthermore, there are completely new dimensions of benefits that need to be included in the consideration of new technologies (Brynjolfsson 1993). To illustrate this with a simple example, reference can be made here to an electronically supported warehouse management system in the field of logistics. This allows the real-time recording of inventories, which was previously impossible. This must be integrated into existing management processes in order to fully realize the benefits of the new technologies. Comparable developments can already be observed in the social and health care sector. One example is the increasing administrative effort in hospitals in the course of digitization. (Kangasniemi & Andersson 2016, 38; Kucera 2018.)

Three essential principles have been defined for the digitalization of social and health administration: customer-driven development of social and health services, ease of use and security of services, and opening of service interfaces to social and health care companies and citizens (Digitalisaatio terveyden ja hyvinvoinnin tukena. Sosiaali- ja terveysministeriön digitalisaatiolinjaukset 2025 2016).

The examples also show that it is necessary to bring together different perspectives when considering digitization. In the area of health care, this means integrating technical and economic perspectives in addition to the core actors which are service providers and patients.

A fundamental challenge is already emerging at the micro level of health service provision. The effectiveness and efficiency of processes must be evaluated both from the medical point of view (service provider) and from patients' point of view. In the context of health care, it is not sufficient to consider only the medical and economic benefits as well as the technical feasibility. Accordingly, it is always important to perceive the patient as an independent actor and customer. In the latter perspective, ethical aspects are also important and must be considered in the development of new technologies and processes. At this point not only the perception of the patient can be followed, because individual emergencies can overlay ethical aspects. As technology advances, ethics and ethical leadership are confronted with new questions: what can technology do and where is the boundary between humans and robots? The importance of ethics is particularly emphasized in the face of new questions when considering the deepest essence of humanity. Existing legislation does not keep up with current technological developments, so responsibility and ethical issues burden the entire work community and pose challenges to the manager in particular. (Bostrom 2014; Leonhard 2016, 133; Työelämä 2025 -katsaus: Työelämän ja työympäristön muutosten vaikutukset työsuojeluun ja työhyvinvointiin 2015.)

The extent to which the processes change resulting from the use of new technologies is noticeable in many innovations. Even if it often seems that processes are only technically supported, the possibilities to document medical treatment processes change considerably. The effect is comparable to the example from the field of logistics as described earlier. Technically collected data will successively change the medical process. This can take the form of artificial intelligence or new health care structures. But there is still a need for work in working life which cannot be eliminated by technological innovation or robots as a Finnish robotics and artificial intelligence project indicates (Kauhanen n.d.; Hyvinvoinnin AiRo-ohjelma #hyteairo 2018).

Disciplines and discipline-specific studies can set boundaries that can be challenging (Mikkeli & Pakkasvirta 2007, 142). Planning and implementing multidisciplinary courses collaboratively lower these boundaries and enable learning. At its best, co-development is a fusion that seamlessly integrates understanding of application and customer needs, complementary competency profiles, and seamless multidisciplinary collaboration (Moisanen, Rantaharju & Kemppainen 2019, 61). The aim of this article is to describe how innovative smart solutions can be designed

and developed in multidisciplinary collaboration between (university of applied sciences) students and teachers.

2.2 Methods

Within the framework of collaboration between Kajaani University of Applied Sciences (KAMK) and the University of Applied Sciences in Neu-Ulm (HNU), Master of Health Care students and Bachelor of Engineering (information and communication engineering) student from KAMK as well as Bachelor of Business Administration, Health Management and Health Information Management students from Neu-Ulm worked together on projects related to smart solutions in health care.

The blended learning course was organized from October 2018 to May 2019 and included two contact teaching periods in Neu-Ulm (December 2018) and Kajaani (February 2019) implemented as intensive courses. Only the Master of Health Care students from Kajaani and the students from Neu-Ulm were involved in the first contact teaching period. The ICT students participated in the intensive course in Kajaani. While the first contact teaching focused first and foremost on revising the initial ideas and build the teams, but the second intensive course was used to further develop the projects and create prototypes. After the week in Neu-Ulm, the teams coordinated their work in virtual groups in Moodle.

The initial project ideas were developed in Kajaani by the Master students. The innovations were largely based on the students' work experience, which gave the innovations a direct practical relevance. These ideas were then analyzed and further developed from both economic and technical perspectives in the two face-to-face workshops. This has made it possible to implement fundamentally multidisciplinary projects that are highly practice-oriented on one hand and technically and economically feasible and meaningful on the other hand. The Study Instruction describes the content of the course (Appendix 1).

During the presence week in Neu-Ulm the team building for the projects took place. Students from Kajaani presented their ideas for smart solutions. The teams from Kajaani and Neu-Ulm then worked out the first ideas further and presented the revised project ideas, the timetable and the project management until February 2019 at the end of the week. In addition to the content work, the Finnish students were given an insight into the German health care system during excursions.

The Intensive Course in Kajaani included various events that provided students with further information on e.g. BPMN and entrepreneurship to prepare their project ideas. In addition, excursions were made to provide the German students with insights into the Finnish health care system. This week, the Finnish ICT students joined the working groups to examine the project ideas in regard to their technical feasibility. Some of the concepts were modified, because otherwise they were not feasible. At the end of the course, the students were able to present the first prototypes of the innovations.

2.3 Results

With their innovations, the teams tackled real existing problems. While these were initially shaped by the Finnish context, in the course of the project the problems were generalized and the innovations became highly transferable. Subsequent projects were worked on.

In particular, older people tend to forget things when they leave the house or apartment. This problem is particularly relevant for people with dementia. For this group of people, an innovation was developed. Smart Reminder, controlled by a wristband, reminds the person leaving the house or apartment to take their personal belongings (e.g. keys, wallet) with them. This smart solution detects when the door is opened and reminds the person of his or her things. If he or she does not respond to this request, a new reminder is issued.

Another smart solution focuses on pregnant women who independently monitor the heart sounds of their baby. In case of irregularities, a public health nurse or a doctor can be contacted. The Health 4 Baby innovation is aimed, in particular, at rural areas where travel times for health care professionals can be long. The psychological stability of pregnant women is particularly important in this innovation. Without the physical presence of a public health nurse or a doctor, fetal heart sounds or their documentation can unsettle the pregnant woman. This must be excluded, as otherwise unnecessary stresses may occur.

The Military Healthcare Application (MHA) innovation looks at a completely different context. The basic idea of this innovation was to design an application for self-assessment of the need for treatment for the Finnish Defence Forces and to make it possible for service men and women to make appointments using the MHA. In this way, waiting times in the garrison hospital can be shortened. Service men and women use the application to communicate about their health problems, which makes it possible to prioritize treatments and plan waiting times accordingly. In the

broader sense, it would also be possible to provide differentiated care for service men and women and allocate doctors' time on non-routine cases.

The Mobile Nursing Assistant (MONA) innovation looks at patient documentation. The documentation of parameters such as blood pressure or oxygen saturation requires the operation of a corresponding documentation unit during patient contact. Usually the documentation is done with a tablet or a keyboard. The idea is to design a documentation voice control so that, after activating the documentation, the information can be entered verbally (speech to text).

The fifth innovation focuses on hand hygiene which represents a highly significant aspect in the field of hospital hygiene and can be seen as a core element of infection prevention in hospitals. The innovation is based on the idea that a mobile application reminds health care professionals, if they have forgotten to disinfect their hands. In addition to the direct effects on hand hygiene in the hospital, this innovation also enhances quality control perceptible to the patient. The patient can see for himself whether the hygiene requirements are being met. As a result, he feels safer, which can also have an impact on the perception of the entire treatment process.

The sixth innovation is in the field of oral hygiene. This aspect is especially important for older patients. The innovation recognizes whether the teeth were brushed in the morning and in the evening or whether the teeth were brushed well enough. If this is not the case, the patient is reminded of oral hygiene and this is documented for the attending staff (e. g. nursing staff). In this way, forgetting oral hygiene is prevented and at the same time a control or documentation is created that can be used to improve the quality of treatment.

2.4 Discussion

The innovations show a high bandwidth in regard to the starting points in the social and health care treatment context. At the same time, the implementations make it clear how technology, treatment processes and economic considerations interact. But we cannot forget the threat of technological and digital innovation, which is particularly linked to ethical issues (Bostrom 2014; Leonhard 2016, 133; Työelämä 2025 -katsaus… 2015).

The automatic documentation in the case of oral hygiene makes completely new quality assurance instruments possible. At the same time, ethical problems may also arise. The question to

what extent the personal freedom of a patient is restricted by the fact that his personal hygiene habits are documented would certainly be justified.

Utilization of technology, artificial intelligence and robots creates different solutions to improve the quality of social and health care functions and services. Artificial intelligence is believed to be a solution to social and health problems such as the aging population and labor shortages. In the long term, the rise of service robotics is expected to bring significant changes to the whole social and health care sector. Automation of the medication process is expected to reduce medication errors, and with automation of medication doses, nursing staff will have more time than before (Baril et al. 2014, 2). Another important area of utilization of artificial intelligence in nursing is the provision of fast access to electronic services and information. For example, virtual and software robots can make effective use of the Internet and cloud computing power (Kangasniemi & Andersson 2016). This facilitates the work of nursing staff when effective documentation, recording and analysis of information is possible.

The innovations developed in multidisciplinary student groups support, among other things, high-quality patient safety by speeding up patient appointments and treatment and enhancing hand hygiene. Innovations also speed up, facilitate and prioritize the work of nurses.

But the challenge of utilizing robotics is the central role of ethical, regulatory and social factors. Artificial intelligence is believed to replace just routine tasks, but, for example, jobs that require employee situational awareness and human interaction remain outside artificial intelligence. This facilitates the work of nursing staff where effective documentation, recording and analysis of information is possible (Kangasniemi & Andersson 2016; Kauhanen n.d.)

The consideration of self-measurement in the case of pregnant women also clearly shows potentials such as the limits of new technologies. Independent data collection can monitor critical parameters promptly, especially in the case of high-risk pregnancies. From an economic point of view, in particular, there is a considerable potential for savings, since service providers and patients do not have to travel to personal appointments. From a medical point of view, highly interesting data series could also be generated, which could certainly provide new insights. However, the psychological factor must not be ignored. Close monitoring can be problematic for pregnant women, as the pregnancy and risks are permanently present and it is not possible to “switch them off".

The innovations clearly show the potential of multidisciplinary teams in their implementations. This becomes again clear in the following detailed representations. The interaction between various disciplines became clear in the further development of the ideas as the course proceeded. The participating students gained a new perspective on problems and valuable insights into project management in multidisciplinary teams through the perspectives from other disciplines.

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Appendix 1

Smart Solutions for Wellbeing Service Development and Management –the evaluate task of the course

- Student groups participating in the course are Social and healthcare Master students, students of information systems and German Neu-Ulm University students (in health care management and information management in health care)

1. KAMK Social and Health care Master student will conduct a survey of employees orientated towards innovation in and connected to your work community and will form an innovation team within your work community. Discuss who should be selected for the innovation team and what the team's targets will be, with your immediate boss or supervisor.

2. Led by the Master student, the innovation team will seek agile development methods using innovations within the his/her organisation/work community supporting smart solutions, in cooperation with the staff, customers and representatives of connected parties.

3. The task of the innovation team is to ensure that the innovations/ideas support the organisation's/work community's strategic activities and to choose one innovation that fulfils the organisation's strategic objectives and smart systems development. The student describes at least one innovation.

4. Master students and students of information systems will meet. Master students present their innovations and students from information systems comment on their technical implementation perspective. Students decide together which of the presented innovations can be combined and which are still being developed. Master students and students of information systems form the teams based on the innovations chosen above.

5. Team-specific folders are created on the Moodle platform, where further work on innovation is continued. Innovations are described as accurately as possible so that German students can choose which team they are involved in. Each team consists of three students from different fields. The team's recommended size is 6-7 people.

6. Master students, the German student and the students of information systems students continue their discussion in Moodle on workplace innovation and its development.

7. Master students (in each team), with the help of the innovation team of the work community and the student team, will prepare a preliminary innovation pilot scheme.

8. Master students (in each team), with the help of the innovation team of the work community and the student team, will prepare a preliminary innovation pilot scheme which will be described by Moodle's team:

    - Why is the innovation needed and what is its purpose?
    - Who will use the innovation (understanding customer needs) and who else will benefit from the innovation?
    - What is the concept of the innovation? What does the innovation look like?
    - What will the innovation affect, what is the desired change?
    - What limitations does the innovation have?
    - How will the user of the innovation be rewarded and how will he/she receive feedback?
    - How will the innovation be used? Is there collaboration with other innovations?
    - Who/what is needed in order to use the innovation? What expertise is required?
    - What are the budget, funding and schedule of the innovation?
    - How will the innovation be evaluated?
    - On which platforms does the innovation work? How can it be shared?

9. Master students and German students will continue to develop innovation in the International Week in Neu-Ulm. If required, they will consult the information systems students about the technical issues of innovation.

10. The development of innovation is continuing throughout Moodle's learning platform.

11. The development of innovation will continue in the teams International Week in Kajaani. Team describes the pilot and evaluation plan presented and prototyped in an international week in the workshops. The team is preparing to present its innovation in a seminar that will be held at the end of the international week.

12. The team writes an article on the innovation process. Student's plan and share responsibilities for writing a joint article. The main responsibility for the article (to lead and organize the writing of an article) is that of the Master sote student who has not participated in the German International Week.

13. Master students describes and possibly piloted innovation experiment in his work community (1-2 weeks).

14. The team reflects the innovation experiment and decides on the basis of reflection on the further development of innovation

    a) Innovation is abandoned ➔ the innovation team selects a new innovation

    b) The experimented innovation will be developed on the basis of reflection and a new pilot scheme will be drawn up

    c) Innovation is complete ➔ prepare a plan for introducing innovation (projecting or productising) eg Kamk business accelerator

15. The students reported the results of the innovation experiment as a international publication.

3 Smart Reminder

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Abstract

The Smart Reminder innovation was developed as part of a course called Smart Solutions for Wellbeing Services Development and Management. The course was designed to create health care innovations. The need for this innovation came from home care employees working with clients with memory disorder. The number of older people living in their own homes is increasing, and technology can be used to support them. Although national programs to support older people's wellbeing and to develop services have increasingly been launched, resources allocated to home care continue to be limited. The idea was that this innovation would remind older people about different items and be placed by the front door of their house. The innovation team included one Master of Social and Health Care student and four Bachelor of Engineering (communication and information technology) students. The aim of this article is to describe how we can respond to problems related to the home care services offered to clients with memory disorders and allocation of human resources.

Keywords: smart solutions for health care, innovation, clients with memory disorders

3.1 Introduction

Due to changes in the brain memory loss commonly leads to the deterioration of cognitive abilities. In addition, as memory deteriorates, the ability to learn new skills also becomes more difficult. The concept of dementia was used in the past to describe reduced cognitive abilities and functional capacity. Alzheimer's disease can now be diagnosed earlier, and patients do not necessarily meet the dementia criteria. Cognitive symptoms are often progressive but may also remain unchanged or be regained to some extent in the case of cerebral infarctions or other brain conditions. (Tilvis, Pitkälä, Strandberg, Sulkava & Viitanen 2010, 29, 120–121; Fried, Heimonen & Jokinen 2013, 9–15.)

The major challenge in home care is the development of its content and the diversification of home services and other support measures (Finne-Soveri, Kuusterä, Tamminen, Heimonen, Lehtonen & Noro 2015, 3). 12,000 people receive a memory disorder diagnosis annually in Finland, so the total number of people with memory disorder is estimated to be around 130,000. Naturally, the large number of people with memory disorders is challenging for the social and health care services. (Leikas & Launiainen 2016, 11.) The need for this innovation came from home care. The number of assisted living facilities for older people is being reduced and the number of older people living in their own homes is increasing. National programs to support older people's wellbeing and to develop services have increasingly been launched. They underline the importance of maintaining older people's functional capacity, supporting living at home, prioritizing community care services and safeguarding adequate, seamless and timely social and health care services. The scope of home services has narrowed, and differences between municipalities are considerable. The number of clients receiving support from community care services and service units has increased over the years. (Tilvis ym. 2010, 65–66.)

In the recent years, technological advances have opened new opportunities to support older people's independent living and to enhance their wellbeing. Technological solutions can include video calls, wellness-TV and a wide range of solutions that facilitate daily activities and mobility. (Immonen & Koivuniemi 2017; Hammar, Mielikäinen & Alastalo 2018, 3.) The development of Smart Reminder was aimed at addressing the problems in home care and allocation of human resources, thereby targeting employee resources at appropriate tasks. Leikas and Launiainen (2016, 7) state that in future technology will play an increasingly important role in supporting older people's daily activities and early detection of changes in functional capacity. It is essential that supportive measures to promote daily activities are provided at home in a timely manner.

Technology can provide tools for maintaining and monitoring functional capacity, making it easier to build a sense of life management. At its best, technology-enabled services promote older people's autonomy and quality of life by supporting daily activities and social relationships and enhancing safety. (Leikas & Launiainen 2016, 41; Immonen & Koivuniemi 2017.) Smart Reminder is based on a vision of a product which considers the user perspective and actual situations it is used. The aim of this article is to describe how we can respond to problems related to the home care services offered to clients with memory disorders and allocation of human resources.

3.2 Background

The Quality Recommendation for Safeguarding Good Aging and Improvement of Services 2017–2019, published by the Finnish Ministry of Social Affairs and Health (2017, 26–27), states that smart building technology and technology that promotes older people living in their own homes needs to supported. Technology also provides the opportunity to communicate with older people and their relatives as well as with those providing home care and/ or services. Technological applications can be used to prolong the time older people can live in their own homes. A wide range of wristbands, special carpets and other products and applications are available.

In addition, the Quality Recommendation for Safeguarding Good Aging and Improvement of Services 2017–2019 (27) claims that robots and automation will take over around 20% of nurses and caregivers' tasks within a few years. "Attention has also been paid to ensuring the accessibility of digital services, developing the methods of authentication for digital services and exploring how digitalization affects people's daily lives" (Digitaalinen Suomi – Yhdenvertainen kaikille 2019). Investment and operating costs may be high initially; however, the benefit will gradually become visible. At the same time, digitalization reduces the need for employing a large staff. The Alzheimer Society of Finland reported that the range of assistive devices for activities of daily life is wide (2017). Technology and assistive devices such as door and fall alarms can increase the safety of clients with memory disorders, support their ability to function and bring the joy and sense of community to everyday life.

Karhinen, Taipale, Tammelin, Hämäläinen, Hirvonen and Oinas (2019) made a survey of the technological feasibility of employees working for older people services. About 50% of the respondents said that technology did not improve their chances of doing their work well but a vast majority of the respondents thought that technology would increase client safety.

The concept of welfare technology refers to devices and systems that can maintain or improve functional capacity, health and wellbeing. Gerotechnology refers to the use of technology to promote older people's independent living and autonomy. The weaker the client's functional capacity is, the more technology can help as part of the care and services package. Technology does support the services most frequently used by older people living in their own homes, but it must also support working with older people and the quality and cost-effective provision of services for them. Using technology to provide home care services is particularly important. When gerotechnology is used in home care, the employees are the key factor in the introduction of technology-enabled services. (Viirkorpi 2015, 5, 45; Immonen & Koivuniemi 2017.)

Finnish society is changing demographically as life expectancy among baby boomers is improving at the same time as fertility and mortality are decreasing. It is predicted that the number of older people in the oldest age groups will increase sharply, which again affects the municipal planning of housing and other services that meet older people's functional capacity. (Paljärvi 2012; Laatusuositus hyvän ikääntymisen turvaamiseksi ja palvelujen parantamiseksi 2017–2019 2017, 11.)

Older people services must respond to the demographic change. In Finland there are approximately 200,000 people with mild cognitive impairment; it was estimated in 2013 that approximately 100,000 people suffered from mild and 93,000 from moderate dementia. Memory disorders are the most significant disease group for social and health care services. People with memory disorders usually want to live in their own homes despite the fact that as the disease progresses, they need help from others. Home care aims to address the support needs of both persons with memory disorders and their families have. (Tilvis etc. 2010, 136; Muistisairaudet 2017.)

Paljärvi studied the central government steering of home care and the organization, content and quality of home care in the City of Kuopio in Finland in a 15-year follow-up study (2012, 35). The results showed that problems with hearing, sight and, in particular, memory had increased considerably from 2003 and 2009.

Kehusmaa, Alatalo and Luoma (2017) pointed out that while the number of home care clients had increased, home care services provided per person had been reduced: home care had on average 3000 clients more daily than two years earlier. Only 2,800 clients received 24-hour treatment. In addition, the number of employees had declined considerably, and staff resources had not been transferred to home care. As the older population continues to grow, the number of home care clients will continue to grow, which increases the client load of home care. Technology can assist

people living in their own homes, but it has not been adopted to the fullest extent. It has the potential to increase the safety of older people.

Because of demographic changes happening, society must adapt to the needs of the older population. Older people should have the opportunity to live a good and safe individual life. They need personalized services that promote their independent living and autonomy. (Laatusuositus hyvän ikääntymisen turvaamiseksi ja palvelujen parantamiseksi 2017–2019 2017, 13.) Smart Reminder contributes to older people living safely in familiar environments. According to Muistibarometri (Finne-Soveri etc. 2015, 74), during a period of ten years the service system seemed to develop in a largely positive direction with regard to the care and services for people with memory disorders. The main focus was on supporting older people living in their own homes.

3.3 Methods

The innovation process began with the definition of the need for innovation, which was implemented by master students in their working communities. Originally, the innovation idea came from home care employees, and the purpose was to develop a GPS device to keep track of people with memory disorders when they leave their apartments. A possible addition to this device could have been a feature that would have allowed nurses or relatives to contact them by asking questions or reminding them about their personal items.

When the ICT students explored the innovation idea, they noticed that the GPS wristbands to locate persons were already available. The idea was modified to focus on reminding people about different items and the device would be placed in clients' home close to the front door. ICT students began to design the device based on the original idea. The master student focused on the features the device should have. During the development of the device, the benefits and challenges of using the device were explored. A smartphone application and email were used for communication within the innovation team. The device was finalized and a prototype presented during the 2019 International Week at Kajaani University of Applied Sciences.

3.4 Technical Specifications and Process Model

Smart Reminder is a device that reminds persons with memory problems to take their belongings with them when they decide to leave their house (Figures 1 and 2). This reduces the risk of the person getting lost or hurt, because they have their phone and wallet with them.

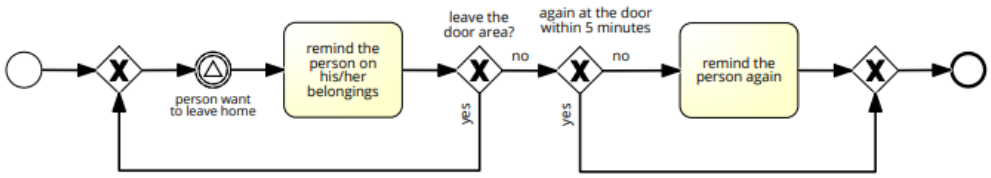

Figure 1. Process diagram of the function of the application.

The innovation project required a microcontroller to handle the communication between all the components that were installed, so the Arduino UNO microcontroller development board was chosen. The Arduino is a microcontroller board based on the Atmega328 architecture. It contains a USB interface which powers the device and many analog and digital ports that can be used to integrate the Arduino into a wide variety of projects and devices. Arduino is an open source platform, which means that the boards can be modified in any way that is desired. This makes the Arduino platform excellent for integration into embedded devices.

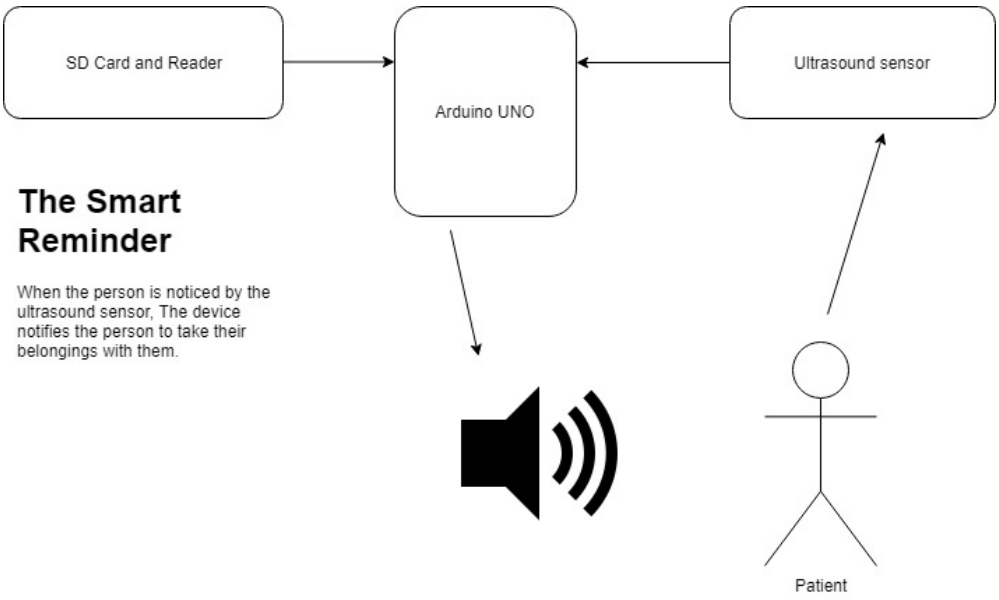

Figure 2. Smart Reminder user case diagram.

The Arduino platform requires an IDE (Integrated Development Environment) application in order to upload the code to the board. It requires C/C++ programming languages to be used. The IDE is available in Windows, Mac and Linux. The IDE is also an open source. It is extremely popular with the DIY electronics community, and that is why it was used in the Smart Reminder project. The Arduino UNO is an excellent base to build a project on. It is cheap and versatile and has an incredible amount of documentation online. It is the preferred microcontroller board of many hobbyists and many schools because of its simplicity and beginner-friendliness. The SD card reader requires a way of communication with the speaker so that the speaker can play the sound file stored on the SD card. The ultrasound sensor also requires a microcontroller in order to process the signals it receives and generates.

Arduino is an open source microcontroller which can be easily programmed, erased and reprogrammed at any instant of time. Introduced in 2005, the Arduino platform was designed to provide an inexpensive and easy way for hobbyists, students and professionals to create devices that interact with their environment using sensors and actuators. Based on simple microcontroller boards, it is an open source computing platform that is used for constructing and programming electronic devices. It is also capable of acting as a minicomputer just like other microcontrollers by taking inputs and controlling outputs for a variety of electronics devices. (Louis 2016, 21.)

The device senses that the client is near the front door about to leave and plays a sound that reminds about the items. Ultrasound technology is used for the detection of the client. The ultrasound sensor emits a high-frequency sound that travels forward from the sensor. When the sound meets an object that it cannot pass (solid objects), the high-frequency sound is bounced back to the device. The ultrasound sensor is then able to calculate the distance between the sensor and the solid object. In this specific case, the client is the solid object in front of the sensor. It was decided to use the HC-SR04 sensor (Introduction to HC-SR04 n.d.; Realtek IoT/MCU Solutions n.d.), because it had all the specifications that were required for the innovation, it was also available for use at the university. The functionality of an ultrasonic sensor was described as following an object detector using ultrasonic sensors. (Object detection using Ultrasonic sensors 2016.)

The ultrasonic sensor transmits sound waves and receives sound reflected from an object. When ultrasonic waves are incident on an object, diffused reflection of the energy takes place over a wide solid angle which might be as high as 180 degrees. Thus, a fraction of the incident energy is reflected back to the transducer in the form of echoes. If the object is very close to the sensor, the sound waves returns quickly, but if the object is far away from the sensor, the sound waves

takes longer to return. But if the object is too far away from the sensor, the signal takes so long to come back (or is very weak when it comes back) that the receiver cannot detect it (Figure 3).

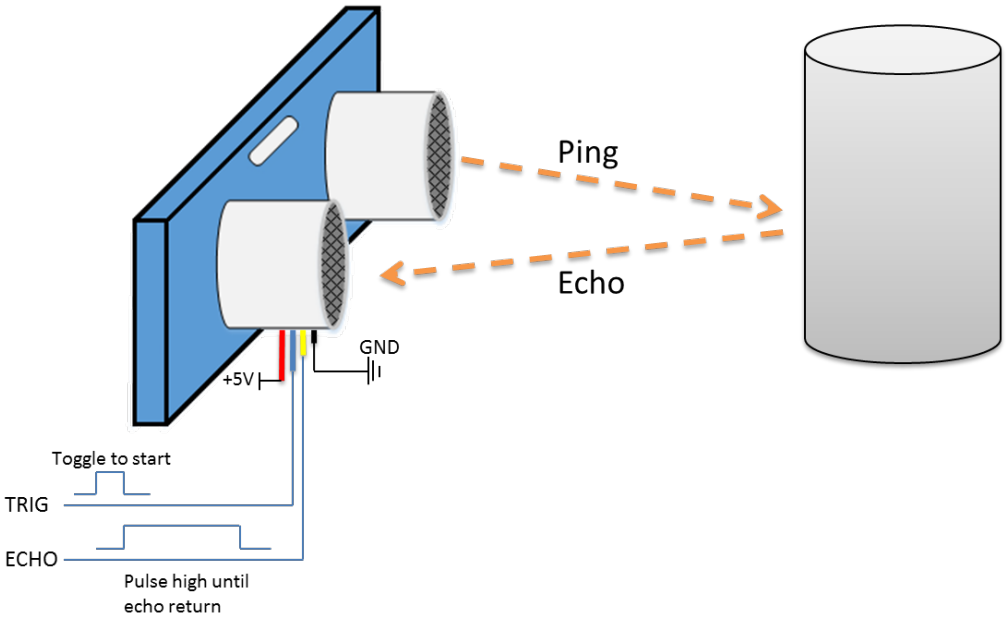

Figure 3. Functionality of a HC-SR04 sensor.

When the ultrasound sensor is activated, the Arduino UNO loads a sound file from the attached SD card adapter. The SD card adapter uses SPI (Serial Peripheral Interface) as a way of communication. SPI is a synchronous serial communication standard mainly used in embedded systems. It is the most prevalent short-range communication technology used in embedded systems. The sound is transmitted to the speaker and played to the client. The speaker is a regular generic speaker.

Before the innovation idea was refined, the original idea was to make a GPS tracking system for home care clients who suffer from memory disorder. The GPS tracker would keep track them when they leave the house. The GPS tracker would be in the form of a bracelet that the client would always wear. The bracelet would have a button that the client could press when they need help from the nursing staff. When the button is pressed, an emergency signal would be transmitted to the home care staff who could then assist the patient with whatever they need.

The signal would be delivered to the nurse's phone which has an app on it that would show their current position and contact details for clients and their family. The GPS tracker would help the home care staff find clients if they go missing. The bracelet could also possibly have a phone functionality built in so that communication was possible. This innovation idea was dropped, because

the technical implementation was more difficult than first realized. The final product was originally thought to be a smart watch, developing a smart watch would have required better resources. It was also discovered that this exact same product had been developed and sold years earlier, so we decided to drop the innovation idea (Figure 4).

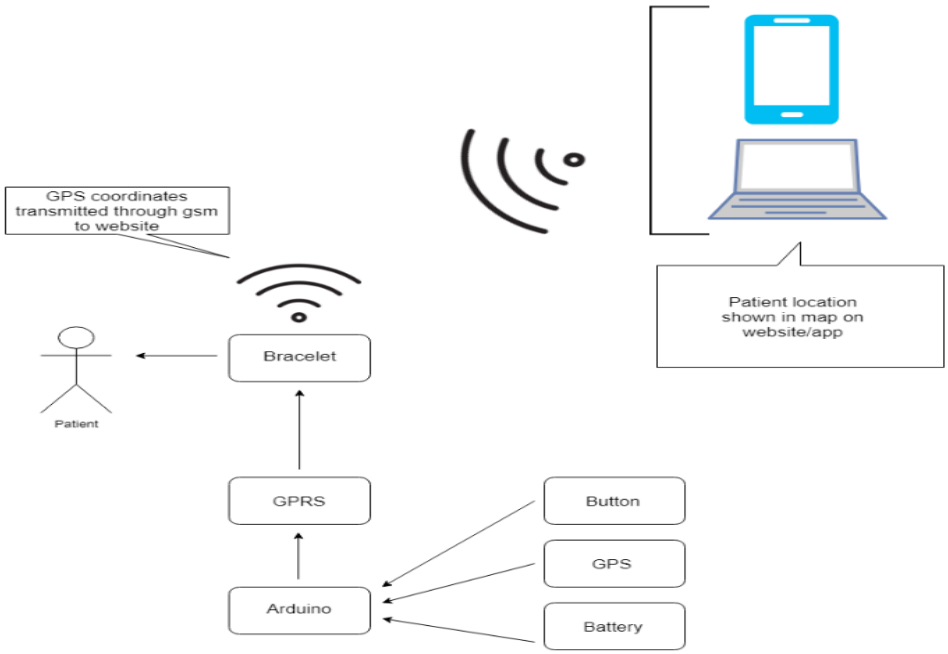

Figure 4. Smart Reminder user case diagram.

The innovation idea that was developed was ultimately a success. The idea of a GPS-bracelet never made it to an actual prototype, but the idea itself was a fairly good one. Smart Reminder was made into a prototype in time for the presentation. It worked well enough for a prototype but had a very rough design.

The device is designed to fit inside a case. The measurement scale is set to be in millimeters (mm.) The device and its components were designed with the Autodesk Inventor 2019 software. Autodesk Inventor is a computer-aided design tool for designing, visualizing and simulating mechanical 3D components (Figure 5 and 6).

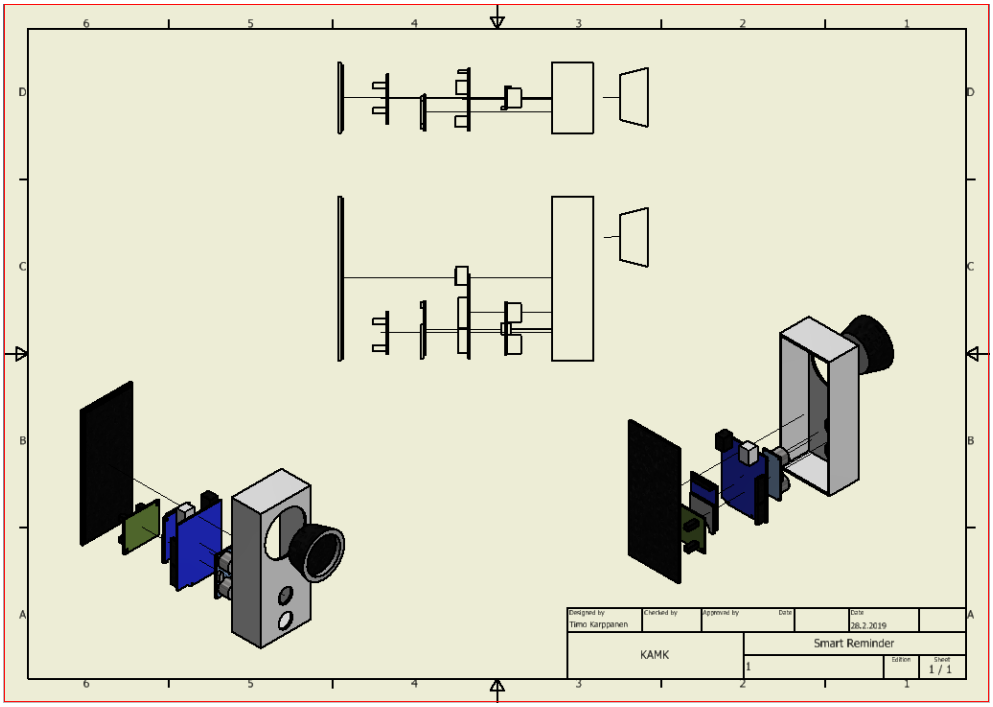

Figure 5. Smart Reminder user case diagram.

A measurement tool was used to measure the accurate dimensions of the components. This helped to visualize how the components would fit inside the case. The process of designing the case for the Smart Reminder was not difficult, because it is ultimately a box with some holes in it.

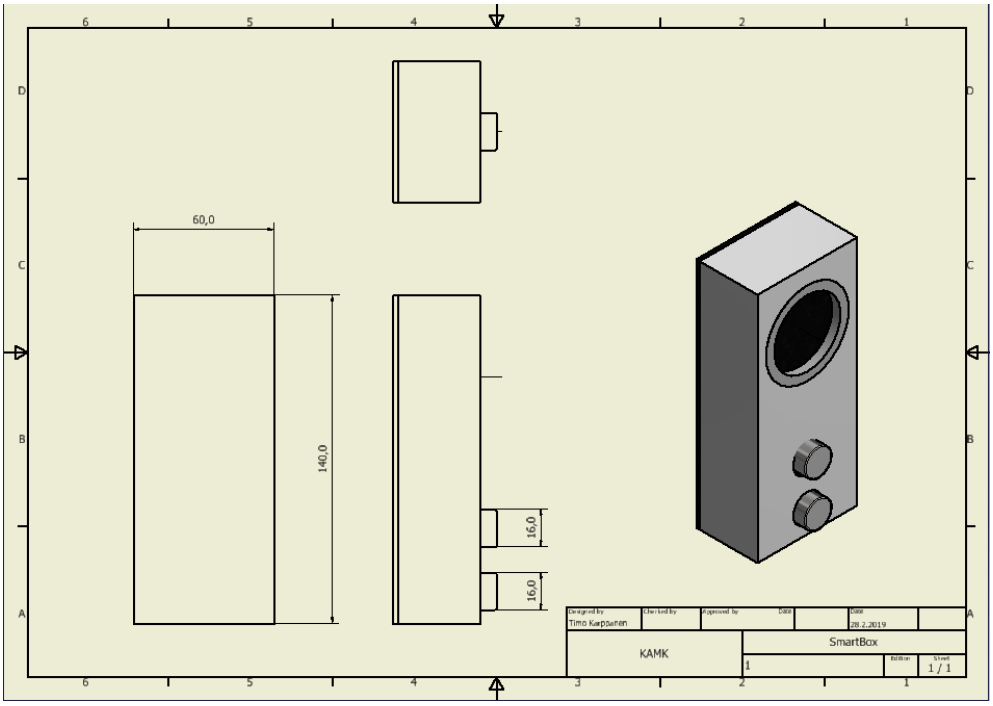

Figure 6. Smart Reminder user case diagram.

3.5 Conclusion

The aim of this article was to describe how we can respond to problems related to the home care services offered to clients with memory disorders and allocation of human resources. Technology is already part of older people's everyday life, and it is assumed that its importance will only be strengthened in future. Technology aims not only to steer employees' work and allocate immediate working time to home care clients but also to improve the opportunities for older people to live in their own homes. (Immonen & Koivuniemi 2017; Hammar 2018, 5.) According to Viirkorpi (2015, 45, 49) technology supports the services most frequently used by older people living in their own homes. It can also be used to provide remote care safely for older people, monitor their activities, strengthen their functional capacity and replace home visits, saving time and costs.

The purpose of the Smart Reminder innovation was to respond to problems that appears in home care because the resources allocated to home care employees are tight, the population is ageing and number of clients with memory disorders is increasing. The development of this innovation was designed to address the problems home care services are facing: the allocation of human resources and appropriate resources to the right places. This innovation makes it easier for older people with memory disorders to live in their own homes as long as possible. Being able to live longer in their own homes can also promote their functional capacity and psychological wellbeing. (Paljärvi 2012; Launiainen 2016; Laatusuositus hyvän ikääntymisen turvaamiseksi ja palvelujen parantamiseksi 2017–2019 2017). Smart building technology can also be used to support older people living in their own homes.

Technology also provides opportunities to communicate with older people and their relatives as well as with those providing home care and/ or services. Technological applications can be used to prolong the time older people can live in their own homes. A wide range of wristbands, special carpets and other products and applications are available. (Digitaalinen Suomi – Yhdenvertainen kaikille 2019.)

Smart Reminder can help home care clients who suffer from memory disorders, but it may be possible that it causes some confusion first. Therefore, Smart Reminder must be introduced to the client early enough.

The goals of this project have been reached. The project team created a working device within the given time frame. The research on GPS bracelets showed that it had already been invented.

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4 Health 4 Baby – a smart solution for listening to fetal heart sounds

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Abstract

Digitalization is an important part of modern social and healthcare services. It enables client-oriented approaches and equal services to everyone regardless of where they live. Health care clients ask for more versatile services and we must respond to their needs but at the same time keep cost efficiency in mind. This article introduces an innovation called “Health 4 baby”. The idea for the device was proposed by the working life. It is an innovation for listening to fetal heart sounds in two different ways by using mobile phone and a Bluetooth stethoscope with remote connection. In Finland it is important to have an innovation like this, because some pregnant women live far away from the nearest maternity hospital. The Health 4 Baby innovation improves consultation practices and reduces unnecessary referrals to hospital, at the same time lowering public health care costs. The basis of Health 4 Baby is a mobile application for Android platforms. The most important function is data processing between a stethoscope, heart rate sensor, database and hospital. This technology is easily accessible because almost everybody a has smartphone these days. A smartphone is all that the client needs so the technology needed is at hand already. The Bluetooth stethoscope is provided by public health care and is not a significant cost for society. The article is based on selected literature. First the theoretical background and methods are discussed. Further the article focuses on the use and technical aspects of the innovation which include the application and stethoscope, legislation on medical devices and data security. The aim of the article is to give tools for public health nurses and facilitate their work through digitalization. This innovation also makes public health care services more easily accessible for clients living in remote areas far away from the nearest hospital and offers more flexibility in treatment processes.

Keywords: pregnancy, fetus, long distances, risk pregnancy, fetal heart sounds, measurement, Android Studio, Bluetooth transmission, database, electronic stethoscope, Java, prototype, SSH

4.1 Introduction

Finland is internationally one of the top countries in healthcare digitalization. The Finnish Ministry of Social Affairs and Health has outlined that people are the most important part in the digitalization of health care. Digitalization opens better access to information so that people can make better choices and get better services. It enables client-oriented approaches and equal services to everyone regardless of where they live. Digitalization changes the world in fast cycles by creating completely new options for old and familiar functions. (Digitalisaatio n.d; Jaettu ymmärrys työn murroksesta 2017, 20–31.) It changes the ways and content of our work in more and more quickly as we go ahead. Also, clients demand more from public services and the use of public money needs to be justified well. For younger generations digitalization is a default value, not just an extension to current services. (Owen 2015, 2556; Digitalisaatio terveyden ja hyvinvoinnin tukena 2016, 4.)

The most significant benefits of digitalization in the social and health care sector are increased service homogeneity and cost-efficiency. In addition, digitalization enables availability and accessibility of services. On the other hand, there is a risk for a new form of inequality, if digitalization is driven too aggressively. The most significant factors affecting the growth of digital services are positive attitudes towards the change as well as the increase in mobile and sensor technologies. The biggest factor in the propagation of digital solutions is change resistance among citizens and professionals. (Pohjola 2016, 50.)

In health care, it is important to have a personal contact with clients. Therefore, not all clinical services can be implemented via the Internet. Digitalization can be used to develop services, such as online forums and services, that specifically support nursing. eHealth services that need to be developed should be carefully considered and adequate. Digitalization tools provide opportunities for the development of counselling work where health communication and health information are essential. (Hakulinen-Viitanen, Vallimies-Patomäki & Pelkonen 2013, 31.)

The Health 4 Baby innovation is a tool for developing health care services. With Health 4 Baby public health nurses can monitor fetal heart sounds remotely. Listening to fetal heart sounds is an important part of monitoring the development of the fetus during pregnancy. Fetal heart sounds have been monitored by listening since the 16th century. At first fetal heart sounds were listened by putting an ear on the mother’s abdomen. Since then various devices have been developed to make fetal heart sounds easier to register. Normal fetal heart sounds mean that the

fetus gets enough oxygen from the mother's bloodstream through the umbilical cord and placenta. Abnormal heart sounds may be a signal that the fetus gets too little oxygen in the blood and tissues. Lack of oxygen can cause damage to the brain, central nervous system or other internal organs. In severe cases lack of oxygen can cause the death of the fetus. Therefore, it is important to listen to fetal heart sounds. (Väyrynen 2009, 196.)

Fetal heart sounds are listened both in the maternity clinic and maternity wards. In the maternity clinic heart sounds are listened with a Doppler ultrasound from the 10th week of pregnancy. The normal range of fetal heart rate variation is 110-160 beats per minute and heart rate acceleration can be heard, for example, when the fetus is moving. Listening to fetal heart sounds is challenging if there are problems in fetal health and there is not a doctor in the maternity clinic (Blincoe 2005, 109). In this case the public health nurse must refer the mother to the hospital for further examinations. Cardiotocography (CTG) is performed in the hospital to determine the health of the fetus. (Klemetti & Hakulinen-Viitanen 2013, 16.) CTG registers fetal heart sounds and uterine contractions. In the interpretation of the CTG attention must be paid to the baseline and variation of the heart rate. CTG is used only in hospitals to monitor fetal health. (Sarvilinna, Isaksson, Kokljuschkin, Timonen & Halmesmäki 2016, 1336.)

The idea for the Health 4 Baby innovation was presented by the working life. In maternity clinics public health nurses work independently without the support of a doctor. The nurse is alone responsible for diverse and sometimes difficult situations. If necessary, the nurse can consult a doctor by telephone but usually in unclear situations the nurse must refer the mother to the hospital for examinations, because the doctor wants to hear the fetal heart sounds personally. This is particularly difficult in municipalities with long distances to the nearest hospital. Health 4 Baby improves consultation and reduces unnecessary referrals to hospital. In some cases, especially in risk pregnancies, the application can be given to the pregnant woman to be used at home from where she could send the fetal cardiac curve to either a nurse or a doctor. We think that this application for listening to and transmitting heart sounds is really a useful device for clinical work. The purpose of this innovation was to give tools for public health nurses and facilitate their work through digitalization. This innovation also makes public health care services more easily accessible for clients living in remote areas far away from the nearest hospital and offers more flexibility in treatment processes.

4.2 Why is the Innovation Needed?

In Finland the challenges for provision of health care services are the low population density, long distances and quality of care. Postponing parenthood, i.e. having the first child later in life, is the biggest single factor behind the declining birth rates in Finland as well as in Europe. In Finland, the number of those who have their first child at the age of 25 is clearly higher than on average in the EU. (Fertility statistics 2017.) The population density in Finland is about 15.6 inhabitants per square kilometer; in the northern regions there are only 2 inhabitants per square kilometer. The number of hospital beds is 22,755, which corresponds to about 44 beds per 10,000 inhabitants. In Germany, there are 49,887 hospital beds, which corresponds to 81 beds per 10,000 inhabitants. The greatest challenge is the distance to the nearest maternity hospital which can be as long as 460 kilometers in Finland. (Äidit tilastoissa 2018.)

According to the Finnish health policy, only maternity hospitals with a birth rate of at least 1,000 births per year are allowed to operate or will be operating with a special permission. In total, there are currently 24 maternity hospitals in Finland (Ennakkotieto: Syntyneiden lasten määrä vähenee edelleen – myös synnytyssairaaloiden määrä laskussa 2018). In 2016, the number of out-of-hospital deliveries was 92 (Äidit tilastoissa 2018.) Health 4 Baby can ensure an early diagnosis of a starting delivery and thus prevent delivering a baby out of a hospital. About 5% of all newborns need respiratory assistance and 0.1% pressure relief or adrenaline medication or both (Nieminen 2015, 10).

In Finland there are on average 170 miscarriages after the 22nd week of pregnancy every year. In 90% of the cases the diagnosis is fetal death. Predictable risk factors include diabetes mellitus, maternal age and weight. Environmental factors such as smoking increase the risk of death. Midwives or nurses refer mothers to hospital if there are changes in the condition of the fetus. (Äidit tilastoissa 2018.) The Health 4 Baby innovation is primarily aimed at these high-risk pregnancies. The findings of a study by Lamminpää (2015, abstract) showed that advanced maternal age (AMA) women had increased risks related to pregnancy and birth compared to younger women aged 35 years or younger. AMA as such was not as big a risk as other risk factors (smoking, overweight and obesity and GDM) in the group of AMA women, but the risks were significantly increased. “The present study demonstrated that these four groups of AMA women are distinct high-risk groups who should be identified early in maternity care clinics as being “at risk” when the potential complications could be detected early and the harm for both the mother and the fetus could be prevented and reduced.” Pursuant to section 15 of the Health Care Act, the municipality must

provide counseling services for pregnant women, pregnant women and children under school age and their families in their area (Terveydenhuoltolaki 1326/2010). The Health 4 Baby innovation makes it possible to diagnose changes in the condition of the fetus early and ensures an early diagnosis of a starting delivery and thus prevents out-of-hospital deliveries.

4.3 Methods

The Health 4 Baby innovation project was started in autumn 2018, and the goal was to create a service that could make the treatment of pregnant women more fluent by using digitalized services. The project was part of a course called Smart Solutions for Wellbeing Development and Management organized by Kajaani University of Applied Sciences together with Neu-Ulm University of Applied Sciences from Germany. The course included project work in multidisciplinary teams with students from both Finland and Germany. Finnish Master of Health Care students innovated ideas based on working life needs from health care. Some of these ideas were chosen for further development and innovations were developed further with Finnish ICT students and German Master of Health Management and Health Information Management students.

The original idea of our team was to create a device that public health nurses could use for listening to fetal heart sounds in the home environment by a public health nurse and sending the data with a mobile phone to a doctor for more accurate evaluation. It became soon evident that this type of device had already been invented so the original idea was discarded. Ideas such as adding different functions to this device and making its use more versatile were also discussed, but they would have been too expensive to put in practice or too complex to create within the given time frame. Finally, an idea of a device that patients could use independently under the remote supervision of a healthcare professional emerged. It was important that data would be transferred in real time and the quality of data transfers would be good enough for use in professional context. The data should also be recorded for further use e.g. in potential research. The benefits of creating this function is to lower health care costs by reducing unnecessary health care visits and to save the pregnant woman from travelling in and out of hospital instead of the issue being taken care of in her home environment.

4.4 How to Use the Innovation?

The Health 4 Baby innovation can be used in two different ways: in risk pregnancies the public health nurse listens to fetal heart sounds, but if the nearest hospital is far away, the pregnant woman or her family member can listen to the fetal heart sounds. Figure 1 illustrates the process model of Health 4 Baby.

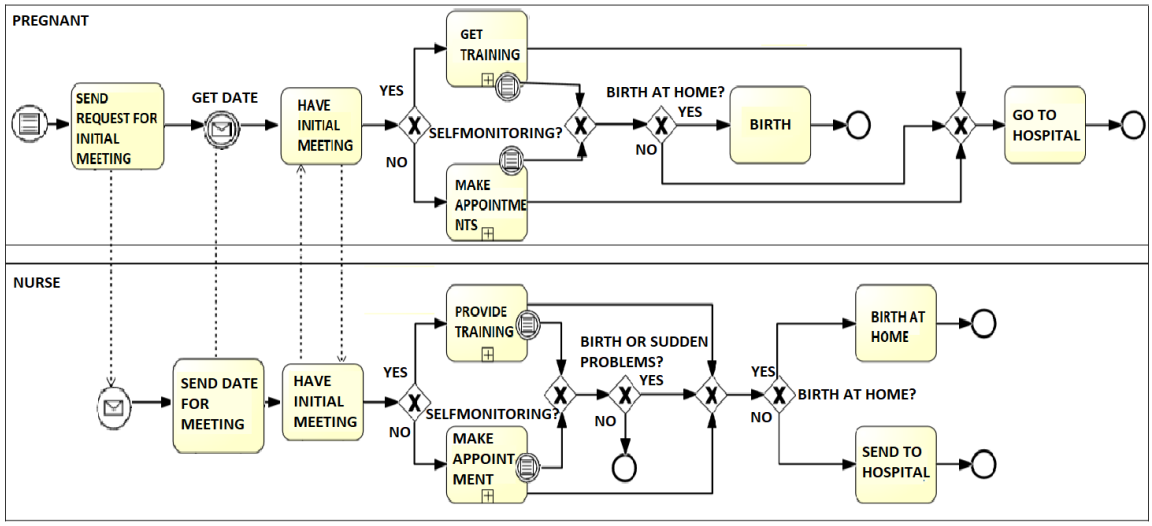

Figure 1. Process model of the “Health 4 Baby” application (Waibel & Schmeller 2018).

The first option illustrates the use of Health 4 Baby without the nurse. The mother makes an appointment with a public health nurse after she has found out she is pregnant. If the pregnancy is not diagnosed as a high-risk pregnancy or if the mother lives at a distance from the nearest nurse and hospital, a relative, friend or partner is invited to accompany the mother to the first appointment. At the appointment, the pregnant woman and accompanying person are trained in the use of the Health 4 Baby by the nurse. This allows telephone appointments to be made with the nurse. When used at home, a personalized code must first be entered into the application for the identification of the pregnant woman. Thereafter, the heart sounds are recorded with the device and sent to the application. These are then sent to the nurse who, upon receiving the results, will assess them. If the findings are inconspicuous, the examination is complete, and a new appointment is made. If the nurse detects changes in the heart sounds, the pregnant woman is referred to the nearest hospital. (Waibel & Schmeller 2018.)

The second option illustrates the use of Health 4 Baby with the help of the nurse. The mother makes an appointment request for a cardiotocography to the nurse who sends her an appropriate appointment. At the appointment, the midwife uses Health 4 Baby to record the heart sounds of

the fetus and assesses them. In case of abnormalities, the patient is referred to the doctor. The nurse submits the data to the doctor and the doctor performs further examinations. If the mother receives a conspicuous diagnosis from the doctor, the process ends with the patient staying in the hospital for further examinations. (Waibel & Schmeller 2018.)

4.5 Technical Specifications

Medical devices must meet restrictive regulations and standards for market access in Finland and the European Union. One of the main purposes in medical device standardization is to ensure that such devices are safe to use and cause no harm to the patient or the person using them. Therefore, one part of the technical design is understanding which standards must be followed in the implementation.

Medical devices and their most essential requirements are defined in the Finnish Medical Devices Act 2010/ 629. The act divides medical devices into four categories depending on their type of usage. Depending on which category each medical device is subject to, they need to follow specific directives and standards. (Laki terveydenhuollon laitteista ja tarvikkeista 2010/ 629.) Regarding to the innovation, the most important standards are related to software application. These standards include standardization for the software life cycle, maintenance of the application, data security and risk management.

The international standard for medical device software and software life cycle processes, IEC 62304 (n.d.), defines requirements for medical software. Especially it sets demands for the software designer to establish software quality documentation and system testing. IEC 62304 includes three safety classifications which are class A, class B and class C. The classification is determined depending on how potentially harmful the system could be for the patient. Due to the reason that the Health 4 Baby innovation was developed for listening to fetal heart sounds, it is convenient to follow the strictest classification which is the class C. The innovation itself does not cause explicit danger to the user or the patient but if the system must be competent for authoritative usage, it is recommendable to follow the strictest standard.

The prototype itself does not meet all the class C requirements in the development stage but the innovation is productized, the requirements must be fully met (Medical device software – Software life cycle process, IEC 62304 n.d.).

The core of the innovation is a mobile application for Android platforms. The most important function of the application is processing data between stethoscope, heart rate sensor, database and hospital as illustrated by Figure 2.

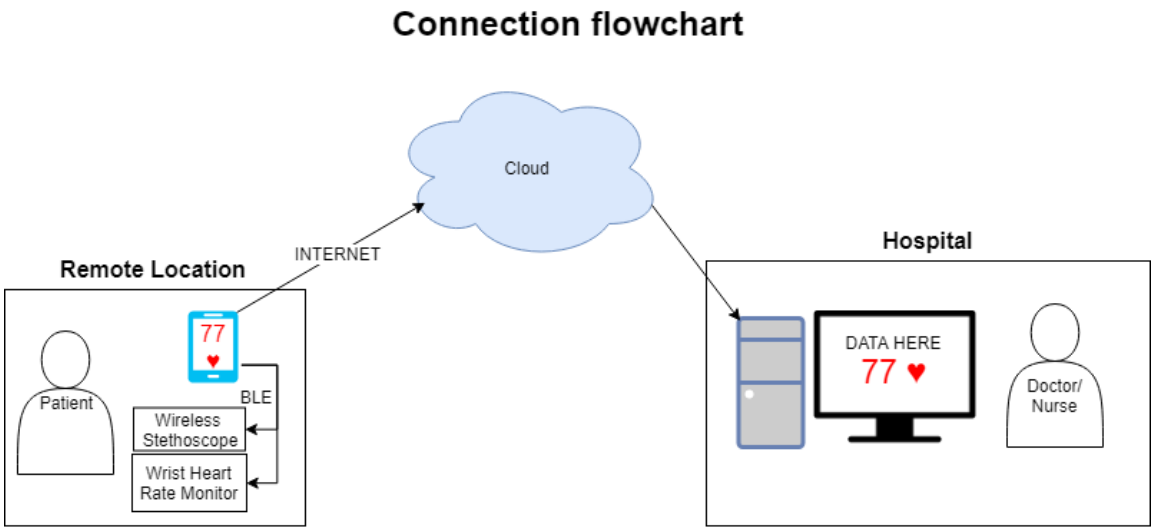

Figure 2. Connection flowchart.

The mobile application, used by the patient, receives wireless data from the stethoscope and the heart rate sensor. It is important to realize that when listening to fetal heart sounds with a stethoscope, there is a risk that the mother's heart rate is recorded instead of the fetal heart sounds. Due to this reason it is important to distinguish the mother's heart rate from the fetal heart sounds to eliminate any errors in the diagnosis. One of the key features in the Health 4 Baby innovation is that the mother's heart rate is measured from the wrist at the same time as fetal heart sounds are listened to. By comparing the wrist heart rate and the recorded fetal heart sounds, it is possible to deduce whether the recorded hearts sounds belong to the fetus or the mother.

The Health 4 Baby prototype uses the Littmann3200 stethoscope which has a feature to record listened sounds and a possibility to send the sound data via a Bluetooth connection. It has also a CE marking which makes it fully competent for medical applications (CE-merkinnän käyttö terveydenhuollon laitteessa ja tarvikkeessa 2011). The disadvantages of using the Littmann3200 stethoscope are its high price and the short length of recordings which are limited to 12 seconds. It would be cost-effective to replace the current stethoscope with one which is customized for the innovation if the innovation is launched commercially. Additionally, the customized stethoscope could have a longer recording length. (Electronic Stethoscope n.d.)

In the prototype, the mother's heart rate is measured with the Polar H10 heart rate sensor. It is capable of transmitting heart rate data wirelessly to the application in real time. The application itself uses an algorithm to compare the data it receives both from the stethoscope and the heart rate sensor. Based on the algorithm the application delineates if the heart sounds belong to the mother or the fetus. In case the mother's heart sounds are recorded, the application informs about it and requires a new listening with the stethoscope. The algorithm is based on the synchronization of the output data from the measuring devices.

Once the application has verified that the recorded heart sounds belong to the fetus, it sends the recording via the SSH protocol to a remote server as illustrated in Figure 3.

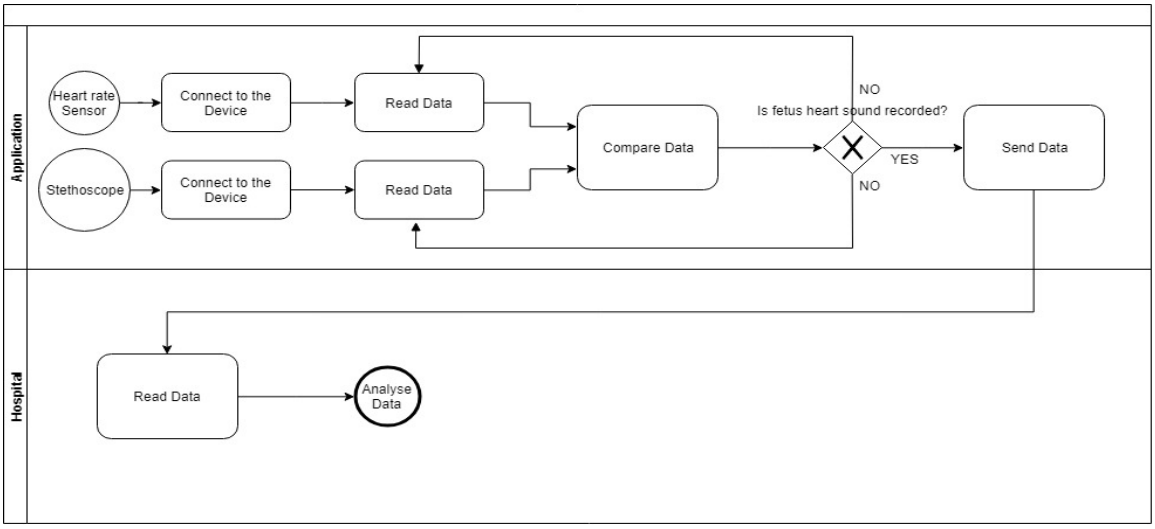

Figure 3. Health 4 Baby software flowchart.

Data security is not compromised in the connection between the stethoscope, heart rate sensor and mobile application, because the connection is local and uses Bluetooth low energy (BLE) technology. Furthermore, the local connection does not include any personal information. Security-wise this means that no encryption is needed for the Bluetooth connection. When the mobile application sends the recorded data to the remote server, it must be hash-checked to make sure that the information will stay immutable. The sent information from the application to the server includes a key code that is associated to patient details. The key code will be given by health care professionals and entered in the application login screen by the patient. In the server side the key code is connected to the patient information. This procedure makes it possible that no critical patient information is transferred between the application and remote server. The prototype version uses the Secure Shell (SSH) between the application and server, but for the commercial version of the innovation, hashing (SHA-2) could also be added in the data transfer to ensure data

integrity. The test server of the prototype does not have an encryption and it is only password-secured. Once the heart sound recording has successfully been transferred to the server, it can be examined by health care professionals. The server side itself is not very relevant for the innovation, because hospitals and health care organizations have already secured and individual systems. Health 4 Baby aims to be adaptive so it can be integrated to any existing digital health care system.

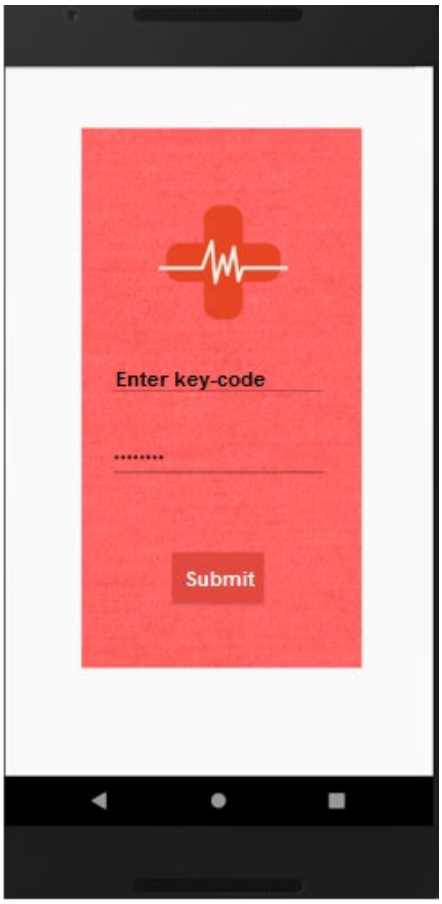

Figure 4. Key code identification.

The Health 4 Baby application is created with the Android Studio environment and Java programming language. The key features of the application are the patient key code submit screen for identification (Figure 4.), comparison algorithm and data transmission to the server.

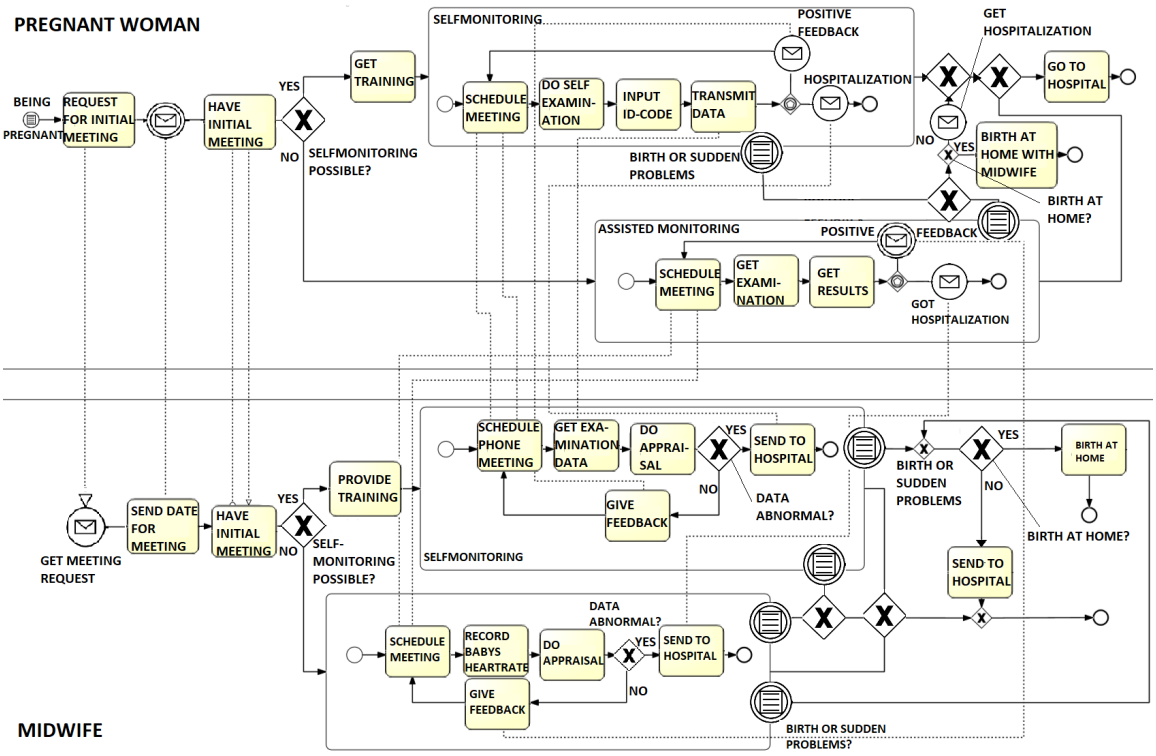

Figure 5. Entire process of the Health 4 Baby application.

The intent is also to collect the heart sound data nationally so it can be used for scientific purposes. Figure presents the entire process of the Health 4 Baby application.

4.6 Conclusion

While the first maternity clinics in Finland were established in the 1930s, legislation considering maternity and child health clinics enabled the establishment of antenatal care throughout the whole country in 1944. Maternity care services constitute antenatal clinics, which offer screening and care during pregnancy, and hospitals, in which possible complications are treated and children are born. Maternity clinics perform screenings of pregnant women which aim to identify possible complications in a timely manner. (Lamminpää 2015, 21.)

The aim of maternity clinics is to ensure the health and wellbeing of pregnant women and fetuses. The purpose is to promote the health and wellbeing of future parents and the whole family. The aim is also to promote public health and prevent pregnancy disorders. The maternity clinic recognizes problems and disorders in early pregnancy and provides the necessary care, assistance

and support without delay. Maternity clinics contribute to reducing health inequalities and preventing exclusion through early targeted support. (Klemetti & Hakulinen-Viitanen 2013, 17.)

It is clear that all social and health services and practices will be reformed and that the role of digital services will also increase in the work of clinics. The digitalization of services offers a wide range of opportunities for developing nursing care. However, digital services cannot substitute well-conducted regular medical examinations that monitor and support health and wellbeing through direct contact with clients and their families. However, digitalization can improve and streamline the services.

The purpose of this innovation was to give tools for public health nurses and facilitate their work through digitalization. This innovation would also make public health care services more easily accessible for clients living in remote areas far away from the nearest hospital and offer more flexibility in treatment processes. The objectives were to save both health care professionals and clients' time to other important matters and reduce the costs that traditional working methods cause for the system and the client. This type of change in the services can improve the quality of care and care can be more client-oriented.

Digitalization is a way to develop services that specifically support nursing. In this case this remotely used innovation was all that the project team had planned for and the technique met the purpose originally set. The eHealth services that are developed should be carefully considered so that the benefits can actually be achieved. This innovation project reached these goals. Digital tools provide opportunities for clients and health care professionals. Nowadays when healthcare costs are too high and need to be cut down, innovations saving time and money are highly valuable for society. Health communication and health information are central in the development of counselling work. (Hakulinen-Viitanen, Vallimies-Patomäki & Pelkonen 2013, 31.)

The Health 4 Baby application provides new technology for patient and professional use. The application is easy to download and simple to use. Almost all clients already have smart phones or tablets which they can use for this innovation, so the utilization does not need any investments from them. The biggest investments for the health care system are Bluetooth stethoscopes and costs of maintaining the application. The Finnish Ministry of Social Affairs and Health has outlined that citizens use electronic services and produce information for the use of professionals. Also, quality facts should be nationwide available for comparison. (Digitalisaatio terveyden ja hyvinvoinnin tukena 2016, 18.) With this application we can support this progress nationwide.

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5 Military Healthcare Application (MHA)

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Abstract

Military Healthcare Application (MHA) is a smart, easy-to-use and affordable innovation for self-assessment of the need for treatment in different operating environments. This application can be downloaded onto a smartphone or tablet. The purpose of this article is to describe, through the MHA innovation, how nursing care is implemented based on triage rating. This innovation was developed to be a practical tool that would facilitate nurses' work in garrison hospitals. The purpose of the application is to reduce the rush in the morning reception and direct those who need care first to the right place at the right time. Servicemen and women can assess their need for treatment themselves with the help of the application and find instructions for further treatment. This can reduce the waiting time for the servicemen and women, so they can make better use of their time. Assessment of treatment needs is linked to the entire treatment process. In addition, the quality of care is improved, as urgent cases are prioritized. The MHA innovation is a simple mobile application that allows you to self-assess your well-being and send this information to a nurse for assessment. The app will be downloaded from the App Store and every serviceman and woman will be provided with a separate login code for the app. This innovation was developed in an innovation workshop during the 2019 International Week at Kajaani University of Applied Sciences. The innovation team included Master of Health Care students, Bachelor of Health Management and Health Information Management student and Bachelor of Engineering (communication and information technology) students.

Keywords: smart solution for health care, assessment of need, self-assessment of treatment, application, innovation

5.1 Introduction

We live in a global, digital and connected world characterized by continuous and rapid social and technological change. Digitization adds advantage to organizations in terms of cost reduction, improves processes and increases productivity. Digital transformation can improve organizations' profitability and customer satisfaction. (Chandana & Ramu 2018, 121, 122, 127.) Mobile applications are predicted to improve the availability of future services and create completely new services. Information security, patient safety and reliability are keys to the generalizing of the wider use of mobile applications in health care. User-oriented design simplicity, easy accessibility, rich content and personalization of content to meet user needs are crucial. (Holopainen 2015, 1285.) Interactive services and social and mobile health services are a daily necessity, especially for young people, which must be taken into account in military health care (Lehesjoki 2018, 113, 114).

As one of the government's key projects, the OMAOLO digital service was developed to help assess the need for treatment in Finland in autumn 2018. OMAOLO gives recommendations on how to act in case of illness. The service contains questions that are related to symptoms and, based on answers, provides self-care instructions or suggests an appointment with a doctor. This service is available to all Finns. (Vainio 2019.) This innovation is practical but does not serve large groups of people who need treatment at the same time at the same place.

The X Brigade is one of the biggest garrisons in Finland with over 4000 servicemen and women every year completing their military service In Finland, there is an innovation that helps in assessing the need for treatment (X Brigade n.d). During a flu season, several hundred sick servicemen and women may seek medical help. With large volumes at the garrison hospital, it is natural that sometimes access to treatment takes longer.

Nowadays, in the X Brigade garrison hospital receives service men and women to the morning reception one company at a time and in need of urgent treatment they may have to wait until afternoon to receive the treatment they need. It has been reported that 30 to 40% of patients coming to the emergency room could well wait until the next day. The purpose of triage is to assess the urgency of patients' need for treatment. An experienced, trained nurse can assess how urgently treatment is needed, based on findings and patients' symptoms. (Seppänen 2013.) Shortening the time patients wait to see a doctor and receive appropriate treatment will not only improve morbidity and mortality, but also improve patient experience (Dippenaar 2019, 1403).

The purpose of this innovation process was to develop an application that would work specifically for large groups. By improving the current process, the procedure should be made easier for the health care staff and servicemen and women. The aim was to admit patients in such a way that urgent cases would receive timely access to treatment and shorten waiting times. For example, a patient with high fever would be admitted immediately to the garrison hospital.

The innovation was designed by a multidisciplinary and multicultural group. This article describes and explains the innovation and the possibilities for further development and introduces a smart, easy-to-use and affordable innovation for self-assessment of the need for treatment in different operating environments. The purpose of this article is to describe, through the Military Healthcare Application (MHA) innovation how nursing care is implemented based on triage rating.

5.2 Health Care during Military Service

National military service guarantees Finland's military security. Military service is used to defend Finland, as a non-military state, independently. In conflict and war, the land, sea and air forces guard and defend Finland with the means provided by national military service. Men aged 18 to 60 must serve their country, but women can also volunteer for military service. National military service is divided into military or civilian service. Military service lasts 165, 255 or 347 days and currently civilian service lasts 347 days. During this time, conscripts acquire skills that they can use to defend the country. After completing their service, they are transferred to the reserve. Reservists can be used for rehearsal exercises or defend their country if necessary. (Asevelvollisuus 2019.)

The Act on Arranging Health Care in the Defence Forces (Laki terveydenhuollon järjestämisestä puolustusvoimissa 322/1987 § 1) states that "the Defence Forces organize health care for persons under their health care responsibilities. Otherwise, the Defence Forces may also provide health care services as provided by this Act". The Defence Forces have health care personnel and necessary health care facilities. Health care services can also be purchased from an external provider. Medical care is given to authorized persons in the event of an illness, disability or fault occurring, confirmed or aggravated during the period of service, or in the case of an illness, disability or defect which has not prevented entering the service upon entry into service.

The Finnish Defence Forces provide patient care comparable to public health care services. The services have been very successful despite the occasional difficulties in recruiting doctors. As a

rule, access to treatment is provided within the time required by patients' state of health. (Eskola & Vainiokangas 2019, 3.) During military service, health care services are provided by garrison hospitals which are open on weekdays. Health services care are also available during military and artillery exercises. Injuries or illnesses requiring special medical care are treated in civilian hospitals. Only diseases that occur during military service are treated. (Terveydenhoito 2019.) During military service, the most common illnesses are upper respiratory tract infections, and exercise-related strain pains and illnesses as well as other symptoms (Varusmies 2017, 24). The MHA innovation helps to assess the urgency of treatment of these diseases.

5.3 Assessing the Need for Treatment

Assessing the need for treatment is a key part of patient care and also required by law. "A health care professional must evaluate the need for treatment no later than on the third working day after the patient contacted the health center. Unless the assessment can be made during the first contact." (Terveydenhuoltolaki 1326/2010, §51.) The responsible qualified physician or dentist or, according to his instructions, any other licensed health care professional may refer the patient to treatment either in the emergency unit, another health care unit or in any other appropriate manner. Referral must take into account the urgency rating to be followed in the emergency unit and an individual's need for treatment and risk assessment. (Holi 2017.) Nowadays nurses assess patients' need for treatment at the reception or over the telephone (Pellikka 2017, 1; Triage och flödesprocesser på akutmottagningen 2010). From the point of view of the functioning of the health care system as a whole, the assessment of the need for treatment is one of the most important things. It is not always a physical patient contact; phone, internet, email or video can also be used. (Syväoja & Äijälä 2009, 27.)

Assessment of the need for treatment refers to an assessment of a patient's health status, access to treatment and urgency of treatment by a health care professional. The assessment is performed by interviewing and observing in order to find out why the patient's health condition requires health care. Assessment of the need for treatment is linked to the entire treatment process. In assessing the need for treatment, the assessor should also know the legislation. The assessment of the need for treatment should determine which symptoms are serious and require immediate treatment and how urgent the need for treatment is. For the assessment to be accu-

rate, all treatment-relevant background information, such as medications, basic illnesses and current symptoms must be available. Thorough and meticulous communication as well as documentation of information contribute to successful assessment of the need for

treatment. (Syväoja & Äijälä 2009, 9–73; Triage och flödesprocesser på akutmottagningen 2010; Holi 2017.)

The Health Care Act (1326/2010, § 50) defines emergency care in the following way: “emergency treatment means immediate assessment and treatment required for sudden illness, injury, long-term illness, or disability that cannot be transferred without the aggravation of the disease or disability.” According to the government decree on urgent care and specialized emergency care, the patient is entitled to emergency treatment at any time of the day. The nursing staff has a duty to guide the patient to the right place of care. The patient must be taken to the emergency unit. (Valtioneuvoston asetus kiireellisen hoidon perusteista ja päivystyksen erikoisalakohtaisista edellytyksistä 583/2017.)

Urgency rating is part of the assessment of the need for emergency treatment. The term “triage” refers to the classification of patients according to how quickly they have to receive treatment. Triage is a tool that can be used to manage the first of those whose health requires immediate or urgent care. Triage is used when all patients cannot be treated at the same time. (Mackway-Jones, Marsden & Windle 2014, 1–5.) An accurate triage decision is necessary for patients to receive emergency treatment in the most appropriate time (Tam, Chung & Lou 2018, 6).

The aim of the Finnish ABCDE Triage is to provide immediate treatment for those in need of urgent care. It also distinguishes patients classified to an E group, i.e. patients not requiring urgent care. The ABCDE classification has five steps: A means initiation of treatment immediately, B initiation of treatment within 10 minutes, C initiation of treatment within one hour, and D initiation of treatment within two hours. E means that there is no need for emergency treatment and patients are sent to their primary health care centre. This classification is designed to be practical and easy to change and can be complemented with local instructions. The ABCDE classification is commonly used in primary health care but is also adaptable to other locations (Kantonen 2014, 23–31.) Triage was developed in France and refers to sorting, organizing, segregation and selection and was originally part of a multi-patient situation, for example in a major accident. In triage, it is essential that patients seeking treatment and treatment should be screened on medical grounds according to the urgency of treatment. The purpose of the patient is to receive timely treatment. (Syväoja & Äijälä 2009, 93–95.) Triage is essential for clinical risk management in all

departments when clinical load exceeds clinical availability (Mackway-Jones, Marsden & Windle 2014, 5) and the staff saves time (Hyppönen & Ilmarinen 2016, 5).

5.4 Methods

The SWOT analysis, developed in the 1960s, is one of the main methods used in strategy development (Künzli 2012). The aim of this analysis is to recognize the internal and external influences on product success and identify potential risks and threats. Strategies can be developed to counteract this from the beginning. (Virtanen 2007, 189.)

Figure 1 introduces the SWOT analysis of the MHA innovation. The analysis consists of the strengths and weaknesses (internal analysis) as well as opportunities and threats (external analysis). The strengths are those features of the product which offer an advantage compared to similar products. In contrast, the weaknesses are the characteristics of the product that are disadvantageous in competitive situations. Opportunities are those factors in the environment or market which can be advantageous for a company. In contrast threats are those factors in the environment or market which lead to a disadvantage or a risk in the company. (Fleig 2018.)

Strengths • Easy to use • Cheap • Available in Android • Easy to download	**Weaknesses** • Incorrect self-assessment • Incorrect urcency rating • Not compatible with patient information management systems
Opportunities • Better process • Better use of time • Usable in different environments	**Threats** • Better assesment by telephone • No added value • Data protection

Figure 1. SWOT analysis of MHA.

5.5 Business Process Modelling and Notation

To successfully build a business it is very important to map the business process beforehand. This can be modelled using the Business Process Modelling and Notation (BPMN), a graphical specification language. BPMN is a standard for process modelling and includes a wide range of different symbols and graphs to model business process diagrams. The later diagram is primarily designed for people involved in the business process, as the process for implementation is as precise as possible. In order to achieve the best possible result, enough detail and clarity must be provided regarding the sequence of business activities. The BPMN thus serves as a gap between the project and implementation. (Was ist Business Process Modeling Notation? 2019.)

Figure 2 shows the BPMN of the MHA. This process is divided into three pools: health station, application and serviceman. The pools represent the participants of the process (White 2004). The pool application is further divided into two lanes: evaluation and appointment transmission. A lane shows the activities for a specific area and defines who is responsible for which parts of the process. (Was ist Business Process Modeling Notation? 2019.)

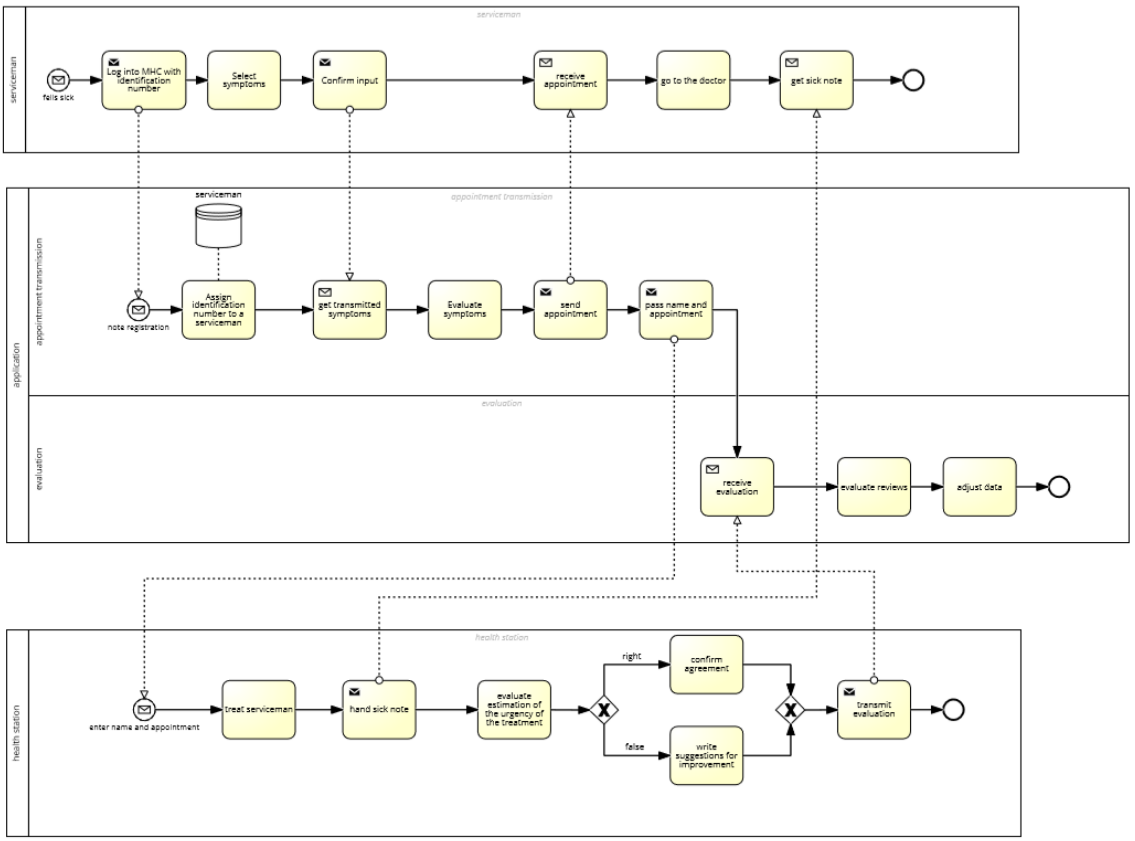

Figure 2. BPMN of the MHA.

Every serviceman gets an identification number which they use to login. The application gets a message and assigns the identification number to one serviceman. After the serviceman has logged in, he can select between certain symptoms, e.g. fever or dizziness. The serviceman confirms the symptoms and the application receives a message with the confirmation. After assessing the symptoms, the serviceman gets a message with an appointment. The health station gets a message as well with the name of the serviceman and the appointment. After treatment, the serviceman gets a sick note and the health station must evaluate the assessment of the urgency of his condition. The application gets the evaluation and can improve the assessment.

5.6 Software and Development

Android (Studio) is the world's most popular mobile operating system, powering billions of devices ranging from phones to watches, tablets, TVs, and more (Android Platform 2019). Seeing as Android is a fully open-source mobile operating system, it was decided to use this as a base for the MHA application. Furthermore, one of the Bachelor of Engineering students working on the software project had earlier experience in using Android Studio and developing applications.

Google's official IDE (Integrated Development Environment) Android Studio is designed specifically for Android development. To support application development within the Android operating system, Android Studio uses a Gradle-based build system, emulator, code templates, and GitHub integration. (What is Android Studio? 2018.)

About Java and XML, when developing apps for Android, the first and most popular option is Java. Java is the official language of Android development, which means that it's the one that has the most support from Google and the one that most apps on the Play Store are built with. Unfortunately, Java is also a little complicated and it's not a great "first programming language." This is what will provide the biggest entry barrier for most people who want to get started with Android development. (Sinicki 2017; PYPL 2019.)

When developing layout and UI (User Interface) elements for Android-based applications, Android Studio uses XML (Extensible Markup Language). XML itself is used to describe data and content, which makes it useful for developing any type of visual content, such as web pages, or, as in this case, Android app UI elements. It is used extensively in multiple programming languages. Furthermore, Android Studio includes a graphical interface for developing the UI for the app. The developer can use an XML-based text editor or a graphical interface, although most developers

prefer to use both, as the interface gives real-time information on the UI and eases the editing of the UI itself. (What is Android Studio? 2018.)

5.7 Software Life Cycle

At first, learning the basics of Android Studio and Java was time-consuming, which was alleviated slightly by the fact that one of the two people developing the app already had prior experience using the IDE. The first and foremost objective was to create a basic UI for the serviceman to input his symptoms using the MHA application. Although the original plan included a log-in system for the user, a database for the sent data itself and a tracking service, so the serviceman would only be able to use the application in the barracks, it was decided to designate these as secondary objectives for the time being.

The user interface was relatively simple to develop, as it is mostly comprised of visual UI elements mixed with transitional scripts. However, implementing the database and log-in system would have required more time and effort – and possibly more manpower – to develop. To use the log-in system, a simulated database would have to be created, as the software developers had no access to the database used by the Finnish Defence Forces. The database would require a secondary interface for a MySQL-based database for Android, and the log-in system would require a cloud-based storage service for the user information and passwords, while also encrypting the data safely.

The initial prototype was successful: the user could enter his symptoms, and the application would designate a time for the user to arrive at the health station. Furthermore, the nurse's version of the UI was developed, although the functionality was limited during this time.

5.8 User Interface

The six principles of interface design were followed in the UI (user interface) design of the application. According to the structure principle the UI should be created with the purpose in mind, in a meaningful way based on clear, consistent models which are apparent and recognizable for users, making similar things resemble one another. To follow the simplicity principle, the application design was made simple, tasks easy to complete, communication from the application to the

user as clear and simple as possible. Implementing the visibility principle requires that the user can view all needed options for a task without being distracted with redundant information. The feedback principle outlines that the user is informed of his/her actions and consequences of those actions, whereas the application design tells users about a change of state, condition or possible errors which are relevant them. To implement the tolerance principle the application design needs to be flexible, which allows the user to make mistakes and revoke and remake those choices. At the same time the design should prevent errors by tolerating varied inputs and sequences. The reuse principle tells us that the design for the application should reuse internal and external components and behaviours, maintaining consistency through the application. (Bieller 2018; Fireart 2019.)

The UI of the MHA application follows these principles and was made with simple and clear models which are easy to use and understand. The user has all the information he/she needs on the screen, the application gives feedback to the user about choices they make, and in most cases the user can revoke and remake those choices (Figure 2 and 3). Materials were reused in the application and the design choices were consistent.

Figure 2. Patients' user interface.

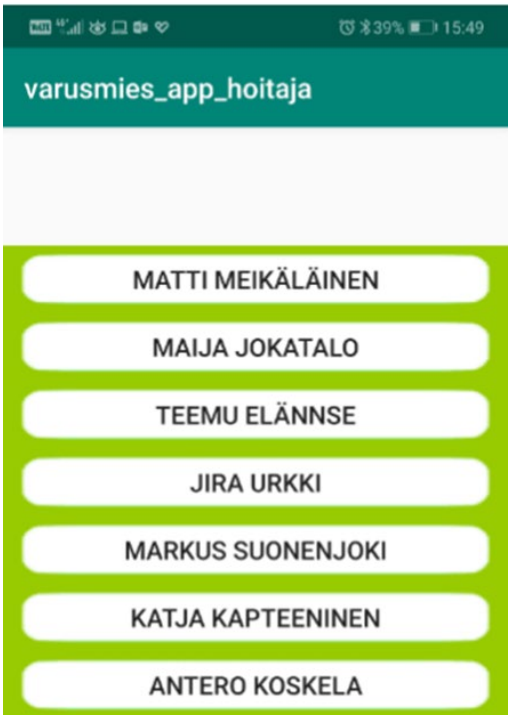

Figure 3. Nurses' user interface.

5.9 Software Testing and Future Development

Android Studio was designed so that an application can be tested while it is being developed. The developer can run an automated test which runs on JVM (Java Virtual Machine) or a test that runs on a device. Automated tests were not used for the MHA. The functions were tested while they were being developed. Android Studio gives the developer two options for testing: the developer can use an Android Studio emulator which is built into the application or use a USB connection to upload the software to the device and test it directly from the hardware device. Both ways are equally valid and help the developer to test the application while they are working on it. (Android Studio 2019.)

Currently the application is an UI for both the patient and the nurse with some elementary algorithmics for patient scheduling. In future, with more development input, both the nurse and the patient applications will communicate with each other through a database which sorts patient information and sends it to the nurse's version of the application.

In future if it would be possible to work with companies that develop software for health centres, the patient application could send patient information directly to the health centre's database,

used by nurses, which would document the information automatically. This would eliminate the need for a different application for nurses and speed up their documentation about incoming patients.

5.10 Conclusion

The team's own purpose was to create a practical tool for nurses and servicemen and women. The purpose of this article was to describe, through the Military Healthcare Application (MHA) innovation, how nursing is implemented based on triage rating. The MHA aims is to facilitate the self-assessment of health while reducing nurses' workload.

The MHA was originally developed for the Finnish Defence Forces, but it was not possible to introduce it there. The MHA would have made it possible to admit service men and women to the nurse's appointment after triage classification. Triage classifies the order of priority in which patients come into the nurse's appointment. An accurate triage decision is necessary for patients to receive emergency service in the most appropriate time (Tam, Chung & Lou 2018, 6). And by shortening the time patients wait to see a doctor and get appropriate treatment improves the patient experience (Dippenaar 2019, 1403).

Increasing digitalisation can positively impact an organization's profitability and customer satisfaction. Digitization benefits organization in terms of cost reduction, improves processes and increase productivity. (Chandana & Ramu 2018, 122, 127.) The MHA innovation could improve nurses' appointment processes and made them more client-oriented, which is good because Lindblad-Palo (2018) have noticed that the most of nurses 'working time is consumed in activities where the patient is not even present. However, the MHA innovation was not introduced in the Defence Forces.

Although we knew the limitations of this innovation, we decided to develop an easy-to-use application that is affordable and can be utilized in health and medical care services more widely. The application could be used, for example, in school and dental health services where clients could self-assess their need for treatment before contacting the services. The MHA supports Kantonen's (2014, 9) opinion that triage can be considered one useful method for also reducing the use of primary health care services. A significant number of emergency care patients could, based on their symptoms, be treated outside the emergency department thus smoothing the access to primary health care services.

Finland had a government-initiated project aimed at modernising social and health service models. An electronic service package, a self-service that leverages the knowledge of professional systems and wellbeing data stored by client themselves, is being built. (Vainio 2019.) Innovations are becoming increasingly available in health care. THE MHA innovation is one of these innovations, and it is inexpensive as well as easy to use. Digitalisation helps social and health professionals to use information systems that support work processes in future. The staff participate in the renewal of policies and acquisition of information systems. They are trained to use new systems and thus ensure a smoother management process that saves time and creates savings. (Hyppönen & Ilmarinen 2016, 5.)

But how would the MHA lessen nurses' workload? It saves their time. Nurses must assess the need for treatment immediately, which can take a lot of time when a patient is visiting the nurse's appointment. The MHA does not eliminate the need for this assessment, but it can help with the assessment.

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6 MONA - Mobile Nurse Assistant

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Abstract

Nursing care is documented continuously. It is important for efficient and smooth documentation that the model used is practical and a functional information management system is available. Documentation contributes to exchanging patient information between nursing staff and other professionals and helps in decision-making. Up-to-date documentation must be available where it is needed. Within the framework of the Smart Solutions for Wellbeing Service Development and Management interuniversity seminar, Finnish and German students of health economics, nursing and information technology worked on solutions for the health care sector. According to Finnish nurses, documentation after patient visits is an enormous effort for the nurses. Documentation takes also a lot of time. The aim of this innovation project was to solve this problem by developing an application for Android-based devices that would make it possible for nurses to do the documentation already during patient visits. The application, which was named the Mobile Nurse Assistant (MONA) by the project group, supports the speech-to-text function. MONA is based on the National Early Warning Score (NEWS) tool. The speech-to-text function simplifies the inclusion of patient-specific data in patient files using a cloud function. In addition, an innovative wristband is used for patient identification. Using an RFID tag, MONA identifies the patient and the nurse can start her round immediately. This innovation offers the added value for hospitals as processes can be streamlined. The challenge of using a smartphone application in a hospital environment is data privacy and strict data privacy requirements. Hospital networks are well-protected, internal systems. Patient information is kept safe and accessible only to those who are entitled to access it. An important factor in careful processing of personal data is access control, user authentication, data encryption and virus protection. The aim of this article is to describe how this innovation – MONA – increases health care professionals' wellbeing at work by changing the content of indirect patient care.

Keywords: application, MONA, RFID-tag, speech-to-text function, cloud function

6.1 Introduction and Background

The Early Warning Score (EWS) were developed in the UK to improve recognition and response to patient deterioration in acute hospital settings. The National Early Warning Score (NEWS) was developed in 2012 by the UK Royal College of Physicians to standardize the EWS across the NHS (Table 1). (Scott, Redmond, Garret, Whiting, Northstone & Pullyblank 2019, 287; National Early Warning Score (NEWS) 2012.) In March 2018, the Finnish Nurses Association published the NEWS manual in Finnish. Using the same NEWS tool nationally, we can ensure that patients' vital signs are assessed using the same criteria in every health care unit in Finland. (NEWS -Aikaisen varoituksen pisteytysjärjestelmä 2018.)

The six physiological parameters that the NEWS measures are respiratory rate, oxygen saturation, temperature, systolic blood pressure, heart rate and level of consciousness. Measurements are scored from 0-3 and added together to give overall scores between 0 to 20. If the patient has supplemental oxygen, two additional points are added to the scores. Lower measurements get higher scores. (Scott etc. 2019, 287; National Early Warning Score (NEWS) 2012.)

PHYSIOLOGICAL PARAMETERS	3	2	1	0	1	2	3
Respiration Rate	≤8		9 - 11	12 - 20		21 - 24	≥25
Oxygen Saturations	≤91	92 - 93	94 - 95	≥96			
Any Supplemental Oxygen		Yes		No			
Temperature	≤35.0		35.1 - 36.0	36.1 - 38.0	38.1 - 39.0	≥39.1	
Systolic BP	≤90	91 - 100	101 - 110	111 - 219			≥220
Heart Rate	≤40		41 - 50	51 - 90	91 - 110	111 - 130	≥131
Level of Consciousness				A			V, P, or U

Table 1. NEWS – National Early Warning Score (National Early Warning Score (NEWS) 2012, 14).

Table 2 describes for clinical risks that come from overall NWES scores. In secondary care, escalation triggers are scores of 3, 5 and 7, with three triggering hourly observations if there is weighting of three points within a single parameter, five triggering hourly observations (regardless of weighting) and seven triggering a critical care referral. In the current system these levels of care can only be delivered in hospital (Scott etc. 2019, 287).

NEW scores	Clinical risk
0	Low
Aggregate 1–4	
RED score* (Individual parameter scoring 3)	Medium
Aggregate 5–6	
Aggregate 7 or more	High

Table 2. NEWS thresholds and triggers (National Early Warning Score (NEWS) 2012, 15).

Documentation is an important part of the Finnish health care system. The purpose of patient documentation is to provide information for care planning as well as implementation and continuity of patient care. Documentation is also a matter of patient safety. Health care professionals are required to document only necessary and purposeful information into the patient information system. (Nykänen & Junttila 2012, 3, 15; L 1050/2018.) Public health care organizations have a legal duty to be part of the national patient information system and patients' personal health information must always be available without risking the safety of the patients. (L 159/2017.) Patient documents that are made personally plays a significant role in patients' right to information and legal protection as well as in the legal protection of healthcare professionals. (Nykänen & Junttila 2012, 3, 15.)

Health care professionals' working time can be divided to indirect and direct patient care and external operations. Direct patient care includes basic care and all nursing activities – whether physical, psychic, social and spiritual – that are done with the patient. Indirect care includes, for example, planning treatments, reviewing examination results and patient documentation. (Hiltunen 2016.) Nurses use less than half of their working time for direct patient care. Indirect pa-

tient care including documentation takes approximately one-fifth of the working time. All professional groups also use a lot of working time for non-clinical tasks. (Lavander 2017, 5.) Direct patient care is estimated to take less than three days of a five-day week among nursing professional. With the help of available robotics, time spent on direct patient care could be increased to almost four working days a week. Instead of reducing the number of staff, technology changes the content of nursing professionals' work, tasks, and time spent on tasks. At best, nurses' working hours can be allocated in a new way, with better patient outcomes, increased effectiveness of work and enhanced economic performance. (Kangasniemi & Andersson n.d. 36, 38.)

Research on nurses' experiences of patient information systems show that nurses who gave the highest ratings to the patient information systems they were using reported less on ICT-related burdens. These nurses experienced less hurry and patient overload than nurses who gave the lowest ratings to the patient information systems they were using. Work autonomy, which protects wellbeing at work, was perceived higher among nurses who gave the best grades to the patient information system they were using, compared to nurses who gave their system the weakest grades. In the documentation of patient information it should be noted that treatment decisions must be accessible at any given time; therefore, the effectiveness of information management as part of patient safety should be given special attention to. (Vehko, Hyppönen, Ryhänen & Heponiemi 2017, 8–9.) Functional information systems enable high-quality patient care and patient safety when information is timely and properly documented. Nurses need computer skills, sufficient software and computers, and access to data stored in information systems. (Casey Halley, Brokel & Sensmeier 2009; Dowling 2013, 36.)

Vehko, Hyppönen, Ryhänen, Tuukkanen, Ketola and Heponiemi (2018, 144) studied health care professionals usability experiences of information and communication technology, stressfulness and wellbeing at work. It appeared that different technical problems caused stress among health care professionals. Downtime, slow multiple logins required for multiple systems and simultaneous use of several systems caused stress. Also lack of time for documentation and electronic patient information slowed down work as well as caused stress and concern for patient safety. Although, in the end, technical problems were not considered to be the major stress factor at work. Employees experienced the burden of patient care and occasional extensive workload a priority factor for their wellbeing at work.

Koivunen, Välimäki, Patel, Knapp, Hätönen, Kuosmanen, Pitkänen, Anttila & Katajisto (2010, 592) and Abu Raddaha (2017, 32) wrote that a nurse's negative attitude to information technology adds to the stress and the time that using technology takes from caring for patients. Nurses are

happy to use new applications and programs to support patients if they receive training, support and evidence-based results. Similarly, technology and easy-to-use systems support nurses' work wellbeing by reducing the experienced sense of rush. For the health and wellbeing of health care professionals it would be important to pay attention to nurses' wellbeing at work and the attractiveness of the sector, also in relation to the information systems and their smooth use. (Vehko, Hyppönen, Ryhänen & Heponiemi 2017, 9.)

6.2 MONA Revolutionizes Patient Documentation

The speech input method is 2.93 times faster than keyboard input in English. Speech text is less error-prone than keyboard input during entry, but slightly more prone to leaving uncorrected errors after entry. This tradeoff might suggest that people are more attentive to their text when using keyboard input. It is practically infeasible to correct speech recognition errors until the entire phrase is dictated. With keyboard entry, users can presumably choose between correcting errors as soon as they notice them and correcting all errors in a separate pass after entering all of the text. (Ruan, Wobbrock, Liou, Ng & Landay 2017, 19.)

Currently various dictation devices are available, but they are used by doctors, their use requires computers and they are analog. Wireless dictation devices are not available for health care and we believe that their use would be a great relief in nurses' day-to-day work and decrease the time spent on documentation.

The goal of this innovation work was to develop a smart phone application that would allow nurses to document patient information immediately with the help of speech-to-text voice recognition. The application uses the RFID sensor in the patient's wristband to identify the patient, thereby accessing the most important patient data and the possibility of recording patient data by voice. If successful, the innovation would reduce the time it takes to log in and increase the time the nurse to direct patient care and other important duties. Most hospitals already have smart phones to which the application could be downloaded.

As a rule, patients wear a wristband with an individual ID number to avoid confusion. During the visit, the nurse takes vital signs in accordance with the NEWS such as heartbeat (pulse) or checks laboratory values. These are compared with the results of previous results and documented accordingly.

The need for documentation depends on the patient's condition; all important information must be recorded. Hospitals in Finland use the NEWS scoring which is taken from all adult patients unless otherwise directed by the doctor. The results are documented by nurses after seeing to a patient and recorded into the patient file. With the use of MONA, this effort can be reduced considerably. Figure 1 shows how this process could be changed.

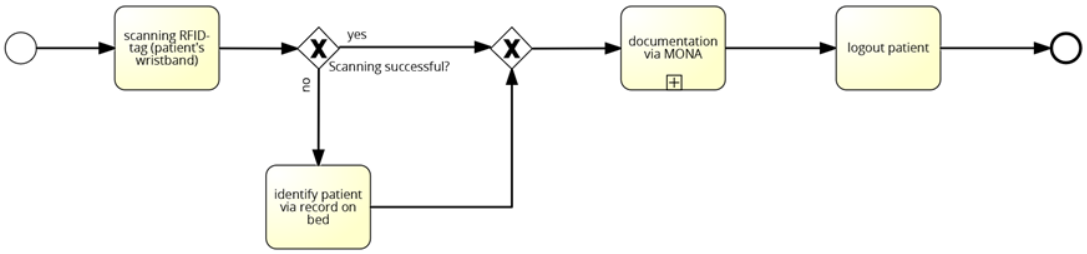


Figure 1. Possible process using MONA.

The innovation begins with the scanning of the patient's wristband or RFID tag. This step requires the supply of patient wristbands. If scanning is not successful, possibly because the wristband is defective, the nurse can also manually select the patient bed with the corresponding patient via the ward card (Figure 2).

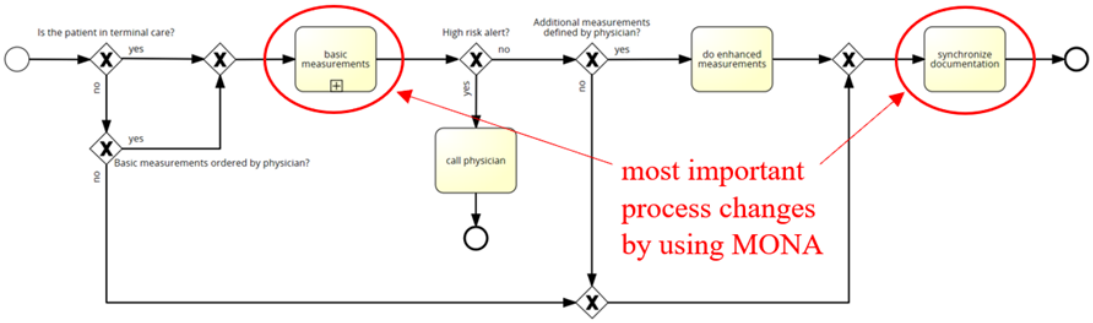


Figure 2. Process changes through MONA.

MONA enables the user to view the course of the patient-dependent basic measurements and to add the data of the current measurement using speech-to-text. In order to do this, the nurse (or user) simply selects the corresponding area in the app, such as “heartbeat (pulse)”, states the current data, and the app transforms the information into text and then adds it to the documentation (Figure 3).

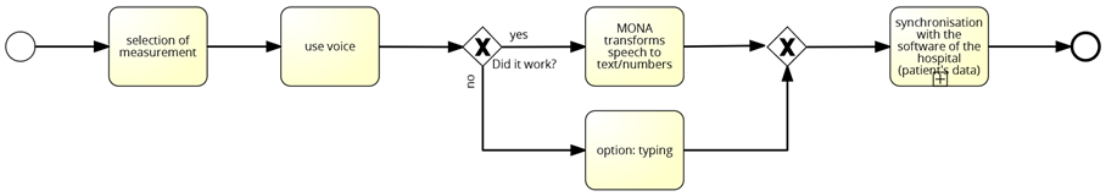


Figure 3. Documentation with MONA.

In the current version, MONA is designed exclusively for basic measurements. However, extended measurements should be possible in future. If the attending physician has prescribed further, more extensive measurements, these can also be viewed and documented directly with MONA. The entered data will be synchronized with the patient file in real time through the cloud function, which means that any other ward employee can view the data immediately. At the same time, the nurse can see updated data on her mobile device immediately after it has been entered. Previously measurements had to be added to patient files after ward rounds with a great deal of writing effort. With MONA this process step is no longer necessary. In principle, the process ends when the patient leaves the hospital.

The goal for the application was to have a simplistic layout with user-friendly features to access patient information and to update the results of measurements and other information to the hospital database. One of the main points for developing this application was to save time that nurses spend on writing; with speech to text it is much less time-consuming to update and access patient information. The main page has a real-time graphical NEWS-chart about a patient and a simple menu for selecting which measurement needs to be taken. After selecting and taking the measurement the nurse says the result loud and the application converts the spoken piece of information into text and updates the hospital database immediately.

6.3 Technical Details

The application hardware consists of a patient's RFID bracelet with flashed ID in it, computers and a working android phone with inbuilt NFC and Google voice recognition features. This type of voice recognizing method was chosen, because coding a completely new voice recognition software would have taken too long. With this in mind, if the application is developed further, the Google voice recognition can be replaced with another software to increase patient data protection.

The RFID tag was chosen over a barcode, because RFID has various advantages and it is a more modern technology for hospital environments. RFID does not have the limitations of barcode scanning. A barcode requires line-of-sight access to each barcode and only one item can be scanned at a time. RFID tags do not require line-of-site. and can be read from a variety of different distances based on the type of tag and the use of a scanner, e.g. a smartphone. (ADVANTAGES OF RFID VS BARCODES n.d.)

The software consists of a hospital's database with information about patients such as names, last names, and results of tests and examinations. The application was developed with a software called Android Studio. The coding language was Java and the target platform Android. The main parts of the code were the RFID tag, speech-to-text function and connection to the database. The present version of MONA does not include the connection to the database as it was rather hard to code due to the narrow timeframe this innovation project had.

6.4 Using MONA

How does MONA work? The application is first downloaded to a smartphone. The nurse presses a button to scan the RFID tag from the patient's bracelet, the camera of the phone with an NFC feature reads the ID and searches patient data from the hospital database and the data is shown on the screen. After this nurse selects a measurement, for example temperature, and a new screen opens. The nurse presses a button to say the patient's temperature loud and the application converts the speech to text displaying it on the screen. The nurse can now modify the text and press a button to send and update the data to the hospital database. Figure 4 shows the main menus of the application.

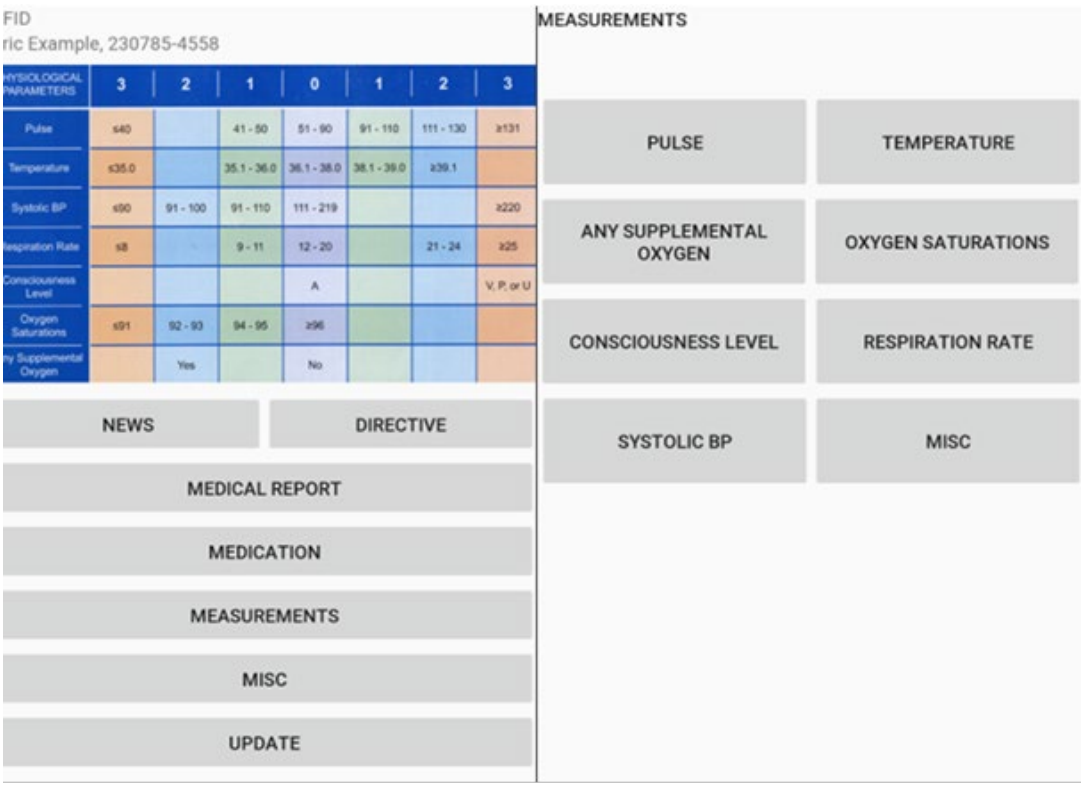


Figure 4. Technical flowchart.

As shown in Figure 5, the RFID tag and phone (NFC) communicate via radio waves that the phone sends to the tag and the tag answers by sending data. The application has a wireless connection to the hospital database, and they communicate with each other.

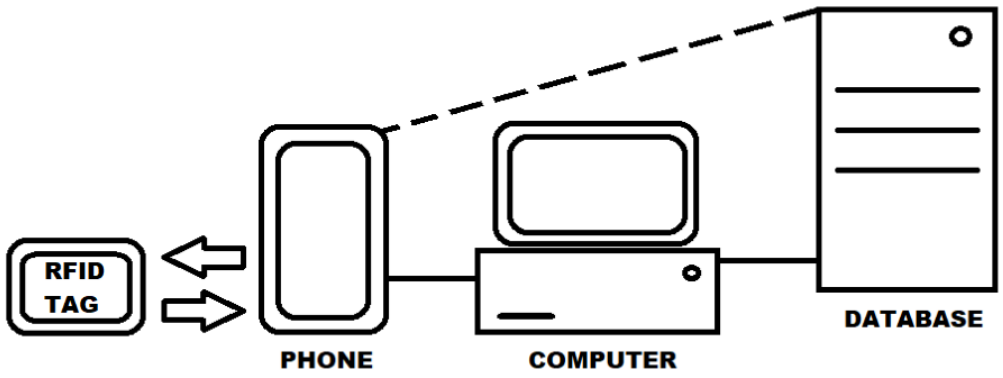


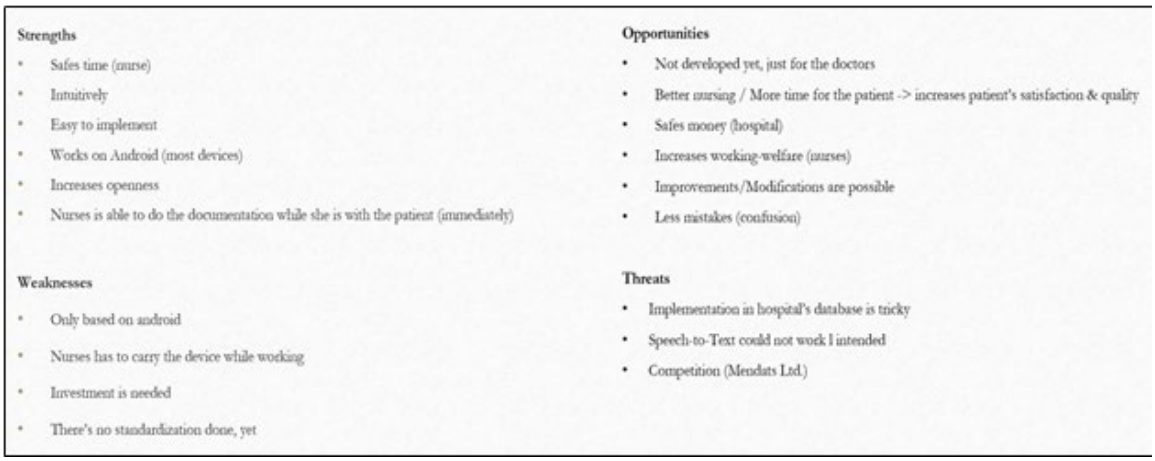
Figure 5. User interface of the smartphone application.

6.5 SWOT Analysis of MONA

The innovation project did not only include the development of MONA and integration of the application into existing hospital processes but also an analysis of the opportunities and threats as well as strengths and weaknesses related to this innovation, i.e. an SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. According to the Finnish nurses involved in the project, there is no comparable software solution for nurses that would combine the functions of MONA available at the moment. In future, new functions can be added to MONA, which means flexibility for any process changes at hospitals.

The application is easy to use and runs on Android-based systems. Android is the most widely used operating system on mobile devices. Using MONA is intuitive with a self-explanatory user interface. One of MONA's benefits is documentation during the rounds and synchronization of data in real time (with patient files). Table 3 introduces the SWOT analysis of the MONA innovation (cf. Lindroos & Lohivesi 2004).

TABLE 3. SWOT analysis of the MONA innovation



Strengths

- Safes time (nurse)
- Intuitively
- Easy to implement
- Works on Android (most devices)
- Increases openness
- Nurses is able to do the documentation while she is with the patient (immediately)

Weaknesses

- Only based on android
- Nurses has to carry the device while working
- Investment is needed
- There's no standardization done, yet

Opportunities

- Not developed yet, just for the doctors
- Better nursing / More time for the patient -> increases patient's satisfaction & quality
- Safes money (hospital)
- Increases working-welfare (nurses)
- Improvements/Modifications are possible
- Less mistakes (confusion)

Threats

- Implementation in hospital's database is tricky
- Speech-to-Text could not work I intended
- Competition (Mendats Ltd.)

Thanks to this innovation, hospitals can streamline their processes and generate time savings. Nurses can treat more patients during shifts, giving hospitals an immediate return on the investment. On the other hand, nurses can use the time saved using MONA to give patients and their social needs more. Consequently, hospitals benefit from increased patient satisfaction, which leads to a better evaluation of the services provided.

6.6 Conclusion

The aim of this article is to describe how this innovation – MONA – increase health care professionals' wellbeing at work by changing the content of indirect patient care. Technically functional and easy-to-use systems support the wellbeing of nurses at work by reducing the experienced sense of hurry (Vehko et al. 2018). As shown by Lavander's (2017) research results, regardless of the professional title, all nurses spent less than half of their working time on direct patient care. Documentation took about a fifth of the working time, and all professional groups had many non-clinical tasks. It is clear that the Mobile Nurse Assistant (MONA) will save nurses' time, as they do not have to document six different vital sign measurements for every patient in the ward separately. Technical problems, such as slow computers, multiple logins required for multiple systems, and the simultaneous use of several systems caused stress. Lack of time for documentation leads to situations in which nurses attempt to record patient data either briefly during shifts or at the end of shifts. (Vehko et al 2018.) Wireless login saves time for direct patient care, reduces nurses' sense of hurry and stress and promotes a sense of control over work.

Vehko et al. (2017) state that technically functional and easy-to-use systems support nurses' wellbeing by reducing the experienced sense of hurry. Studies also show that nurses who gave the best ratings to the patient information system they were using reported less stress and hurry caused by information technology or clients, when compared to nurses who gave the patient information system they were using a poor rating. In addition, nurses who gave the highest ratings to the patient information system reported higher quality ratings of work autonomy than nurses who gave a poor rating to the patient information system they were using. In other words, the IT solutions that nurses use in their work have a significant impact on their wellbeing at work. It is essential that information technology works smoothly and is flexible. In addition, nurses feel they can use IT equipment effectively if they receive guidance and training in using the systems. (Koivunen ym. 2010; Abu Raddaha 2017.) MONA is a good example of this. Promotion of health care professionals' ICT-related wellbeing should include, for example, the development of single logins, usability of documentation and retrieval of patient data and provision of peaceful documentation environments. MONA is the answer to overcoming these ICT challenges.

The collaborative development of this application was interesting. A challenge in application development are the consideration of data protection in patient information systems (L 159/2017; L 1050/2018). Further development of this application requires collaboration with hospital ICT

departments and closer discussions on patient data protection and access to hospital networks, which requires testing and licensing.

The challenge in introducing this application is that nurses need a mobile device. Hospitals need to invest not only in the implementation of MONA but also in the purchase of numerous mobile devices. The software of the application requires compatible hardware, which can discourage some hospitals. Additionally, software hospitals use is not standardized. Therefore, MONA must be able to interact with different programs in order to enable data synchronization, which may be the biggest challenge in introducing MONA more widely.

Introducing MONA in everyday hospital life can, therefore, prove to be particularly difficult in the beginning, especially since institutions must be convinced that the purchase of the software and hardware required for the application can actually be amortized. In addition, the staff must also be convinced of the advantages of MONA especially since it cannot be expected that every member of staff is confident and competent in the use of Android-based devices.

In conclusion, it can be said that many things could have been made differently during the innovation process. The innovation team tested various options during the 2019 International Week at Kajaani University of Applied Sciences. MONA turned out to be an enjoyable product even though it is not yet complete. Internet searches showed that there are numerous similar projects being in the process of development. Of course, there would have been different approaches to do a project of this kind, i.e. different software programs, coding languages and development platforms. We feel that we achieved our goal and created an innovation that can help nurses to do patient documentation more smoothly, increase health care professionals' wellbeing at work and save time. In future, it would be interesting to see how nurses' ICT competence to use MONA has developed.

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7 Hand Disinfection Reminder (HDR)

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Abstract

The health care industry and especially the hospital sector are currently facing many challenges. In addition to rising costs and an aging population, the pressure is growing on hygiene guidelines and requirements. Especially in hospitals, every human error is documented in more and more detail and causes are investigated. As some studies have already shown, many diseases can be attributed to the inadequate disinfection process. Therefore, hand disinfection plays an important role in infection prevention. To meet the challenge of inadequate hand disinfection, innovation and technological solutions are essential in today's digital world. The aim of this article is to describe how patient safety can be improved by developing an innovation consisting of an application called Hand Disinfection Reminder (HDR). The HDR application monitors and secures the entire hand disinfection process of hospital staff. In addition to the reminder for hospital staff, the application offers a number of other advantages which are described in the following article. The described innovation was presented in an innovation workshop during the 2019 International Week at Kajaani University of Applied Sciences. The innovation team consisted of Master of Health Care students, Master of Health Management and Health Information Management Student and Bachelor of Engineering (communication and information technology) students.

Keywords: health care, hygiene guidelines, hand disinfection, patient safety

7.1 Introduction

Patient safety is the right of every patient and it is defined to be a part of the quality and safety of care. Patient safety refers to the measures that healthcare professionals and organizations take when they ensure the safety of services and care. Practices that promote patient safety should be known and used by every employee every day and for each patient. (Kinnunen & Roine 2018, 114.) Health care-associated infections (HCAI) are not completely preventable, but they can be reduced. At least every fifth infection – and probably many more – can be prevented by simple means, the most important being hand hygiene. (Laine 2018.)

HCAIs affect hundreds of millions of patients worldwide every year. Infections can lead to more serious

illnesses, hospital stays and added costs to patients and their families. (WHO 2009, 1.) HCAI refers to an infection that occurs during or after treatment given in a health or social care unit. It is estimated that 100,000 HCAIs occur annually in Finland and cause the death of 1,500-5,000 persons. (Hoitoon liittyvät infektiot 2019.) HCAIs are transmitted through direct or indirect contact, droplets, and air. The most common way is transmission through the contaminated hands of health care professionals. (WHO 2009,1.)

In 2005 the World Health Organization (WHO) launched a global campaign called “Clean Care is Safer Care”. It was the first global patient safety campaign. The goal of the campaigns was to reduce HCAIs worldwide. This campaign led to the preparation of the WHO Guidelines on Hand Hygiene in Health Care. (WHO 2009, 1.) These evidence-based guidelines recommend hand hygiene in five situations which have been found to play a key role in the spread of infections. These situations, which were named “My 5 moments for Hand Hygiene” (Figure 1) are the following: before patient contact, before antiseptic task, after body fluid exposure risk, after patient contact, and after contact with patient surroundings. (WHO 2009, 27; Palomares 2019.)

Figure 1. My 5 Moments of Hand Hygiene (WHO 2009, 123).

According to the current hand hygiene recommendations, hand cleaning with an antiseptic hand rub is the most common way to break infection transmissions in health care. An antiseptic hand rub is a liquid material that is meant to be used in hand disinfection. (Syrjälä & Lahti 2010, 165–167.) With an antiseptic hand rub, health care professionals remove microbes from their hands before and after they have touched a patient or the environment near the patient.

Hand hygiene is the primary measure to reduce infections. It is the most important single way to prevent treatment-related infections. (Syrjälä & Ojanperä 2018, 122.) Hand hygiene reduces and eliminates the risk that health care professionals contaminate a patient or cause an infection through their hands. According to the WHO guidelines, the greatest risk for this is the contacts inside the patient zone. These areas are the patient himself, patient bed and bedside table. (WHO 2009, 109.)

Finnish acute hospitals participated in a study on treatment-related infections and antimicrobial use conducted by the European Center for Disease Studies. At least one treatment-related infection was reported in 8.8% of the patients. The incidence was highest in intensive care units (21%) and among hematological patients (29%). The most common types of infection were surgical site infections (21%), severe general infections (20%) and pneumonia (19%). (Sarvikivi, Toura, Arifulla & Lyytikäinen 2018.)

Interventions that increase hand hygiene have been statistically shown to have a therapeutic effect on reducing blood poisoning (Chen, Sheng, Wang, Chang, Lin, Tien, Hsu & Tsai 2011). Improving hand hygiene compliance among health care professionals reduced methicillin-resistant

staphylococcus aureus (MRSA) infections that require hospitalization in neonatal intensive care units. MRSA infections were reduced by 48% when staff in intensive care units practiced proper hand hygiene in over 80% of situations requiring it. (Song, Stockwell, Floyd, Short & Sing 2013.)

Because hand hygiene is a critical element in patient care, it should be learned and reinforced so that it becomes an autonomous behaviour (Wearn, Bhoopatkar & Nakatsuji 2015, 425). The contradiction between perceived action and actual behavior is one of the widely accepted beliefs today that certain events affecting behavior are unconscious (Vuerto 2015, 198). Sax and Clark (2015, 6) recommended designing workplaces so that they support the existing mental models, which could be accomplished by using a classic human factor engineering approach. According to this approach, the environment is designed so that it enables safe behaviors to prevent errors by providing visual clues such as reminders.

The aim of this article is to describe how patient safety can be improved by developing an innovation consisting of an application called Hand Disinfection Reminder (HDR).

7.2 Need for Innovation

The main idea of the HDR innovation is to improve the quality of nursing care by reducing infections caused by inadequate hand disinfection (Chen et. al 2011; Kanerva 2008; Kirkland, Lasky, Ptak, Taylor & Spaine 2012). According to a study by Kampf, Löffner and Gastmeier, doctors and nurses disinfected their hands only in 50% of the required situations. Especially in critical situations with high work density and personnel shortcomings, the compliance dropped even further. With better hand hygiene, 40% of hospital infections would be avoidable. (Kampf, Löffler & Gastmeier 2009.)

7.3 Business Process Model and Notation – BPMN

Figure 2 illustrates how the HDR application works as a process. The representation is made using the Business Process Model and Notation (BPMN). The BPMN is a standard for graphical business process modeling. With the available elements and symbols, in form of activities, events and different gateways, a uniform representation and analysis of the processes becomes possible. (Göpfert & Lindenbach 2014, 2.)

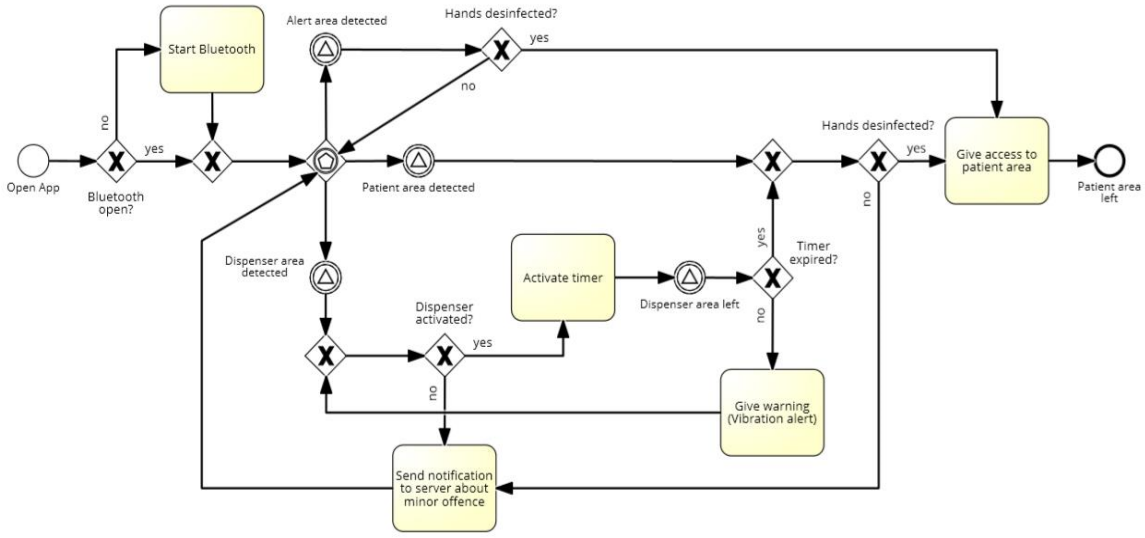

Figure 2. The process diagram of the function of the application.

The process starts by opening the application on a terminal device. In order to guarantee the function of the innovation, consisting of the application and the three different areas, a Bluetooth connection is required. Now the hospital staff can start disinfecting their hands. The application checks whether a disinfectant dispenser is activated. If this is not the case, a reminder of this minor error is sent to the server. At the same time, the timer on the application switches on so that the minimum time of the disinfection process is adhered to. Then the user leaves the dispenser area and enters the perception area in front of the patient bed. The system checks whether the time specified for hand disinfection has been adhered to and whether the timer has already expired. If this is the case, the patient area can be entered without further ado. However, if the time limit is not met, the terminal begins to vibrate, alerting the user to a new and more thorough disinfection. Once the hands have been disinfected in accordance with the guidelines, the user can enter the patient area. The process ends when the patient leaves the patient area.

7.4 Technical Specifications

In the following, the three main components of the application and their technical specifications are explained.

Mobile Application

The HDR is an open application for mobile use with the mobile application being the main connection point. The purpose of this application is to handle communications with the beacon devices, medical bed and disinfectant dispenser by using Bluetooth Low Energy (BLE) connections (Figure 3). The Android platform supports the Bluetooth network which allows a device to wirelessly exchange data with the medical bed and disinfectant dispenser. The application framework provides access to the Bluetooth functionality through the Android Bluetooth application interface (API). APIs allow applications to connect to other Bluetooth devices wirelessly and enable point-to-point and multipoint wireless features. (Bluetooth overview n.d.)

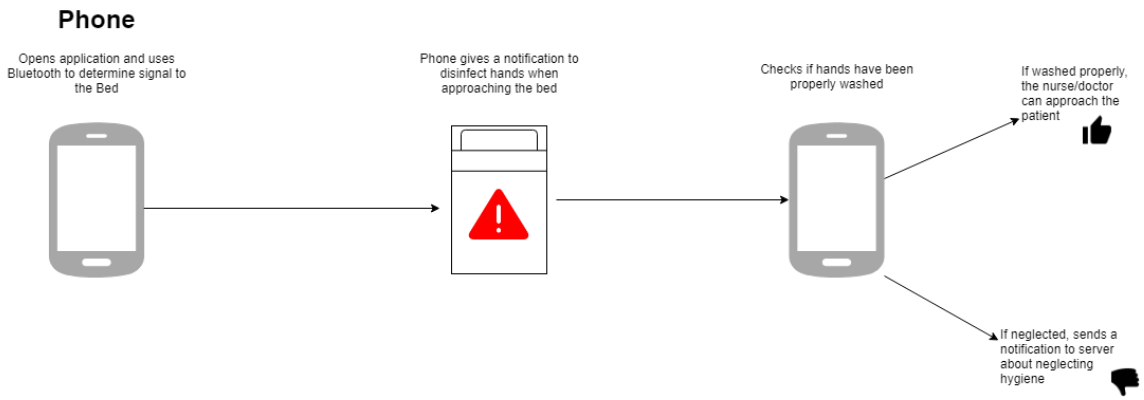

Figure 3. Mobile application.

The application keeps track of the state of nurses and doctors' current hand hygiene. For this application to work they need to have a smartphone or other smart device with them all the time. Interaction with the smart device is needed to reduce the possibility of infections spreading from the phone back to the newly disinfected hands.

Smart Disinfectant Dispenser

Disinfectant dispenser has a BLE beacon just like the bed does (Figure 4). The beacon calculates the distance and makes sure the hand disinfection process lasts long enough before it sends an "OK" reminder to the application. After the "OK" has been sent, the professional can walk into the patient's contact area without getting a "neglected" notice from the beacon in the patient's bed.

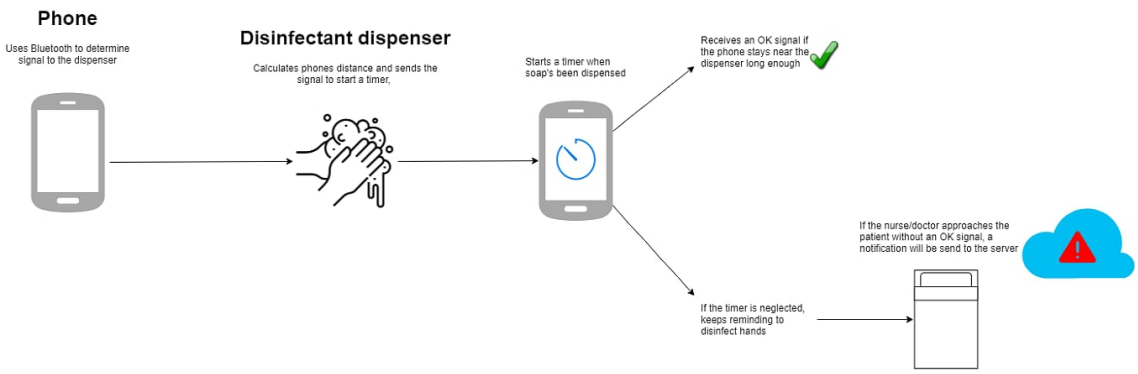

Figure 4. Smart disinfectant dispenser.

Smart Medical bed

The smart medical bed has also a BLE beacon attached to it. The beacon checks the Bluetooth signal from the professional's phone and calculates the distance between the bed and phone. There are two areas surrounding the bed: a reminder area which gives an alarm to the mobile application after a professional steps into it and a contact area which checks if the professional has acted according to the reminder. If the reminder has been neglected, the beacon sends a reminder to the database.

7.5 Benefits and Further Development

Every employee should work in an organization where process planning has taken people's ability to make mistakes into account. Processes should be designed to minimize the possibility of errors. (Kinnunen & Roine 2018, 117) Hand Disinfection Reminder will develop the entire disinfection process and make it more transparent so that tangible hygiene successes lead to an increase in self-regulatory hand hygiene. Patient safety means that the patient receives the necessary and correct treatment with minimal harm. The competence of the staff, as well as ensuring and developing it, is of paramount importance. (Terveydenhuollon laatuopas 2019.)

As mentioned before, the main feature of the HDR innovation is the automatic connection with BLE beacons, so that the devices do not have to be reconnected each time. Touching the smartphone after disinfecting the hands can spread microbes to clean hands. Furthermore, the use of this application is convincingly simple and effective. The hospital staff receives feedback based on the data sent and stored by the server. In addition, it must be said that no additional documentation is required because the data is automatically stored. The hospital can also gain

advantages from the innovation. For example, a sharpened quality profile is created, which makes hand hygiene measurable and can, therefore, generate high savings through shortened lay times. All these factors contribute to better positioning in quality competition.

In future the functionality of disinfectant dispensers can be extended with a scanner. When an alcohol-rich disinfectant is used, the disinfectant causes the hands to lose heat via the evaporation of the alcohol compound in the disinfectant solution, and the heat loss or areas with most heat loss can be detected with a thermal camera. This is still an early idea that needs further research.

7.6 Conclusion

The aim of the Hand Disinfection Reminder (HDR) innovation was to develop an application that would support hospital staff during the hand disinfection process. Hygiene-specific sensing technology ensures that health care professionals perform hand hygiene in accordance with the WHO Five Moments for Hand Hygiene. Proper hand hygiene also increases accountability among health care professionals. (Chen et. all 2011; Kanerva 2008; Kirkland et. all. 2012; Palomares 2019.) Dangerous infections due to insufficient hand disinfection are to be prevented with the HDR in future. The innovation would improve the quality of nursing care and make it more innovative. Technological developments and solutions need to be integrated in everyday nursing care. However, it must be noted that innovative technologies are not intended to replace human beings and human care but to support it. (Herzog 2019.)

Hand Disinfection Reminder can significantly enhance patient safety by immediate feedback from hospital staff after their unsafe behavior. A study by Sax and Clark shows that missing or delayed feedback following unsafe behavior promotes faulty operating models that view unsafe behaviors as harmless, because negative outcomes are not observed and that systems with missing or delayed feedback are difficult to control. (Sax & Clark 2015, 5.) The HDR application can help hospital staff to build the right operating model for health care professionals' hand hygiene competence.

The HDR application provides support for nursing and hospital staff so that patient care they give is safe and full concentration is given to patients. As mentioned in the beginning of this article, the hospital sector faces many challenges. Every innovation idea is, therefore, of great importance, as it makes an important contribution to the efficiency of hospitals. This also applies to the application described in this article. The user-friendliness of the HDR application is ensured,

as it runs automatically in the background as soon as the terminal devices are connected via Bluetooth. Furthermore, the application can be used without any training of the hospital staff.

Increasing quality standards and stricter monitoring in the health care sector are also reinforcing the use of smart technologies. With this innovation, hygiene standards can be more accurately targeted and captured as data is automatically sent to the server in the event of malpractice. This results in a targeted approach in case of misconduct, which prevents future infringements and thus bacterial infections among patients. New automated technology can encourage staff participation in learning and improve hand hygiene compliance in health care (Higgins & Hannah 2013). At the same time, the pressure on hospital staff is reduced as the innovation reminds staff of an inadequate hand disinfection process.

The daily work of nursing and hospital staff becomes more efficient, which contributes to improved quality management. Quality management is the management, planning, evaluation and improvement of activities to achieve the set quality objectives which are based on the organization's own quality policy. All levels of management are responsible for quality management, but all members of the organization are involved in its implementation. (Koivuranta-Vaara 2011, 6.) All applications, smart innovations and health technologies contribute to a continuous improvement of patient care and at the same time increase the quality of care.

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8 MEMbrushORY

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Abstract

Population in every industrialized country is aging rapidly. In Finland the proportion of people aged 65 is predicted to be over 28.8% in 2060; in 2010 it was 17.5%. The number of older people has an impact on present oral and dental health care services. At the present the value of oral hygiene, use of fluoride toothpaste and standard of living have contributed to improved dental health. For older people, good oral hygiene means good quality of life. As oral health care services are not available for them, the responsibility for taking care of oral hygiene is transferred to medical staff or relatives. Good oral hygiene effectively prevents perforation, mouth infections and their effect on general health. The aim of this article is to describe how we can promote older people's oral health with an innovation – the MEMbrushORY reminder. Our vision with this innovation is high quality of oral hygiene for older people. The reminder which will help older people to remember to brush their teeth in the morning and evening was developed in an innovation workshop during the 2019 International week at Kajaani University of Applied Sciences (KAMK). The innovation team had seven members: three Master of Health Care students from KAMK, one Master of Business Studies in Health Care Management B.A. student from Neu-Ulm University of Applied Sciences (Germany) and three Bachelor of Information and Communication Technology students from KAMK. MEMbrushORY is easy to use and compatible with all toothbrushes. It also provides an opportunity for further innovations helping older people to take care of their oral hygiene at home. This article discusses and describes the process of creating the innovation and possible advantages for nurses in their daily work.

Keywords: toothbrush, reminder, older people, oral hygiene, innovation, MEMbrushORY

8.1 Introduction

Good oral hygiene is a basic treatment among older people. Good oral and prosthetic hygiene can help reduce aspiration pneumonia. In this way, human suffering and treatment costs can be reduced. Considering the quality of older people's life, home is the most important place for them. Oral care enhances their wellbeing, participation and social interaction. The ability to take care of one's own oral hygiene is part of everyday life. Different home-oriented counseling services are offered to help older people take care of their oral health at home. (Vanhuus ja hoidon etiikka 2008; "Toimintamalleja muuttaen parempaan suun terveyteen ikääntyneillä" 2015, 11–12.) Our innovation, MEMbrushORY, is a good start for improving the oral health of people in every age. The use of this reminder is easy, and it works with every kind of toothbrush. The original idea was to create an electric toothbrush with a suction function, but it had already been developed. When the plan was changed, the possibility of a robot hand assisting in brushing teeth was considered. However, designing and manufacturing a robot hand would have been challenging and would have been costly to do. Finally, a reminder was chosen because it is feasible.

The reminder is implemented in the form of a toothbrush holder and is designed for bathrooms or toilets where teeth brushing presumably takes place. Its function is to remind the user to brush their teeth twice a day at certain intervals, and it instructs the brushing process using sound. The reminder also considers hearing-impaired clients with a light signal. Its purpose is also to recognize that tooth brushing is actually completed. MEMbrusORY can be used at private homes as well as in assisted living homes. This reminder can help to maintain and improve older people's right to take care of their oral hygiene. Thus, this innovation contributes to comprehensive oral care.

The innovation is based on the notion that good health and oral hygiene should be human rights. The two main goals for developing MEMbrusORY were based on the Finnish Act on the Status and Rights of Patients (785/1992, according to which "every person who is permanently resident in Finland is without discrimination entitled to health and medical care required by his state of health within the resources available to health care at the time in question. Concerning the right to treatment of persons who are staying in Finland temporarily, what has specially been provided for or what has been agreed upon between states reciprocally shall apply". (Laki potilaan asemasta ja oikeuksista 785/1992.)

The first goal was that the MEMbrushORY reminder would make nurses' work easier. It had been suggested that around 20% of nurses and practical nurses' responsibilities can be replaced by

existing robotics and automation applications within the next few years (Laatusuositus hyvän ikääntymisen turvaamiseksi ja palveluiden parantamiseksi 2017, 26–27). MEMbrushORY includes an application with which the reminder sends a message to nurses' phone, if older persons forget to brush their teeth or they often brush them with a poor outcome. Thus, they do not need daily supervision, which saves a lot of nurses' time. Combined with an electric toothbrush, which measures pressure and time and includes audio introduction, older people can brush their teeth regularly and well longer on their own.

The second goal was that older people could live at their own homes independently longer, as good oral hygiene is an important aspect when nurses and relatives decide if older persons need homecare or need to live in a nursing home. Smart home technology is one of the ways to support older people living independently at their own homes. (Laatusuositus hyvän ikääntymisen turvaamiseksi ja palveluiden parantamiseksi 2017, 26–27.) Prevention of oral diseases is based on good self-care: everyone should be taught to take care of their oral health and have their teeth regularly examined. Methods of good oral care are the same for everyone: taking care of oral hygiene, not smoking, healthy diet and regular dental check-ups. Inadequate oral hygiene is a common problem among older people; particularly older men do not brush their teeth twice a day as recommended. Positioned teeth and prostheses as well as general dryness of the mouth increase the plaque (biofilm) accumulation on the teeth surfaces and make it difficult to cleanse the mouth. (Siukosaari & Nihtilä 2015, 39–41.)

There are many more functions, which could be included in MEMbrushORY, and many more ways of how it could be used. This article discusses and describes the process of using the MEMbrushORY innovation, with the focus on the purpose of reminding older people to brush their teeth and introducing possible advantages for nurses in their daily work, if the innovation is used in hospitals or health care units.

8.2 Oral health care background

According to Siukosaari and Nihtilä (2015), in the future most older people will retain with their natural teeth. As risk factors increase and oral health changes with aging, older people are more susceptible to various oral gum diseases. (Siukosaari & Nihtilä 2015, 36.) A study made in 2014 shows that 39% of over 64-year-old people have at least one treatment-requiring cavity in their teeth. In long-term care, it has been studied that 37% of people over 60 years have a need for

dental restoration. (Karies (hallinta) 2014, 3-4.) Every third women and every second man over the age of 75 have caries that requires treatment. Correct treatment of caries is difficult but repairing the damage is of paramount importance. Dental care is mostly needed by people aged 65-74. (Siukosaari & Nihtilä 2015, 36–37.)

In the last twenty years, the health of older people in Finland has improved and life expectancy has increased. Over the decades, the need for oral care has focused on older people, as their number in relation to the rest of the population is increasing. The proportion of toothless persons is decreasing, and the number of prosthesis users is even lower. (Paavola, Lahtinen, Ainamo, Eerikäinen, Eerola, Huhtala, Nordblad, Rantala, Remes-Lyly & Siukosaari 2003, 7.) Despite the overall improvement in oral hygiene, socio-economic differences are still very common among adults. The health of least educated people is clearly poorer than that of other education groups. (Suun terveys 2019.) Dental infections are most common among high-educated older people, which is largely due to the fact that they have more teeth left than low-educated people. High age, female gender, rural residence, low education, cardiovascular disease and smoking have been associated with toothlessness. The most common consequences of poor oral hygiene are pain, inflammation and toothlessness. (Paavola et al. 2003, 22; Nihtilä et al. 2017.)

At present the value of oral hygiene, use of fluoride toothpaste and standard of living have contributed to improved dental health. On the other hand, different risk factors have also increased. The most common risk factors are general illnesses, inadequate self-care, decreased salivary secretion, smoking and carcinogenic diet. As a result, dentition may be in poor condition or even decayed. The decreased amount of saliva and impaired defenses of saliva, caused by many medicines, are one of the major risk factors for caries and other oral diseases such as fungal infections. As oral care of older people decreases, the responsibility is transferred to the medical staff or relatives. (Siukosaari & Nihtilä 2015, 36–37.) Diseases require help with oral hygiene at home or in a nursing home (Keskinen 2015, 350). It must be ensured that oral hygiene remains good (Siukosaari & Nihtilä 2015, 36–37).

For older people, good oral hygiene means good quality of life (Keskinen 2015, 150; Siukosaari & Nihtilä 2015, 36–37). Therefore, caries care should consider the causes and risk factors and not just repair the damage that has already occurred. Corrective treatment is difficult and halting damage is paramount. (Siukosaari & Nihtilä 2015, 36–37.) The most common oral disorders among adults are gingival diseases, which are bacterial infections, and, if untreated, they can even lead to tooth decay. Smoking increases gingival and mucosal diseases that can be

prevented with good oral treatment, regular examinations and nutrition. (Suun ja hampaiden hoito 2008, 2.)

Oral health affects bowel function, speech, respiration, physical appearance and joints. Thus, it affects physical, mental and social wellbeing and quality of life. Physical problems must be reported if they are to be considered. Mental problems such as pain are reported as anxiety and restlessness. Social problems such as fear of bad breath lead to isolation. (Ekelund 1996, 466–467.) The two health problems that most likely affect the health of older people are musculoskeletal disorders and memory disorders. Disorders of the musculoskeletal system may prevent regular dental visits, while the person suffering from the memory disease is dependent on the help of others, both in daily oral care and use of the oral hygiene care system. (Christensen, Borge & Siukosaari 2018.)

Maintaining oral hygiene can be more difficult if vision, hand motility or memory are impaired. Many medicines and diseases cause dry mouth. When saliva production is reduced, other oral diseases such as fungal infections become more common. Good oral hygiene effectively prevents perforation, mouth infections and their effect on general health. Inflammation beneath dentures is an aging disorder. (Nordblad 2002, 86–88; Keskinen 2015, 149–150, 350.) Most oral diseases can be prevented with good and careful oral hygiene. Oral self-care is important and should be done daily. Oral hygiene includes daily regular and careful cleaning and brushing teeth twice a day, and a diet. Oral diseases are silent infectious diseases that cause symptoms only at a later stage. Good oral hygiene can prevent infection complications, improve the balance of hygiene for many long-term illnesses and maintain the ability to function. In the future services should be provided innovatively where the elderly can best be reached. (Siukosaari & Nihtilä 2015, 36–38.)

Good oral hygiene is part of general health, wellbeing and quality of life. Oral and dental hygiene are also linked to heart health. Effective self-care maintains good oral hygiene and prevents inflammations. Chronic inflammations in the mouth should be treated in a timely manner as they can be related to several diseases such as cardiovascular diseases. Periodontitis, which destroys the tissues surrounding the teeth, increases the risk of heart attack and stroke. Oral diseases are caused, for example, by poor oral hygiene, smoking, hereditary factors, and certain common conditions and medications, such as inadequately treated diabetes. However, the risk of oral diseases, as well as other diseases, varies from person to person. (Ikäihmisten suun hoito-opas sosiaali- ja terveysalan henkilökunnalle 2003, 22–24; Keskinen 2015, 148.)

According to a doctoral research, which studied 75-year-old people living in Kuopio, older people need much resources, time and money for preventive dental care. Over 80% of older people without teeth prosthesis and 55% of older people with teeth prosthesis would require preventive dental treatment. Future services should be innovative and given where they reach older people most efficiently. (Siukosaari & Nihtilä 2015.) According to the WHO recommendations, the best bite is successful with at least 20 natural teeth. In Finland, the older generation has an average of 10 natural teeth, while e.g. in Sweden the WHO target has been reached. (Närhi & Syrjälä 2017.)

The Finnish Act on Supporting the Functional Capacity of the Older Population and on Social and Health Services for Older Persons (Laki ikääntyneen väestön toimintakyvyn tukemisesta sekä iäkkäiden sosiaali- ja terveyspalveluista 980/2012) aims to support older people's functional capacity, wellbeing and health, to increase the opportunities for influencing the development of municipal services, and to improve older people's access to quality services. The Act defines an older person as a person of retirement age, i.e. over 63 years of age. The Act complements other social and health care legislation and focuses on social welfare.

Technological innovations can prevent oral infections and thus improve older people's quality of life. An inflammation in the mouth or a cavity in the teeth may make eating difficult and cause distress if oral health care services are not sought. Therefore, oral hygiene and dentures should be taken care of. In addition, monitoring latent and asymptomatic infections of the mouth is important: older people should have oral and dental check-ups regularly, even if they have no natural teeth. (Syrjänen & Söderholm 2007, 242–243; Keskinen 2015, 148.)

8.3 Methods – Innovation Process Model

The journey from an idea to an innovation is often long and involves many steps. The idea is just a spark of innovation being born. (Jokela & Räsänen 2011, 2.) Every change in an organization that is ready for a change is usually subjected to a thorough needs analysis to determine the nature of the innovation to be implemented or transferred (Väyrynen 2010, 15–16). The problem to be solved was the poor oral hygiene among older people in Finland.

The first step was to make sure that every team member knew about the problem and the scope of the project. Therefore, a preliminary analysis was made to answer the issue of responsibilities, to provide a short orientation to reasons why this particular problem was chosen and to designate project goals and "not-goals". Then the benefits of the project – or in this case the innovation –

were discussed and criteria for the completion of the project was set. The third step was to define the tasks that to be done. These tasks included the following:

- completing a needs analysis
- contacting IT students
- conducting a feasibility study
- formulating work packages

Also, boundary conditions such as strengths and risks related to the project or innovation, time period and budget were identified in the preliminary analysis, which could also be referred to as the project analysis, and was used for creating the SWOT analysis in the next step. After ensuring that every group member had the same idea of the innovation, a SWOT analysis of the strengths, weaknesses, risks and opportunities related to the project was discussed. The SWOT analysis (Figure 1) helped to define the strategy for the project, to use resources and budgets properly, to initiate projects and to take measures. (Fleig 2019; SWOT-toimintamalli 2013.)

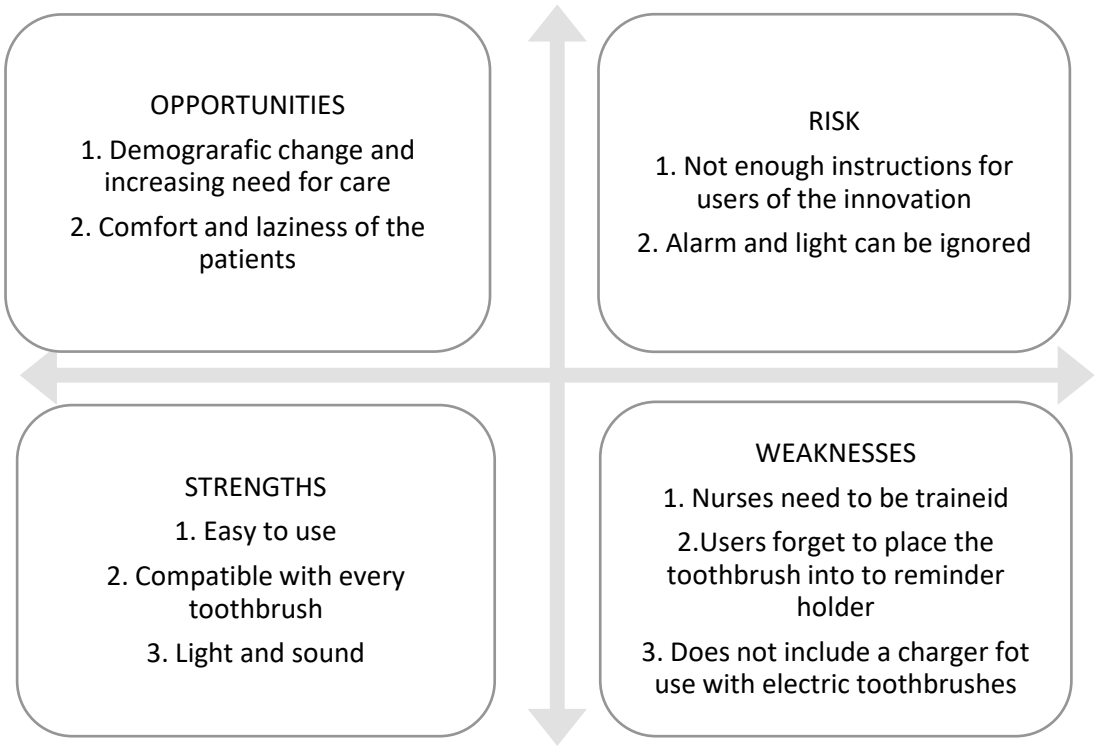

Figure 1. SWOT analysis.

In an early stage, a needs analysis was made to map out people who could be interested in the innovation and what they thought about it. Needs analysis is a description of the current state. Data can be collected from statistics, interviews with experts and clients, and surveys. (Toikko & Rantanen 2009, 73.) A needs analysis may also offer further arguments for a SWOT analysis from another point of view. The following questions were asked in the needs analysis completed:

- Do you think the innovation is useful?
- Who do you think would use it?
- Who benefits from this innovation?
- How much money would you spend to have such an innovation?

The questions were answered by healthcare professionals and a teacher. As mentioned before, the original idea was to develop a robotic arm. However, both IT students and possible stakeholders considered it to be too expensive saying that no one would spend much money on it. Therefore, the process had to be started from the beginning and all the described steps had to be taken again to finalise the idea of MEMbrushORY. Fortunately, most of the steps such as the project analysis and SWOT analysis could be used almost as they were. Only the needs analysis with the same questions was repeated. This time the respondents said that they would use the innovation and would also pay a realistic price between 30 to 60 euros, which provided a good foundation and an extra motivation for developing MEMbrushORY.

After the project analysis, SWOT analysis and needs analysis an exact model of the process which described how the innovation should be used was drawn. Process models provide insight into a process, help teams to come up with ideas for optimizing processes, foster communication, and enable process documentation. They detect bottlenecks, unnecessary repetitions and delays and help to identify process boundaries, responsibilities in a process and metrics as well as the effectiveness of processes. (Was ist ein Prozessmodell?). Figure 2 introduces a process model.

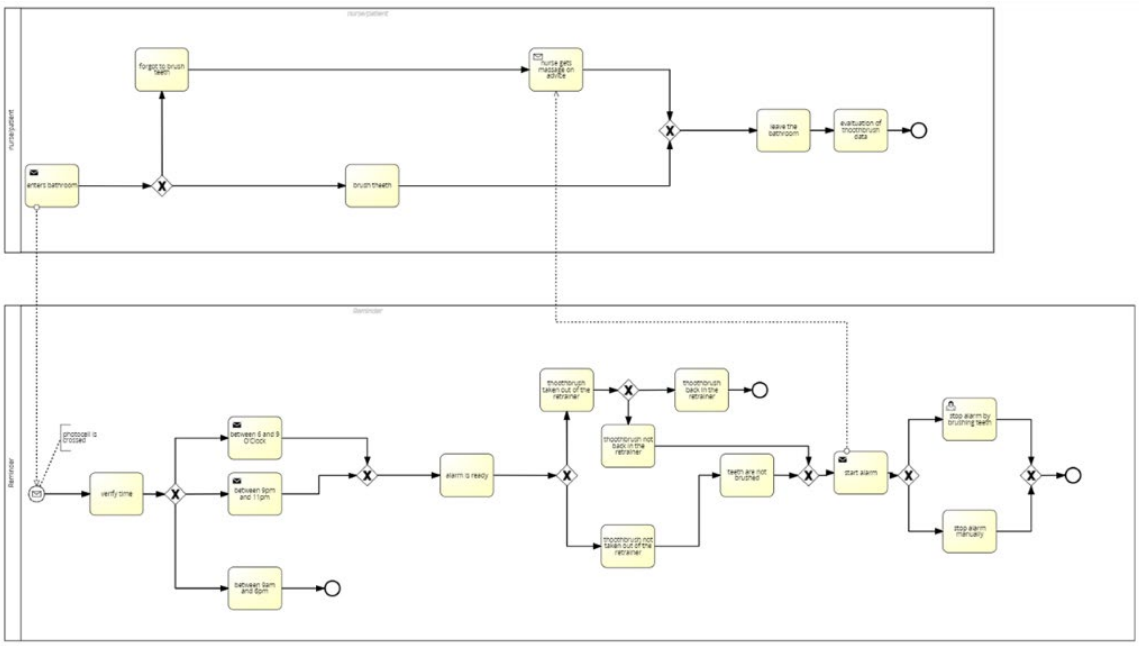

Figure 2. Process model.

The process model for MEMbrushORY is split into two pools: one pool for the process of the reminder and the second pool for nurses or older people using the reminder. As the model shows, there are connections between both components, which is important for a well-working process. The exact workflow of MEMbrushORY is described later in the article.

8.4 Technical Components

The features that needed to be included in the MEMbrushORY reminder were listed in the beginning of the planning process. They were influenced by dental health care clients' needs at home. The options were a separate reminder or an electric toothbrush with an integrated reminder. The electric toothbrush was discarded because it already exists, its interchangeability is challenging, and it is also unnecessary for clients with dentures. Instead, it was decided to design a separate device, a toothbrush holder, in which older people can put their own toothbrush regardless of the model. The purpose of the innovation was to remind older people of tooth brushing twice a day with voice and light control. The challenge was to set the times for reminders as older people have different daily rhythms. Therefore, the MEMbrushORY reminder had to have a two-hour timeframe during which the reminder occurs once. Turning on the toilet lights for the first time during the specified timeframe triggers a reminder.

When the reminder is triggered, the reminder LED light is turned on and voice control (alarm) prompts the user to wash their teeth. LED (Light Emitting Diode) is a semiconductor component that produces light. When using the right materials, the diode produces visible light at various wavelengths. (McKinsey 2011.) The innovation detects when the toothbrush is lifted from the holder and starts voice control for brushing the teeth. Sounds can be modified according to user needs, depending on whether they have natural teeth or dentures. At the end of the control, the voice control prompts the user to restore the toothbrush back to the holder so that the reminder recognizes the toothbrush recovery and the timer switches back on to remind the user of the next time in twelve hours. The innovation can receive power in two different ways. The first option is a rechargeable battery that is charged via a micro-USB port. The second alternative is an induction charge (or "wireless charging") that transfers energy between the charger and the battery using a variable electromagnetic field between the devices.

8.5 Components of a prototype

The components were chosen on the basis of the type of microcontroller that could be utilized. Arduino is an open-source platform and was, in principle, invented for people who are interested in making their own devices, but have not necessarily been trained in electronics design or software engineering. Arduino aims to lower the learning threshold so that simple functions such as blinking the LED, controlling the motor or reading a sensor can be performed. Arduino can also be described as fast prototyping development and can easily be programmed with at least two different programs. (Arduino-opas 2017.) Arduino Uno is cost- effective and easy to program and was therefore chosen for the prototype. In addition, Arduino's good features are its user-friendliness in connection design. In terms of the size of the final reminder, MEMbrushORY, the compact size of the Arduino saves space. In terms of functionality, the first point to note was the basic idea of the reminder. The reminder must detect the lights in the toilet to allow the reminder to start. The simplest and most economical option was to install a light sensor model called Silonex LDR (Light Dependent Resistor) NORPS12. It is suitable for use in applications like street light auto-flashers and camera light meters. (RS Components Ltd n.d.)

Voice control requires a built-in speaker with a compact but powerful PRO SIGNAL ABS-222-RC speaker. The speaker receives sound from the SD memory card where voice controls are stored. The memory card needs its own reader and the Arduino SD card module was selected. A memory card is the easiest way to implement user specification for whether users need instructions for

cleaning natural teeth or dentures. The audio control specification is selected using the rear switch. The timer was implemented with the OPEN-SMART RTC (Real Time Controller) v1.1 component. Open-Smart is compatible with Arduino UNO R3. Hardware resources are very rich, do not need any DuPont wires and usage is very simple. It is very suitable for Arduino learners. (Open-Smart manual 2017.) It is a battery-powered real-time clock that can be used to track time after re-programming or power-down. Its performance is excellent for timers and alarms and works great with Arduino.

The reminder should detect when the toothbrush is lifted and placed back into the holder. The options are a pressure sensor or another light sensor. The pressure sensor detects the weight of the toothbrush while it is in the holder and the light sensor detects a change in light when using the toothbrush. The final choice is made when the prototype is finished, which makes it possible to see which of the two options works better. Light control can be implemented with an ordinary Led light considering its size.

8.6 3D model

Industrial design makes products and services both aesthetically pleasing and user-friendly. Well-designed products, services and systems enhance efficiency, improve productivity and security, reduce frustration and increase satisfaction. Product design emphasizes consumer value and personal preferences. Product performance is the sum of ease of use, ergonomics and optimization of manufacturing. A good product is natural to use, but at the same time it is possible to produce the product at a reasonable production cost. (Teollinen muotoilu n.d.) The reminder was designed to be versatile. It can be attached to a wall or placed in a lower cabinet. We also wanted to consider the aesthetics and designed a reminder that is elegant but minimalist and practical. In addition, the reminder does not have sharp corners and edges, so it is safe to use (Image 1).

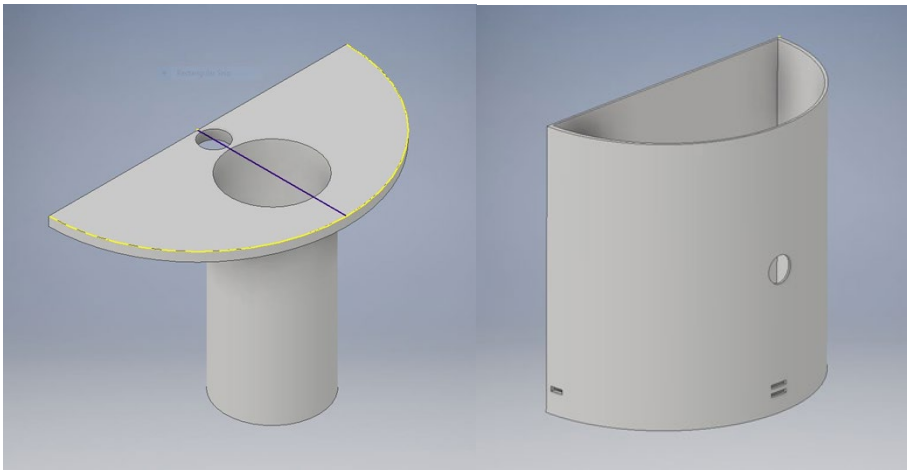

Image 1. Pictures of the innovation.

The toothbrush opening is also designed to be wide, so it is suitable for toothbrushes of different thicknesses. Thanks to its shape, its placement is easy regardless of the bathroom. The MEMbur-shORY reminder is also easily detectable. The only point to note is the proximity to a socket, so it can be charged easily when needed.

8.7 Conclusion and discussion

MEMbrushORY helps to promote the right to good oral hygiene as defined in the Finnish Act on the Status and Rights of Patients (Laki potilaan asemasta ja oikeuksista 785/1992). MEMbrushORY improves older people's quality of life and reduces oral health care costs. It also prevents mouth infections and provides social savings. However, older people need to be involved in promotion of their oral and dental health so that their chewing ability would remain good and they would not have mouth pain. An inflammation in the mouth or a cavity in the teeth may make eating difficult and cause distress if oral health care services are not sought. (Keskinen 2015, 147.) Therefore, oral hygiene and dentures should be taken care of. In addition, monitoring latent and asymptomatic infections of the mouth is important: older people should have oral and dental check-ups regularly, even if they have no natural teeth. (Keskinen 2015, 148; Syrjänen & Söderholm 2007, 242-243.)

Uniformity requires that clients with a similar need for treatment are treated according to similar principles. Provision of treatment must not depend on the age, place of residence, social status of the client, nor on any person's characteristics. Everyone has the right to be safe when they age, which includes the right to adequate and good care. As a society, we have a duty to ensure that

older people receive the care they need and that they can retain their dignity and sovereignty and their own values. We can assess the current state of development and the development needs of elderly care by considering how we would like we need to be treated when we need help and care. (Vanhuus ja hoidon etiikka 2008.)

The result of a research may be an invention that is a new and surprising solution to the problem being investigated. For example, the invention may be a method for preparing a substance or a solution, which makes it possible to produce a new product. (Jokela & Räsänen 2011, 3.) The aim of this article is to describe how older people's oral health can be promoted with an innovation, in this case the MEMbrushORY reminder. It helps older people improve their oral hygiene and quality of life. MEMbrushORY is easy to use and compatible with every bathroom and toothbrush. It also leads the way to further innovations helping older people take care of their oral hygiene at home.

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