Robotic socialites

the implementation of socially assistive robotics in closed elderly care facilities in the Netherlands

Dembski, A.V.

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The implementation of socially assistive robotics in closed elderly care facilities in the Netherlands

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By Artem Vladislavovich Dembski
TU/e identity number: 0870828

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Supervisors

dr. B.M. Sadowski	TIS, Eindhoven University of Technology
dr. P.J. Nickel	TIS, Eindhoven University of Technology
dr. G. Papachristos	TIS, Eindhoven University of Technology
A.L.J. Hermans	Implementation Consultant, Bright Cape

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Summary

Developed countries are experimenting with socially assistive robotics to support the healthcare system which are facing challenges from increasing elderly population. Socially Assistive Robots (SAR) are enablers to support the caregiving process by focusing on aiding elderly and caregivers through social interactions in the healthcare environment. In order to enhance benefits from SAR, the implementation within the workflow of caregivers and existing technological systems of elderly care homes needs to be guided through an implementation framework of IT adoption and implementation focused on healthcare technology.

This thesis takes the focus on studying the implementation of SAR in closed elderly care facilities to achieve the adoption of SAR within the daily, routine workflow of caregivers. Currently, there are few studies focused on the longitudinal implementation and adoption of SAR within elderly care facilities and these studies recommend further investigation on long-term implementation and adoption of SAR within the daily, routine workflow of caregivers in elderly healthcare facilities. The research question guiding this thesis: *How can socially assistive robots be implemented in elder care work environments using the Integrated Technology Implementation Model (ITIM) in order to reduce workload of caregivers in routine, daily tasks?*

With this focus, the research finds its roots in trends in the elderly healthcare sector in OECD countries and the rising demand of elderly care and its societal and economic consequences, the SAR taxonomy and variety of offerings in the market, IT implementation frameworks for healthcare and elderly care organizations including the workflow of caregivers. Literature and theories from these fields where reviewed as the foundation of this thesis and informed the methodology and analysis to answer the research question.

From the literature regarding the trends in the elderly healthcare sector in OECD countries and the rising demand of elderly care and its societal and economic consequences, it becomes apparent that the rise of the amount of elderly as part of the total population results in an increasing burden on the closed elderly care industry as the rising demand for care by the elderly consequently results in high experienced workload and increased turnover and sick leave among caregivers.

Additionally, this thesis analyses the SAR market through the review of academic literature on SAR development and online research of SAR availability in the market shows that there is a wide variety of SAR available in the market based on SAR development according to the taxonomy of SAR and various features relevant for the competition aspect of the SAR market. This thesis suggests dividing the available SAR in three main types that are commercially offered: Plug and Play Bots, Social Health Assistants and Multi-Industry Robots. The main differences between the three types are the availability of software updates, degrees of implementation support and customization options in terms of hardware and software.

Further, the research on various implementation models for IT has shown that the main difference is the focus of the implementation as Technology Acceptance Models (TAM) are developed for adoption by users while Implementation Science (IS) models are developed for adoption of IT by organizations. ITIM appeared to be a suitable model for SAR implementation in closed elderly care as it combines the concepts of TAM and IS models and focusses on the implementation of healthcare technologies in healthcare environments.

The methodology put forward for the analysis takes inspiration from the literature reviews of IT implementation models and the SAR market analysis. Here various models are compared in order to identify the most suitable IT implementation model for SAR implementation in closed elderly care facilities. Various concepts are defined and adjusted for SAR application purposes. Based on ITIM theory, an ITIM with adjustments is developed for SAR implementation purposes with the goal to facilitate durable integration of SAR within the caregiver workflow of caregivers in closed elderly care facilities. Also, the Continuous Improvement Framework (CIF) is researched and described.

The results in this thesis are presented according to five sub-questions which consider (1) the applicability of the ITIM for long-term implementation of socially assistive robotics in closed elderly care, (2) developing an adjusted implementation model based on the 12 concepts of ITIM including the incorporation of CIF, (3) analysis of the effect of SAR implementation on the workflow of caregivers, (4) analysis of workload measurements of caregivers from both elderly care organizations, and (5) analysis of usage log data in order to measure the progress of adoption.

For the first sub-question, ITIM appeared to be a suitable model for SAR implementation in closed elderly care as it combines the concepts of TAM and IS models and focusses on the implementation of healthcare technologies in care environments.

For the second sub-question, various ITIM concepts are adjusted and a distinction is made between fixed and variable concepts as the nature of the technology is predetermined to be SAR and the outer concepts regulation, economic environment and vendor are predetermined once a choice has been made to implement a specific SAR in a specific elderly care organization, with predetermined financial means, that is located in a country which determines the regulatory and economic concepts. The inner concepts of users and leadership have been combined as these concepts both specify stakeholders and their powers and interests. The result of this distinction is the Adjusted ITIM consisting out of variable concepts: users, workflow, interfacing systems and facilitator role. Further, the Continuous Improvement Framework (CIF) is described and its repetitive cycle feature that ensures a cyclical approach towards implementation of SAR allowing for improved feedback gathering on capabilities and usability. The resulting Adjusted ITIM with CIF is accompanied with a guide on how to apply the adjusted implementation model.

The Adjusted ITIM with CIF has been applied in two separate case studies where fixed concepts like type of SAR, vendor, and regulatory and economic environments were described. The variable concepts have been determined by applying various analyses. First, users are determined through stakeholder analyses and semi-structured qualitative interviews which resulted in a selection of relevant stakeholders for SAR implementation. Second, the workflow analyses using information on patient care plans, information on both closed elderly care facilities, analyses of usage logs, and semi-structured qualitative interviews, resulted in the understanding of the relation between specific functionalities and their preferred application during the routine, daily work schedule of caregivers. Finally, interfacing systems are determined mainly through semi-structured interviews where it is suggested to integrate SAR in the existing communication and reporting technologies, but this has not been attempted nor implemented due to the limited time and scope of the case studies.

For the third sub-question, it has been strongly suggested by interviewees that a relation exists between the type of functionality and the routine, daily work schedule of caregivers. The results suggest that functionalities that could contribute towards the efficiency of primary care task performance like medicine delivery, would boost efficiency of caregiver workflow.

Further, the implementation is suggested to have negatively impact the workflow of caregivers as they have an additional task to experiment and use the SAR during their routine, daily work schedule. Also, the implementation efforts based on CIF, especially the information, training and evaluation sessions take up a lot of time for the caregivers as they work part-time shifts and the scheduling of these sessions is not fully compatible with their work schedules. Finally, due to the experienced high workload and predetermined schedule of work meetings, caregivers do not have time to consider useful applications of SAR if management does not provide them with this time.

This thesis suggests to management of elderly care organizations to provide caregivers some additional time to enhance their understanding of the benefits of SAR and implement SAR within their routine workflow for the benefit of the elderly and the caregiver team.

For the fourth sub-question, the results of the workload measurements show that the workload of caregivers has not made any significant changes. It is apparent that the implementation of SAR cannot decrease the workload by itself as overall workload of caregivers is subject to many factors outside the scope of SAR implementation and adoption. This thesis concludes that investigating workload of caregivers is only relevant to determine the workload itself and is not useful to analyse the workload during the implementation of SAR.

For the final sub-question, this thesis concludes that by gathering and analysing usage logs and combining these results with calendar data, work schedules, and information on daily routine and activities, it allows stakeholders of the implementation to understand why the SAR is used and propose suggestions to increase the use of SAR and boost adoption.

This thesis has provided and tested an easy-to-use model and guide for future SAR implementations in healthcare environments that can be adjusted and improved upon based on prospected requirements. The analyses show that the implementation of SAR can be achieved if managed properly with all relevant stakeholders and if the facilitator accounts for the existing workflow of the closed elderly care facilities. The most important aspect of the implementation is continuous communication without any obstacles as it allows stakeholders to debate on intermediary results, evaluate feedback and adjust the implementation schedule. This thesis complements studies on SAR implementation by showing that by analyzing usage logs and perceived workload combined with qualitative feedback useful insights are generated which allow the stakeholders to effectively evaluate the progress of implementation of SAR.

From a policy perspective, this thesis suggests developing policies on national and regional level that stimulate e-health providers to offer active implementation support for healthcare organizations. A useful tool to achieve this is co-innovation subsidy grants that allow collaborating organizations to allocate funds for implementation of e-health technologies like SAR.
Second, this thesis suggests that healthcare organizations' management allows caregivers to learn e-health application and integration on the job while having full accessibility to information and advice on effective e-health implementation.
The first allows for enhanced cooperation allowing for innovative solutions where demand in healthcare is high. The second allows for enhanced education. Policymakers can examine the changes in quality of life for clients and caregivers, in efficiency of caregiving task completion, and in reduced care demand to caregivers, and consequently develop policies allowing time and resource allocation for advanced caregiver education and training.

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In the last months, I have carried out my thesis at Bright Cape on a very exciting topic that I will always remember. The implementation of socially assistive robotics in closed elderly care facilities in the Netherlands has resulted in an amazing experience. This project inspired me to contribute towards improvement of social assistance for the elderly and reducing the high burden on caregivers. This thesis represents the academic and hands-on implementation experiences for which I am grateful.

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Artem Dembski

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List of acronyms

SAR	Socially Assistive Robotics
ITIM	Integrated Technology Implementation Model
CIF	Continuous Implementation Framework
TAM	Technology Adoption Model
IS	Implementation Sciences
NASA TLX	National Aeronautics and Space Administration Task Load Index
OECD	Organization of Economic Cooperation and Development
WHO	World Health Organization
EBP	Evidence-based practice
UTAUT	Unified Theory of Acceptance and Use of Technology
SARA	Social Autonomous Robotic Assistant

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1. Introduction

Worldwide people are aging, and developed countries are looking at assistive technologies that can take up significant challenges in the healthcare systems like the increasing workload and time pressure that caregivers are experiencing (WHO, 2015). Also, nursing shortages are experienced by many countries as a result of the growing demand of the aging population on the healthcare system (Kachouie, Sedighadeli, Khosla, & Chu, 2014). Socially Assistive Robotics (SAR) are suggested by human-computer interaction experts worldwide as enablers to support the care giving process (Bemelmans, Gelderblom, Jonker, & de Witte, 2012; Kachouie et al., 2014; Tapus, Maja, & Scassellatti, 2007). SAR are robots that focus on assisting people through social interaction (Feil-Seifer & Matarić, 2005). Various qualitative and mixed-method studies on SAR application for elderly healthcare purposes with a focus on human-robot interaction, technology acceptance by users and healthcare have been conducted that have recorded positive outcomes (Shukla, Barreda-Angeles, Oliver, & Puig, 2017; Tiberio, Mitzner, Kemp, & Rogers, 2013). As acceptance of SAR's integration in the process of caregiving increases, the contributions to care in favor of both elderly and caregivers become obvious (Bemelmans et al., 2012; Shukla et al., 2017; Shukla, Cristiano, Oliver, & Puig, 2019). Recent advancements in socially assistive robotics like cognitive human-robot interactions, daily caregiving tasks and implementation in daily work routines of multi-disciplinary teams show that healthcare providers are ready to include SAR's in the task management of elderly care homes. Eventually, total incorporation of SAR in the process of care giving is expected to have a positive influence on both quality of care and life for care givers and recipients. These benefits are expected to alleviate the burden experienced by the elderly healthcare system.

However, SAR implementation in elderly care institutions has been confined to controlled academic studies with the disruptive presence of researchers. No longitudinal studies have been conducted with a focus on SAR implementation within live healthcare environments have been conducted in the field of SAR. Since 2010, studies within this field focused on the possible contributions that robotics could have on quality of care and whether robotic systems would be accepted by caregivers and recipients. Other research has provided evidence on the possible benefits for elderly in long term SAR implementation and investigated preferences regarding implementation of a robot in daily work routines (Bemelmans et al., 2012; Broekens, Heerink, & Rosendal, n.d.; Coco, Kangasniemi, & Rantanen, 2018; Kachouie et al., 2014; Salichs, Encinar, Salichs, Castro-González, & Malfaz, 2016). Also, ethical concerns have risen regarding the issue of objectification of elderly and way of carrying out elderly care tasks (Feil-Seifer & Mataric, 2011). The most recent research has started to investigate the effect on labor focusing on the effects of SAR on caregiver workload, time pressure and possibilities of integrating SAR within the caregiver's workflow and complementing human resources (Shukla et al., 2017, 2019). These studies have been performed by applying mixed-method research methodology using questionnaires, time tracking and qualitative interviews in controlled environments. Field research is needed in order to investigate how SAR can be implemented in live, closed elderly care environments where elderly with dementia live in an adapted physical environment in order to protect the clients. Caregivers can benefit from SAR integration in their workflow and its interface with technological systems already used in these care environments. A framework for IT adoption and implementation focused on healthcare technology, like the Integrated Technology Implementation Model (ITIM), may have positive implications for SAR technology adoption and implementation (Schoville & Titler, 2015). They have provided insight in changes in subjective workload, division of caregivers' time and overall experiences regarding SAR implementation. Implications for long term implementation are not clearly stated in research results and discussions recommend investigating how perceived changes in labor and workflow could affect elderly care work environments.

1.1 Research questions

The central research question of this study is:
How can socially assistive robots be implemented in closed elder care work environments in the Netherlands using the Integrated Technology Implementation Model in order to reduce workload of caregivers in routine, daily tasks?

This research question addresses various lines of inquiry. This thesis differentiates between five sub-questions in order to provide clear oversight of the structure for answering this question. To the author's knowledge, there has been no literature regarding the longitudinal implementation of socially assistive robotics in closed elderly care environments nor has the Integrated Technology Implementation Model been applied in the context of SAR. Therefore, it is essential to identify whether the ITIM is applicable for SAR implementation. This aspect is the basis for sub-question 1:

Sub-question 1:
To what extent is the ITIM applicable for the long-term implementation of socially assistive robotics in elderly care?

ITIM framework is a basis for the implementation of healthcare technologies and lays thorough groundwork by elaborating on the 12 concepts necessary to consider for the implementation of a not specified healthcare technology. In order to apply ITIM, these concepts must be clarified and adjusted in detail to fit the SAR technology. Also, ITIM does not specify any constrains regarding the timeline of e-health implementation, which is crucial for implementation projects as the goal is to achieve a certain degree of adoption within a given time period. Literature regarding implementation including a timeline offered the Continuous Implementation Framework (CIF) which provides a cyclical aspect to the e-health implementation (Victores, Jardon, Bonsignorio, Stoelen, & Balaguer, 2010). These two aspects lay the basis for sub-question 2:

Sub-question 2:
How can the ITIM be adjusted into an easy-to-use SAR implementation model that incorporates the continuous improvement framework?

The adjusted concepts of ITIM combined with the incorporation of the CIF allows for an integration of SAR into the workflow. To the best of the author's knowledge, there has not been no literature regarding the effect of SAR on the workflow of caregivers in closed elderly care environments. Sub-question 3 addresses this:

Sub-question 3:
By applying the Adjusted ITIM, what effect does socially assistive robotics implementation into the caregiver workflow have?

The implementation of SAR into the workflow of caregivers is suggested to reduce their workload in healthcare facilities by literature. One controlled research study has shown some reduction in workload of caregivers, but to the author's best knowledge, there has not been a study regarding the effects of SAR on workload of caregivers in live elderly care environments. Sub-question 4 addresses this:

Sub-question 4:
How is workload of caregivers affected and which workload factors are affected because of socially assistive robot implementation?

The process of implementation of SAR can best be controlled through usage logs to analyse how and when the SAR is being used in the closed elderly care facilities. To the best of the author's knowledge, there has been no usage log analysis in literature regarding SAR.

Sub-question 5:
How can the implementation of SAR using the Adjusted ITIM be monitored through usage log data?

By answering the five sub-questions, this thesis aims to obtain an integral understanding of the implementation of SAR in closed elderly care facilities and the effect on the workload of caregivers. Additionally, it provides insight in how to adjust the ITIM for the SAR technology, stimulate the implementation through continuous improvement and analyse the process of implementation through usage logs, workload measurements and qualitative data from interviews with staff of closed elderly care facilities. The novel methodology and specific scope of this study provide a unique perspective which means this study is exploratory. It explores the implementation of SAR in closed elderly care facilities and its effect on the workload of caregivers.

1.2 Thesis setup

This current study has chosen an exploratory, mixed-method approach by conducting an extensive literature study on trends in the elderly healthcare sector in OECD countries and the rising demand of elderly care and its societal and economic consequences. Further, the rise of socially assistive robotics as an academic interest and early applications are examined in existing literature. As there has been little research focused on the implementation of SAR in the healthcare sector, this study has researched various implementation frameworks focusing on technology and has chosen to research the Integrated Technology Implementation Model (ITIM) by Schoville & Titler (2015) in the context of SAR. This framework combines the individual level of analysis and focus on adoption of technology provided Technology Adoption Models (TAMs) and the organizational level of analysis and focus on adoption of evidence-based practices in Implementation Sciences (IS). Further, the ITIM framework is especially designed for innovative technologies in the healthcare industry as it considers both internal and external factors, stakeholders, and various key concepts central to the process of technology adoption and implementation (Krau, 2015; Schoville & Titler, 2015). As this model has not yet been tested for SAR in healthcare applications, the application of this model may result in possible benefits for caregivers like reductions in workload which would benefit the organizations as workload increase affects turnover and sick leave. This study has adjusted the ITIM in order to be applied for SAR implementation purposes. This Adjusted ITIM is further developed by integrating the Continuous Improvement Framework which allows for cyclical implementation of SAR within closed elderly care environments. Also, the effect of SAR on caregivers is studied through semi-structured, qualitative interviews, usage log analyses and subjective workload measurements. Previous literature studies especially note benefits for care recipients but are still in very early stages of showing benefits to caregiver working conditions allowing them to guarantee a high quality of life to their elderly clients, perform their caregiving tasks more efficiently and reduce the perceived amount of workload which may result in less turnover and sick leave (Brose et al., 2010; Flandorfer, 2012; Kachouie et al., 2014; Khosla et al., 2012; Shukla et al., 2017). This depends on the level of applicability of SAR and its functionalities in their routine, daily work.

In two explorative case studies conducted in the current study, the implementation of SAR through the Adjusted ITIM with CIF is analyzed by applying the adjusted implementation model within two live closed elderly care environments both located in the Netherlands. Based on the theoretical concepts and necessary adjustments made for SAR implementation applicability, the ITIM framework is for the first time put to the test.

All use of the SAR in the scope of the case studies is logged, which allows analytics to assess which functionalities are used during which parts of the routine day. By analyzing the logs and sharing the findings with caregivers, they can be guided to apply the SAR in specific moments of the day and during specific tasks in order to work more efficiently and reduce their perceived workload. By measuring caregiver workload using a qualitative method called the NASA Task Load Index (NASA TLX), the subjective workload during various healthcare tasks can be analyzed and differences in perceived workload over time can be interpreted. Further feedback from caregivers can elaborate on the perceived changes in workload and explain whether these changes occurred as a result of SAR integration in the workflow. This can show the benefit of adopting and implementing SAR in elderly care facilities. Finally, semi-structured qualitative interviews are conducted to analyze subjective impressions of caregivers with the robot regarding robot's usefulness of workload reduction.

By applying the adjusted ITIM with CIF for SAR, a practical roadmap for SAR implementation in closed elderly care facilities located in the Netherlands is developed using key technology implementation factors. Further, various visualization options for ITIM are proposed in order to develop a generalized and practical tool for applying the ITIM framework in cases for SAR implementation in elderly care facilities. Also, the potential benefit for elderly care facilities that are struggling with high caregiver workload and stress, increasing turnover and sick leave numbers, is outlined and supported through two explorative case studies. The results of these studies combined with the conclusions and recommendations of SAR technology research and healthcare technology implementation studies are provided. Finally, various limitations of this study are presented and recommendations for future studies are outlined. Section 5.5 describing the implications for policy makers is added to provide recommendations in order to improve the quality of life of caregivers and prepare the elderly care industry in OECD countries for socially assistive robotics.

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- Conclusion and discussion

Figure 1: Outline of the thesis

2. Theoretical background

2.1 Healthcare for Elderly

As the population all over the world is getting older, the process of ageing and taking care of the resulting elderly age group poses an increasingly bigger challenge for all parts of the society. The definition of an elder person is one of 65 years and above. The share of the population that is 65 or older will be 36% in Europe by 2050 (Haseltine, 2018; OECD, 2019). Due to the steady improvement in health-care delivery services, people are able to get older and older resulting in an increasing percentage of elderly in our global population (EY, 2019). This demographic transition will lead to changing demands to health care systems in developed countries. The potential support ratio, that is the number of persons aged 15-64 years per 1 older person aged 65 years or older, is expected to heavily reduce from 4.8 in 1995 to 2.1 in 2050 (Flandorfer, 2012). This severe reduction of the potential support ratio will increase the imbalance between caregivers and care recipients, resulting in increasing demand pressure on the Western European healthcare system (Bemelmans et al., 2012).

Healthcare is now tasked with not only offering cures to diseases but also providing aid in daily life. Support of elderly in day-to-day help with activities like washing, dressing and household tasks along with some types of medical care is called long-term care (OECD, 2019). The development of long-term care services is regarded as one of the main challenges for the innovative capabilities of Western European welfare systems, which are not able to meet the rising care demands of long-term care (Haseltine, 2018). The challenge of changing demands towards long-term care should be addressed by joint strategies and collaborations of both the public and private sector.

Throughout the aging process, some types of conditions become more prevalent like chronic diseases, physical disabilities, mental illnesses and other co-morbidities (Shrivastava, Shrivastava, & Ramasamy, 2013). 20% of elderly suffer from a mental or neurological disorder that are very important to provide treatment for (WHO, 2017). Dementia and depression are most common. Dementia incidence increases exponentially between the ages of 65 and 90 years with an overall incidence rate of all-cause dementia of 18.2% per year similar for men and women (Corrada, Brookmeyer, Paganini-Hill, Berlau, & Kawas, 2010; OECD, 2019). The increase in cases of dementia in OECD countries and the rest of the world, requires the OECD to again review their policies regarding quality of life improvement of people diagnosed with this condition. The measures until now have had some positive effect on the quality of care that people with dementia receive but these measures are still in their pilot phase and only applied in OECD countries (OECD, 2019).

2.2 Rising demand and consequences

Demand for long-term care is expected to rise due to ageing populations and the increasing prevalence of long-term conditions such as dementia. Within OECD countries, there tends to be a high variety in available and affordable long-term care services with public spending ranging from 4% of GDP in the Netherlands to less than 0.5% in countries like Latvia, Poland and Estonia (see Figure 2) (OECD, 2019). Also, a general shortage of nurses is a public health concern in many countries including OECD members. This is the result of various negative working conditions that affect caregivers which are presented as high turnover and prolonged sick leave among caregivers. In order to compensate for the turnover and sick leave, care facilities resorted to more expensive self-employed short-term personnel. These negative effects are most felt by the disability and long-term care sectors as most care personnel are employed in these sectors, which makes them most vulnerable to turnover and sick leave (EY, 2019; Lieshout, 2019).

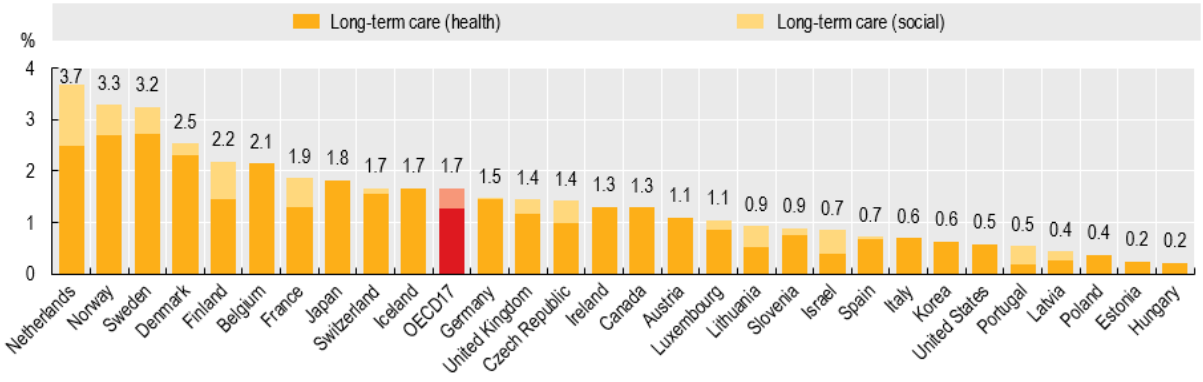

Figure 2: Long-term care expenditure (health and social components) by government as a share of GDP, 2017

The turnover and sick leave numbers are relatively equal amongst all age groups of caregivers. It is important to note that younger healthcare professionals tend to mention mental issues as the main cause while older healthcare professionals mention physical complaints (Elst, 2018; WHO, 2015, 2017). High workload and resulting stress experienced during caregiving tasks is highly indicative of sick leave (Fjelltun, Henriksen, Norberg, Gilje, & Normann, 2009; Xiaoming, Ma, lisa Chang, & Shieh, 2014). Also, more complex caregiving tasks seem to contribute to higher experienced workload. Several studies suggest that some caregivers are more sensitive to high physical workload, while others are more sensitive to mental workload. Also, the demanded pace of performing tasks and the number of tasks seem to be determinants of experienced workload. Finally, emotional burden as result of performing caregiving tasks and perceived performance of these tasks are also related to high workload (CBS, 2016, 2019; Fjelltun et al., 2009; Xiaoming et al., 2014). Due to the high workload and resulting sick leave, a shortage of personnel is noticeable throughout the entire healthcare sector. This shortage puts again more pressure on working caregivers which in turn leads to higher sick leave and eventually an increase in turnover.

2.3 Dementia

Dementia is defined as an overall term for diseases and conditions which have a negative effect on memory, language problem-solving and other cognitive skills that affect the ability to perform in everyday activities. Memory loss is the most common example of dementia and Alzheimers's disease accounts for 60 to 80 percent of cases of dementia (Government.nl, 2017; Ienca, Jotterand, Vica, & Elger, 2016).

More than 260.000 people are living with dementia in the Netherlands and this amount is expected to rise by 2050 as the average age will become higher and the amount of elderly will keep on growing (Government.nl, 2017). After being diagnosed with dementia, people tend to live at home where family and relatives take care of them. Once more professional and continuous care is required, they are moved to long-term care solutions.

In the case of most progressive dementias, there is no cure and no treatment that slows or stops the progression of dementia. While drug treatments may temporarily improve symptoms, non-drug therapies can also alleviate some symptoms of dementia. It is suggested that encouragement to use novel technologies can improve the quality of life for people living with dementia. The application of intelligent assistive technologies, which includes SAR, that compensate for specific physical, cognitive and behavioral deficits of people with dementia, are suggested to alleviate caregiver burden related to long-term care and institutionalization (Ienca et al., 2016).

2.4 Caregivers and tasks in closed elderly care

This section introduces the routine day of caregivers in closed elderly care facilities including their tasks and standard time schedule. This provides insight to the reader into the routine daily workflow of caregivers which is essential to understand for the implementation of SAR as this allows implementation facilitators to achieve benefits for the caregivers and elderly.

Elderly with progressive dementia are often placed in closed elderly care facilities that offer a 24-hour, seven days a week protection, nursing and intensive mental care. The caregivers working in these facilities have a wide range of tasks and functions (Aginginplace.org, 2018; Ananz.nl, 2018).

Below a list of 12 main tasks of caregivers in closed elderly care facilities is shown. Most tasks are done every day, multiple times per day, by caregivers.

- Assisting with personal care
- Basic preparation of food
- General health care
- Mobility assistance
- Personal supervision
- Emotional support
- Transportation
- Mediation
- Home organization
- Handle a crisis or medical emergency
- Back-up caregiving
- Administration

Also, a standard time schedule of a routine day in a closed elderly care facility in the Netherlands is provided. Sometimes activities like bingo, physiotherapy and family visits take place during the day. See table 1.

7am – 10am	Morning care including medicine delivery, assisting with personal care, physical exercise and breakfast
10am – 12pm	Free time
12pm – 2pm	Lunch and napping
2pm – 5pm	Free time
5pm – 10pm	Dinner followed by evening care including medicine delivery and assisting with personal care

Table 1: Standard time schedule for routine day in closed elderly care facility in the Netherlands

2.5 Defining workload

As staff in elderly care tends to leave work due to high and continuous stressors at work and experience burnout effects from workload, it is necessary to measure the subjective workload experienced by caregivers in elderly care during the implementation and adoption of SAR (Hoonakker et al., 2011; Kachouie et al., 2014; Xiaoming et al., 2014). As the concept of workload is difficult to conceptualize, workload has been defined in three components; (1) There is an operator (caregiver), using his or her resources to respond to (2) external physical or cognitive demands to (3) perform a certain task (Hoonakker et al., 2011).

In order to examine the causes of high workload, identify the strategies, methodologies and tools to analyse the perceived workload of caregivers. Hoonakker et al. (2011) suggests trying the operator-based approach which considers characteristics of the caregiver and interactions between the caregiver and the work environment. A frequently used method to measure subjective workload is the NASA Task Load Index. This instrument is one of the most widely used instruments to assess overall subjective workload in hundreds of studies, according to a recent estimation (Hoonakker et al., 2011).

2.6 Nasa Task Load Index

The subjective workload during various healthcare tasks can be measured and differences in perceived workload over time can be analyzed. The NASA-TLX questionnaire that assesses mental demand, physical demand, temporal demand, performance, effort and frustration, also asks which care tasks have been performed by caregivers during routine workdays (Hoonakker et al., 2011; Pires De Pires et al., n.d.; Shukla et al., 2017). This can show the benefits experienced by caregivers and their organizations of adopting and implementing SAR in elderly care facilities as both studies and companies in the SAR market have suggested that perceived workload may be reduced. Limitations regarding studies that measured the workload of caregivers who have applied SAR are discussed in section 2.9.1.

2.7 Socially Assistive Robotics: What and why

The field of socially assistive robotics (SAR) has been defined as the intersection of assistive robotics, robots used to improve independence and quality of life of people with disabilities (Brose et al., 2010), and socially interactive robotics, robots tasked to perform basic social interactions (Feil-Seifer & Matarić, 2005). Therefore, a SAR is tasked with providing assistance to human users through social interaction and develop connections to the caregivers and elderly. Also, SAR is expected to achieve measurable progress in rehabilitation, learning and similar activities (Feil-Seifer & Matarić, 2005). Fong (2003) has defined a taxonomy consisting out of eight properties and Feil-Seifer & Mataríc (2005) have added four more properties in order to completely describe the interaction component of a socially interactive robot (Feil-Seifer & Matarić, 2005; Fong, Nourbakhsh, & Dautenhahn, 2003). The 12 properties are stated and briefly described in Table 2.

Feature	**Description**
Embodiment	Measure of influence the robot and environment have on each other based on its morphological design considerations (anthropomorphic, zoomorphic, caricatured, functional)
Emotions	Complex phenomena that are tightly coupled to social context. The integration of emotions into robot interface and design exists out of 5 parts; Artificial emotions, emotions as control mechanism, speech, facial expression and body language.
Dialogue	Joint process of communication that involves sharing of information that consists of data, symbols and context between two or more parties. (low-level, non-verbal, natural language)
Personality	The Big Five Inventory consisting of extroversion, agreeableness, conscientiousness, neuroticism and openness. Social robots tend to use the following five common personality types: tool-like, pet or creature, cartoon, artificial being and human-like
Human-oriented perception	Perception optimized for interacting with humans and on a human level. Focus on types of perception, people tracking, speech recognition, gesture recognition and facial perception.
User modelling	Detection and recognition of human action and communication through various approaches of user modelling; quantitative, qualitative, stereotype, cognitive, additional, etc.

Socially-situated learning	Learning through various techniques like direct tutelage, observational conditioning, goal emulation and imitation.
Intentionality	In social interactions the robot needs to provide evidence that is intentional for the human to consider the robot is acting in a rational matter. This evidence can be provided through goal-directed behaviours (expressiveness) and exhibition of attentional capacity.
User populations	SAR are able to address various populations of users, ranging in age, impairment and need. (target audience)
Task examples	Tasks of the robot are driven by the needs of the user. (tutoring, physical therapy, daily life assistance, emotional expression)
Sophistication of interaction	Interactions need to be treated separately from 'emotions' as this feature only describes how human-robot interaction but does not describe reciprocal interaction by the human user. (speech, gestures, direct input)
Role of the assistive robot	Definition of the role of the robot is crucial for crafting its appearance and interaction modalities.

Table 2: Simplified features of Socially Assistive Robotics by Feil-Seifer and Mataríc (2005)

By defining SAR and providing a taxonomy of interaction components, a summary of related work in the field of socially assistive robotics is stated benefitting the selection of properties for SAR implementation and adoption in elderly care facilities.

2.7.1 Proposed additions to SAR taxonomy

Various SARs like the Paro Therapeutic Robot are especially designed to recognize and process people and their environment through a variety of sensors including tactile, light and temperature ("PARO Therapeutic Robot," n.d.). As Fong (2003) has defined human-oriented perception as "Perception optimized for interacting with humans and on a human level. Focus on types of perception, people tracking, speech recognition, gesture recognition and facial perception. (p.155)" for which gesture recognition is focussed on gestures used by humans to clarify speech. Both studies failed to identify additional sensorial capacities of socially assistive robotics like tactile gestures, a common sensorial capacity applied in various SARs in order to make communication between human and robot possible if speech is not possible (Feil-Seifer & Matarić, 2005; Fong et al., 2003). This study argues in favor of adding these missing sensorial capacities to the taxonomy list designed by Fong (2003) and Feil-Seifer and Matarix (2005). Especially the addition of perceiving touch and haptic communication, would benefit the socially assistive robotics taxonomy, as humans tend to also express themselves through touch (Rose, 2015).

2.8 The SAR market

Using the taxonomy of SAR interaction components and systematic review by Kachouie et al. (2014), a list of various, available SAR options at the moment is provided in order to create an overview of the market for SAR. Main similarities and differences are outlined in Appendix A. This analysis is mostly based on the previous selection and analyses in the systematic review (Kachouie et al., 2014). The systematic review was conducted by searching a wide range of databases[1] for publications on socially assistive robotics in elderly care using a variety of terms like "robot*", "assis* device*", "assis* technolo*", and "self-help device", "aged", "elder*", "senior*", "old person*", "old people", and

[1] Databases: MEDLINE, PubMed, BioMed, IEEE digital library and JSTOR

"dementia" and the names of specific robots with a presence in the market were used. Further, reasonable inclusion- and exclusion criteria were maintained in order to deliver a thorough and effective systematic review.

This current study acknowledges that the market analysis does not include all SAR existing companies as there are many SAR companies in foreign countries, like China and Japan, which provide information in their native language which were out of scope as this study could not include them due to the language barrier. Also, a variety of small companies or start-ups are experimenting with SAR technology and application, some of which are included in this market analysis, but others may have been left out due to the lack of online material on the SAR, no mentioning in academic literature, and no current application as it is still being developed. Due to the lack of existing research focused on the SAR market, the resulting market analysis is an initial contribution towards future research of the SAR market.

In order to determine the differentiation in the market, this study has selected the SARs provided by the study of Kachouie et al. (2014) and included some recent competitors in order to make up for the years since the systematic review in 2014. Every SAR is analysed according to the Feil-Seifer and Mataric (2005) taxonomy presented before in Table 2. Additional variables like hardware and software companies, type of offering (sale, sale including service, etc), programmability and listed price are added to provide more detail to the analysis. The full analysis is presented in Appendix A.

2.8.1 Types of SAR

The SARs analysed by Kachouie et al. (2014) and the additions made through online research may have multiple purposes in the field of healthcare. This market analysis (N=22) focusses on only the application of SARs in elderly care facilities. Other applications are out of scope for the SAR market analysis but are briefly introduced to provide an encompassing overview of the SAR market, derivative applications in social robotics, healthcare platforms and academic research.

First, it is noteworthy that most SARs are developed in either Japan, America or Western Europe with some exceptions like Cruzr (China) and Healthbot (India). Second, there is a clear distinction between the type of offering with SAR as there are research platforms like Bandit and iCat, which are set up through collaborations of companies and universities, collaborative healthcare platforms, which are software platforms with integration of healthcare service providers, smart healthcare devices and third party software and hardware applications, and commercial product offerings for healthcare-related use.

This study focusses on the commercial product offerings for healthcare-related use by businesses and consumers, preferably applicable in elder care. The type of offering varies from the sole *product including customer service availability* to *product including customer service availability, implementation assistance by supplier, software updates, open software platforms, product and service subscriptions, and development workshops*. The full variety of offerings is depicted in Table 3. Further, the selection in Table 3 is analysed according to the additional taxonomy properties added by Feil-Seifer and Mataric (2005) to Fong's original SAR taxonomy; Their intended field of application (*User population*), *task examples*, *sophistication* and *role*. These properties relate to the supplier's intention of applicability and preferred sector of application. Rows in grey are excluded as the robots are not designed to be applied in healthcare related environments. Additional and more detailed information is available in the complete SAR analysis in Appendix A.

The selection in Figure 3 is developed as a result of the SAR market research. It divides the SAR market in various categories according to the extent of offerings by the supplier.

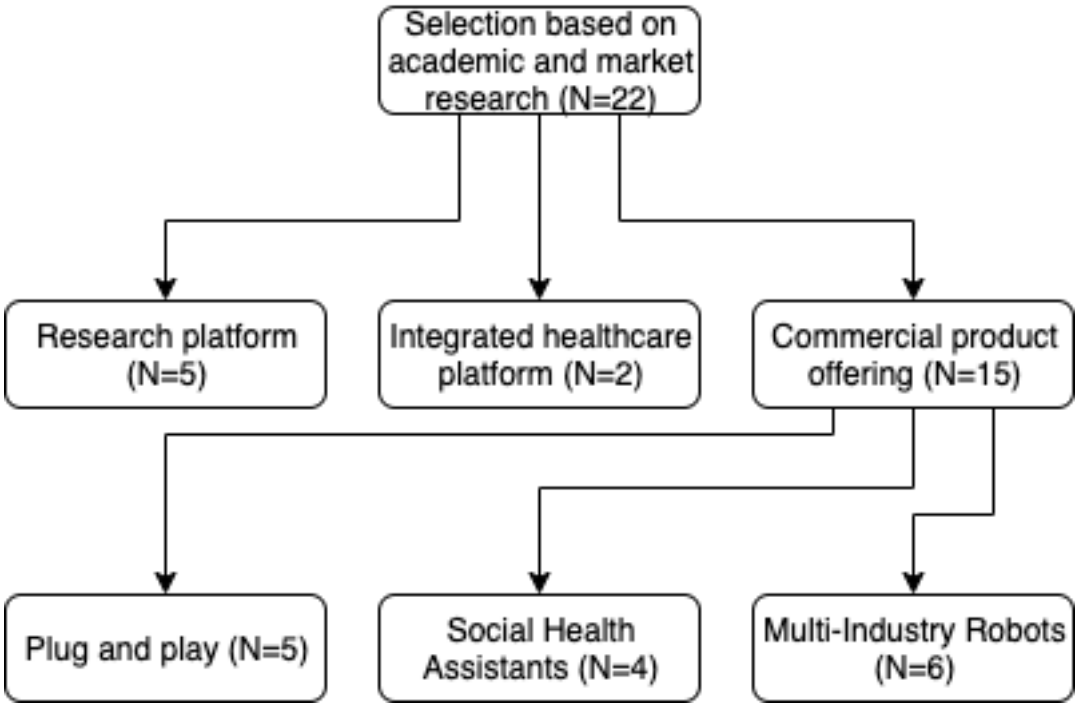

Figure 3: Selection flowchart of SAR developed by this current study based on SAR market research

Plug and play bots

The most common commercial offering for healthcare is the product and service combination, which entails that the supplier offers the SAR and provides some type of servicing like customer service and repairs. However, the supplier does not offer any implementation facilitation regarding implementation. These robots tend to be cheaper as limited additional services are provided.

Social Health Assistants

The robotic products are provided alongside with manufacturer software updates, a form of implementation support and the possibility to customize software through the open software platform. Further, various product and software subscription plans may be offered. These robots tend to be more expensive due to the additional implementation support and customization options.

Multi-Industry Robots

Highly customisable products in terms of hardware and software dedicated for very specific industries with a high degree of implementation support. The supplier provides full-service packages throughout the use of the robot. These robots tend to be the most expensive of the three types of SAR as their implementation and customization service packages are very extended.

SAR	Robot	Service desk	Implementation support	Software updates	Open software platform	Open custom hardware platform	Development workshop	Product and software subscription	App
AIBO	•	•		•					
Buddy (PRO)	•	•		•	•	•			
Cruzr	•	•	•	•				•	•
iPAL	•	•		•	•	•	•		
Nabaztag / Karotz	•	•		•	*				
Nao	•	•							
NeCoRo	•	•							
PaPeRo Petit (and series)	•	•						ü	
Paro	•	•							
Pepper	•	•	•	•	•				
Robovie-X (X PRO)	•	•		•	*		ü		
SARA	•	•	•	•				•	•
Tessa	•	•	•	•	*			•	•
Unazuki Kabochan	•	•							
Zora	•	•	•	•	•				

Table 3: SAR market analysis of Commercial Product Offerings according to variables describing the type of offering by supplier.

*Adjustable software platform limited to pre-defined options defined by supplier

2.9 SAR and the elderly – Limitations of previous studies

The elderly care industry is looking for solutions that will enable it to cope with the rising demand and reduced workforce pressures. While the elderly prefer healthcare provided by human caregivers, these caregivers have expressed strong needs towards assistance, human or otherwise (Kachouie et al., 2014). Many researchers and companies in the medical and robotics industries develop possible solutions like social robotics which have a proven, positive impact related to the support of caregiving processes (Kachouie et al., 2014; Khosla et al., 2012). Further, a mixed-method systematic review of 86 studies conducted by 37 study groups on the topic of SAR in elderly care has made several recommendations regarding current limitations of existing research and future research and applications. This review recognizes that SAR implementation in elderly care can possibly benefit elder clients' well-being and reduce workload of healthcare professionals in the respective industry (Kachouie et al., 2014). A generalized summary of positive effects of SAR on elderly is presented in Table 4 (Kachouie et al., 2014). It is important to note that the positive outcomes regarding emotion, engagement, relationships, meaning, achievement and other effects were all reported outcomes by elderly care recipients. Caregivers' acceptance and effects on wellbeing has been studied but there are limited studies regarding the implementation of SAR and related barriers and enablers (Papadopoulos, Koulouglioti, Lazzarino, & Ali, 2020).

Construct	Outcomes
Positive emotions	Improvement in feeling and mood, improvement in emotional state, feeling good experience, decrease in stress level, increase in laughter, elderly become calmer, increase in sense of security and joy of life, richer expressions
Engagement	Evocative experience, increase in activities, ease to externalize elderly internal emotions, increase activity during occupational therapy, motivating physical activity, more active movements
Relationships	Increase in social interactions and activities, increase in social networks and ties, positive social effects, decrease in loneliness, encourage and smooth the communication, attachment to robot, facilitate the establishment of friendly relationship
Meaning	Decrease in depression
Achievement	Sense of achievement in winning one-to-one or group games
Other effects	Positive psychological effect, improvement in cortical neurons, positive reaction of vital organs to stress, decrease in CgA, improvement in abilities, decrease in physical disruptive behavior and overall agitation, improvement in personalization of care

Table 1: Summary of outcomes. Generalized effects of SAR on the elder in elderly care facilities (Kachouie et al., 2014)

This study did have some limitations which threaten the generalizability of the results mentioned above. First, the cultural background of participants affects their attitudes toward robots and most studies on SAR implementation have been conducted in Japan. Second, the majority of studies used robots with an animal-like exterior which may have an impact on the results as the appearance of a robot has a strong effect on the expectations and the acceptance of the robot. Third, most user tests were conducted in clinical conditions and not in live elderly care environments (Kachouie et al., 2014). Because of these limitations, Kachouie et al. (2014) recommends engaging in studies with robots having a variety of appearances, study SAR in more culturally diverse contexts and in various developed nations. A multilingual robot is suggested to possibly be of great advantage.

Next to that, most elderly participants in the reviewed studies were women which influences the results as gender is proven to affect people's reactions to robots. Also, it is important to structurally review and manage user's expectations as these affect the interactions between human and robot. Further, broader and more consistent stakeholder analyses are necessary in order to functionally consider the perspectives of users, caregivers, family members, managers and others. Many studies have failed to identify and examine the variety of stakeholders and their expectations. Especially the perspectives of elderly have to be taken more into account (Kachouie et al., 2014). Also, the novelty and Hawthorne effects have not been mentioned in most of the studies, which threatens external validity and influences generalizability of results. The elimination of the novelty effect is only possible if studies would be conducted with a longer duration. The Hawthorne effect can only be eliminated if supervised interaction, which was the case of many SAR studies, would be lowered and eventually non-existent.

Finally, some general remarks are made regarding the weak reporting quality of SAR studies and low replicability of trails due to missing information regarding the design of trials, their conduction and analysis. Important details regarding methodology tend to be omitted in reports (Kachouie et al., 2014).

2.9.1 Limitations regarding SAR and workload measurements

Various studies have not suggested what a SAR should be able to do and what kind of functionalities it should have in order to achieve such a workload reduction (Kachouie et al., 2014; Khosla et al., 2012). No further requirements are specified by these studies. The perceived reduction in workload that was noted in one recent study was achieved under a controlled environment where caregivers first performed a task for entertainment purposes without a SAR and then with a SAR. Their subjective workload was measured and analysed, which resulted in a perceived workload reduction (Shukla et al., 2019). There has not yet been any research conducted on SAR implementation in live care environments.

2.10 e-Health Innovation Policy in the Netherlands

The government of the Netherlands stimulates its healthcare industry to offer and apply more digital care or e-health to its patients. In general, it is focussed on three main purposes: Increased digital access to medical records, performing measurements on your own and sharing these online with care professionals, and online communication with care providers.

In order to stimulate these goals, the government takes various actions. First, it aims to make e-health possibilities and applications more popular as they are not being used often in daily care circumstances. Second, it promotes research efforts regarding healthcare innovation. Also, the government offers subsidies to stimulate e-health development by the industry. Further, it supports healthcare innovators through an online platform which is designed to efficiently allocate subsidies and promote exchange of knowledge. Finally, it provides incentives to promote safe online medical record collection and sharing (rijksoverheid.nl, 2019). The government does not specify any promotion of stimulus regarding robotics for elderly care, but the innovative role of SAR contributes towards research efforts for healthcare innovation. The government's aim is to decentralize the stimulus policies for e-health and delegates the development of investment programs for e-health to the provinces.

Also, online healthcare consortia are investigating the application of robotics in elderly care with a focus on assistive robotics. These consortia post reviews and e-health implementation advise on their online channels to support other care organizations. This signals that healthcare providers in the

Netherlands are willing to innovate and contribute towards the Dutch e-Health goals (zorgvoorbeter.nl, 2019).

2.11 Concluding remarks on SAR in closed elderly care

This section has provided the developments within the closed elderly healthcare environment with a focus on the rising demand for long-term care by elderly due to their rising age and consequential increase in the number of dementia cases. Also, this section provided insight in the experienced workload increase by caregivers in their routine workflow in closed elderly care facilities. The proposed solution of SAR is explored through literature reviews including limitations. Also, taxonomy and market analyses have provided a thorough overview of the three current types of commercial SAR offerings differentiated based on additional services including software, implementation and development. Finally, the current e-health policies in the Netherlands are elaborated. These various subsections are interlinked and essential to understand the scope of SAR and be able to further develop the prospected environment for SAR implementation. In order to achieve a high degree of adoption by caregivers, a fitting implementation model needs to be developed.

3. METHODOLOGY

This section analyses various technology adoption and implementation science models for healthcare purposes and describes the development of a fitting implementation model and guide for SAR. Also, it elaborates on the various types of analyses that are necessary to conduct in order to enhance the implementation of SAR into the elderly care work environment. Based on the adjusted SAR implementation model and guide, various hypotheses are developed which are analysed in two case studies. Finally, this section elaborates on the case studies describing the SAR implemented in two closed elderly care facilities in the Netherlands.

3.1 Literature study: Previous studies on SAR impact on caregiver workload

This study has chosen a mixed-method approach by combining an extensive literature study on the elderly healthcare sector in the Netherlands and the rising demand of elderly care and its societal and economic consequences. Further, the rise of socially assistive robotics as an academic interest and early applications are examined in existing literature. As there has been limited research focused on the implementation of socially assistive robotics in the healthcare sector, this study has researched various implementation frameworks focusing on technology adoption and implementation (see Table 5) and has chosen to research the Integrated Technology Implementation Model (ITIM) by Schoville (2015) in the context of SAR. Also, the effect of SAR on caregivers and elderly is studied through extensive literature studies which especially note benefits for care recipients but have not yet shown benefits to caregiver working conditions, like reducing workload, which may result in less turnover and sick leave.

3.2 Technology adoption models

Various technology adoption models (TAM) are widely applied in the context of technology use and acceptance by the individual user focusing on perceived usefulness, ease of use, actual use, and social influences. Newer TAMs addressed additional factors such as relative advantage, compatibility and complexity of these technologies (Ammenwerth, Iller, & Mahler, 2006; Lai, 2017; Schoville & Titler, 2015). The strong suit of these models is their focus on technology adoption by the individual. But these models are limited by their lack of consideration regarding strategies and processes for systematic

implementation of technology. As organizations are comprised of multiple individuals that all contribute towards organizational behavior, individual technology adoption may be beneficial for one employee and detrimental for the other. Organizational behavior is not addressed by TAMs which leads to a lack of understanding the organizational variables that are necessary for technology implementation within the organization. Organizational variables not addressed by TAMs are depicted in Table 5.

3.3 Implementation science models

In order to understand how and why implementation strategies work, what strategies are applicable in which contexts and why, implementation science theories and frameworks try to depict how innovations are diffused and sustained in health care organizations. While all implementation frameworks and models are diverse in their key features, precision and actual process of implementation, a dependent variable, adoption of the innovative technology, is shared. Their shared purpose is directed at the design of implementation frameworks and models in order to achieve successful translation of research evidence into practice (Krau, 2015; Schoville & Titler, 2015). Further, as the main purpose of IS models and frameworks is to introduce and implement evidence-based practice (EBP), an innovation according to IS theory (Krau, 2015; May, 2013; Schoville & Titler, 2015), these resulting approaches are useful in assisting in successful implementation strategies for technological innovations through evidence, individuals and contexts.
In order to define potential users of technological innovations like healthcare providers and healthcare systems, common functionalities of IS models are problem identification, analysis and synthesis of evidence, definition, selection and use of fitting implementation strategies and evaluation of adoption of technological innovations (Krau, 2015; Schoville & Titler, 2015). There is limited research published with the focus of using IS models for healthcare technology implementation. Some studies have researched how to apply knowledge into practice using technological tools as one element of implementation while others have researched the variety of users' needs during implementation of technological innovation.

3.4 Similarities and differences of TAMs and IS models

To summarize, technology adoption models and IS models both apply analysis of innovation adoption at the individual level. They differ significantly as IS models focus on strategies for implementation while TAMs focus on the perceptions of individuals regarding technological innovation. IS models provide analyses at the organizational level limited to healthcare systems, take external influences such as policy and regulatory aspects into account, and provide various implementation strategies. In general, the process of implementation is described from an organizational perspective while the TAMs focus on the perception of the individual user regarding usefulness, ease of use and actual use. The latest iterations of TAMs do include user demographics, social influences, context, attributes of the technological innovation, and surrounding conditions that influence adoption (Ammenwerth et al., 2006; Cresswell & Sheikh, 2013; Schoville & Titler, 2015). See Table 5 for the complete comparison between TAMs and IS models.

Comparison	**IS model**	**TAM**
Level of analysis	Organization	Individual
Dependent variable	Adoption of Evidence-Based Practice	Adoption of technology

Implementation interventions	Yes	No
Context	Healthcare	Information technology and other technologies
Assess for barriers	Yes	No
Patient experience	Yes	No
External factors considered	Yes	No

Table 5: Comparison of IS and TAM Models from Schoville & Titler (2015)

3.5 Integrated Technology Implementation Model

The implementation of information technologies is difficult in the healthcare industry due to many inter-related technical, social and organizational factors, for which there are few systematic approaches that have been empirically studied (Ammenwerth et al., 2006; Cresswell & Sheikh, 2013; Jacobs et al., 2015; Tiberio et al., 2013). A systematic search and critique of implementation and adoption of healthcare in organizational settings by Cresswell and Sheikh (2013) states that there are a range of technical, social and organizational considerations that need to be analysed. These insights will improve successful implementation of technological innovations that are beneficial for individuals, care recipients and caregivers, and for organizations. Due to the inter-related nature of these dimensions, there is a need for strategic implementation models that benefit the decision-making processes regarding individual and organizational factors (Cresswell & Sheikh, 2013). The two main spheres of models and theories related to technology use in health care environments are technology adoption and the sciences of implementation. Technology adoption considers how technology is adopted by users while implementation sciences is concerned with methods that encourage the use of evidence-based practice (Krau, 2015; Schoville & Titler, 2015).

ITIM focusses on combining the key concepts of both TAM and IS in order to provide an all-encompassing model for IT implementation in healthcare environments that aligns end-user adoption needs and organizational structures. The ITIM model, depicted in Figure 4, is designed in order to develop strategies for successful implementation with focus on innovation, methods, interventions and variables (Schoville & Titler, 2015). There are two environments, the inner context and the outer context, into which all other concepts are organized. These 14 concepts are described below in Table 6.

Figure 4: Integrated Technology Implementation Model by Schoville (2015)

Concepts	**Definition**
Inner context	Organizational context that influences the adoption, spread, and sustainability of the technology innovation through active implementation strategies
Adoption (Dependent variable)	When a user is introduced to a new technology and begins to use it routinely and fully when delivering patient care
Implementation	The path to identify specifications, creations, and installation of technology; organizational readiness; and active implementation strategies, including users' attitudes, are changed, skills are built, and policies/procedures for each of the components are defined and executed
Nature of the innovation/technology	Technology innovation is a device that is used when delivering patient care and usually has two components: software—provides information; knowledge, hardware—tool that embodies the technology as material or physical object. Characteristics include the relative advantage, complexity, compatibility with norms, values, perceived need, trialability
Interfacing systems	Supplementary technology that interfaces or communicates with the new primary technology (innovation)
Workflow	The systematic steps of accomplishing a patient care task (when using a technical process or device) to achieve a desired outcome
Users (adopters)	Individuals who are in a social system (ie, LTC) that the technology is targeted to be used by for delivering care; may include RNs, LPNs, aides, physicians, pharmacists, administrators, directors of nursing, clerks, and patients. Characteristics include users' education preparation, profession, context of the work environment, experience with using technology
Leadership	Roles, specific responsibilities, and required activities (executives, managers, consultants) that promote technology adoption

Communication	Is the process of sharing information with a targeted social system using a variety of strategies that include interactive education programs, written communication, communication roles and networks, and audit and feedback
Outer context	The processes and factors external to the organization that have a synergetic relationship to the internal factors affecting a successful technology implementation. These include accreditation standards, the economic environment, regulatory requirements, vendor, technical environment changes
Accreditation/regulation	An official agency (external force) that identifies criteria to meet established standards that influence the adoption of the technology
Economic environment	The extra-organizational economic determinants that affect the organizations innovativeness such as the changing economic and political environment, government sponsor program, business competition, etc
Vendor	Any person or company that represents, sells and services the technology, which may/or may not be the innovator. Commitment of the vendor to assist and support the facility operations (quality, knowledge, resources, costs), experience with implementing the technology, etc
Facilitators (boundary spanner)	A person who assists, directly or indirectly, by providing guidance to the implementation of technology. This person can be internal or external to the organization

Table 6: Description of the 14 concepts of the Integrated Technology Implementation Model by Schoville (2015)

Section 3.6 elaborates on various critiques on ITIM as Schoville (2015) does not mention some effects that are often experienced in the process of technology implementation and does not provide a guide on how to apply ITIM for the implementation of specific technologies.

3.6 Critiques on ITIM and Effectiveness of SAR by Shukla (2017)

Both Schoville & Titler (2015), authors of the ITIM paper, and Shukla (2017), author of the latest workload measurement of caregivers working with SAR, have not mentioned nor accounted for the possible consequences of the Hawthorne Effect. This effect stipulates the alteration in behavior by the subjects of a study due to their awareness of being observed (Cherry, 2018). Shukla (2017) has accounted for the novelty effect but Schoville & Titler (2015) do not mention the possible consequences of novelty regarding healthcare technology implementation (Melkas, Hennala, Pekkarinen, & Kyrki, 2020; "What is a Novelty Effect? | Glossary of online controlled experiments. | Analytics ToolKit," n.d.).

Where Schoville's ITIM paper provides a conceptual guide for selecting interventions for healthcare adoption research studies, the author's guide lacks an easy-to-use version of the model for analyses of the various concepts that make up the Integrated Technology Implementation Model.

3.7 Development of the Adjusted ITIM for SAR

In order to develop an easy-to-use model, the 14 concepts of ITIM that Schoville & Titler (2015) has described in extensive paragraphs have to be redacted, clarified and supplemented with SAR-specific

information into comprehensive characteristics per element which will benefit clarity and oversight. So, each element is presented in a concise way while maintaining all its important building blocks. Second, as implementation is a process that aims to increase adoption over time, the Adjusted ITIM can benefit from the addition of a model that considers cyclical measures including feedback sessions and evaluation moments in order to stimulate adoption. Finally, a guide can be provided which selects the concepts that are relevant for the specific scope of the implementation while other concepts can remain more abstract as they are less or not relevant for the implementation process and can be applied as control variables.

3.7.1 Clarification and additions of ITIM concepts

As the ITIM is developed for the implementation of a variety of technologies, its concepts are described quite broadly. The ITIM concepts need some clarification and additions in order to be fully applicable in the implementation and adoption of SAR. The adjusted concepts are used for the Adjusted ITIM in section 3.9.

Inner context

Nature of the innovation/technology: Socially Assistive Robotics

As described in the Theoretical Background, section 2, the nature of SAR is described extensively through the taxonomy by Fong (2003) and Feil-Seifer and Matarix (2005) and additional properties in Table 1. These properties describe the multiple variations of SARs currently available in terms of robot design and type of offering to the elderly care market. Section 3.6 contains the analysis of a selection of socially assistive robotics and the complete analysis can be found in Appendix A.

Interfacing systems

Supplementary technologies that interact with the SAR are dependent on both the ability of the chosen SAR to connect and exchange information with supplementary technologies, and the availability of supplementary technologies at the elderly care institutions. Some supplementary technologies are necessary for some SARs to operate e.g. WIFI, while others are optional and dependent on the needs of the elderly care organization e.g. Electronic Health Records, entertainment technologies, and planning and staffing software. In order to analyse connection opportunities and their availability, a technology opportunity analysis and stakeholder analysis are mainly applied within ITIM.

Workflow

Considering the personnel in the elderly care industry, it is important to take into account the impact of SAR on the daily work schedule, their routines and general workflow of the elderly care institution. Understanding how SAR can support caregivers in their daily caregiving tasks and during which caregiving tasks the SAR would be beneficial, is essential to the implementation of SAR. Identifying caregiving tasks that caregivers would or would not accept SAR assistance and understanding caregiver preferences and acceptance of SAR in daily caregiving tasks can be done through semi-structured qualitative interviews based on validated UTAUT questionnaires, stakeholder analyses, NASA-TLX workload measurements and SAR usage log analysis.

Users

User characteristics, power and interests are important to consider during the implementation of SAR. Through adjusted demographic ID questionnaires, stakeholder analyses and semi-structured qualitative

interviews based on validated UTAUT questionnaires, users can be analysed and implementation facilitators can act and manage the stakeholders accordingly.

Leadership

Specific roles in management of the organization and consulting related to adoption are important to consider as these stakeholders have the most power and influence in the implementation process. Just like in *Users* these roles can best be analysed using the same methodologies as described in the paragraph above. This current study suggests combining the concepts of *Users* and *Leadership* in the adjusted ITIM.

Communication

Various communication strategies are required in order to achieve the right level of information on the SAR, the implementation and further background for each stakeholder. These strategies may include interactive education programs, written communication, communication roles and networks, and audit and feedback. The chosen strategies are based on the preferences of the organization. Basic information about the new SAR including its possibilities and user manuals is particularly useful for the end-users like caregivers and relatives of the elderly, while information on the alignment of SAR implementation with the elderly care organizations strategic innovation goals is useful for innovation advisors, managers and directors.

Outer context

Accreditation/regulation

ITIM incorporates accreditation and regulatory requirements from official agencies in the Netherlands regarding the criteria to meet established care standards, which influences the selection of SAR. The Dutch National Institute for Population Healthcare and Environment acknowledges that healthcare is changing due to an increase in elderly and that various technologies including assistive robotics may provide solutions to improve the quality of life of elderly, decrease the demand of care which would decrease workload of caregivers, and improve elderly care efficiency (RIVM, 2013, 2018). These concepts and expectations are extensively described in *2 Theoretical background*.

Economic environment

External factors related to the ability and consent to purchase and apply SAR in elderly care, are beneficial for the adoption of SAR and other robotics by elderly care organizations in the Netherlands as both policies and subsidies from the government promote innovative incentives of elderly care organizations regarding robotics. The elderly care organizations are the decision maker in the process of innovation and if their board of directors and innovation consultants agree on the decision to invest in SAR, the organizations are fully able to do so from an economic perspective. Some organizations might have more funds due to investments or more innovative policies, which explains the variety regarding adoption of robotics in elderly care organizations in the Netherlands.

Vendor

The supplier of the SAR may have a significant impact on the user acceptance and implementation. Also, the vendor may offer various customization options regarding SAR functionalities, offer implementation consultation and a variety of service packages. The various types of SAR vendors and their variety of implementation and service offerings are described in *2.8 The SAR market*.

Facilitator role

The person or team guiding the implementation depends entirely on the characteristics of the SAR, the functionalities, the level of service and implementation support the elderly care organization desires and the level of functionality customization, implementation consultation and service packages the vendor provides. This role can be taken up by a third party which is experienced in IT or robotics implementation, e.g. a consultancy. Also, this role can be shared by a team existing out of stakeholders of both the organization and the vendor with the possibility of including a third party to streamline the implementation process, aid in project management and designing functionalities.

Another essential aspect of the facilitator role that is not mentioned by Shoville (2015) is the importance of time management during the implementation process in order to boost the adoption over time within closed elderly care facilities. Scheduling and planning are the most important aspect that the facilitator is required to keep in mind in order to achieve a successful implementation.

3.7.2 Continuous Improvement Framework

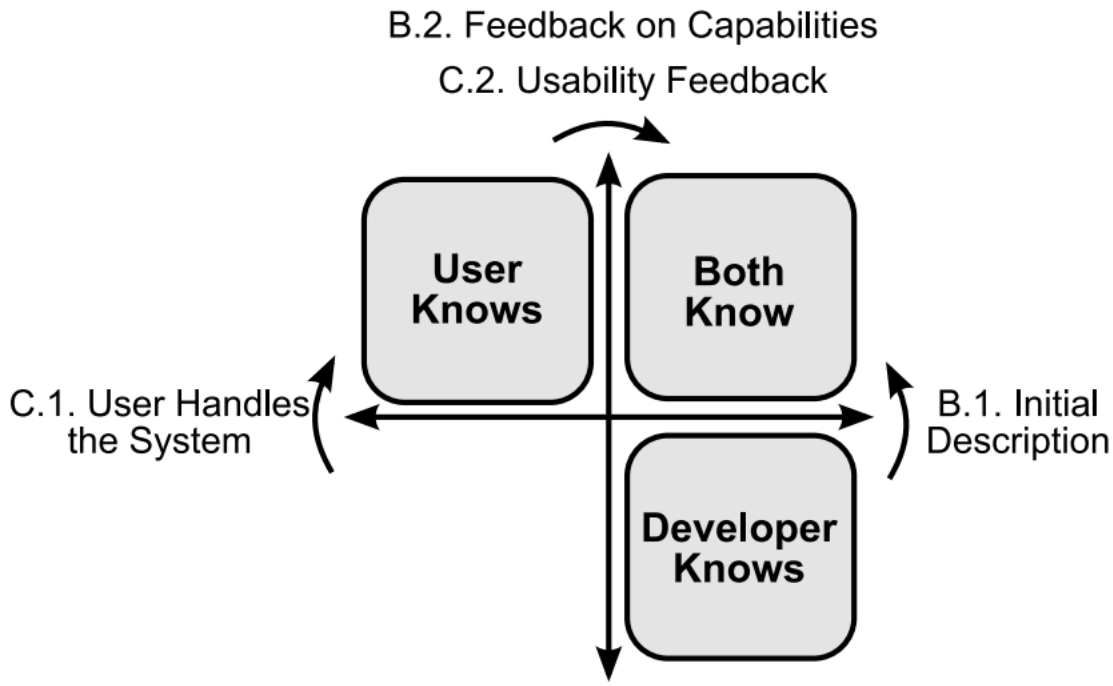

Figure 5: Continuous Improvement Framework by Victores et al. (2010)

As ITIM does not specify any repetitive or cyclical measures, like feedback sessions and evaluation moments, for implementation in order to stimulate adoption over time, this current study suggests applying the Continuous Improvement Framework (CIF) methodology in combination with the Adjusted ITIM in order to achieve a repetitive improvement of the SAR implementation. The CIF promotes the transfer of end-user knowledge to developer knowledge and the implementation of assistive robotics (Victores et al., 2010). The theoretical CIF exists out of three phases: Targeted population study, Initial description and feedback on capabilities, and Usability feedback. Phase A, the Targeted population study is a stakeholder analysis (Victores et al., 2010). Phase B is the first session of each cycle where the new functionality of the SAR is presented to the stakeholders and feedback is provided. During phase 3, the users handle the SAR and feedback is formulated, gathered and collected in order to provide usability feedback for the end of phase 3. See Figure 5.

In order to apply this methodology, some modifications are made; First, the Targeted population study is already done in the stakeholder analyses of the Users-concept thus these analyses only have to be repeated once the stakeholder group changes if new functionalities for the SAR are introduced or the scope of the implementation is altered. Second, the repetition of the sequential phases B and C, needs to be adjusted to the preferred timeframe of the facilitator and other relevant stakeholders. Adjustments to the timeframe, stakeholder group and feedback collection can be made depending on the SAR functionalities and preferences of the stakeholder group. This cycle can be repeated in order to continuously improve the implementation of a SAR and its functionalities. This cycle has various benefits for the stakeholders as, for example, it allows the SAR provider to start implementing its minimum viable product and incorporate feedback from users while developing its functionalities.

3.7.3 Guide for applying the Adjusted ITIM with CIF

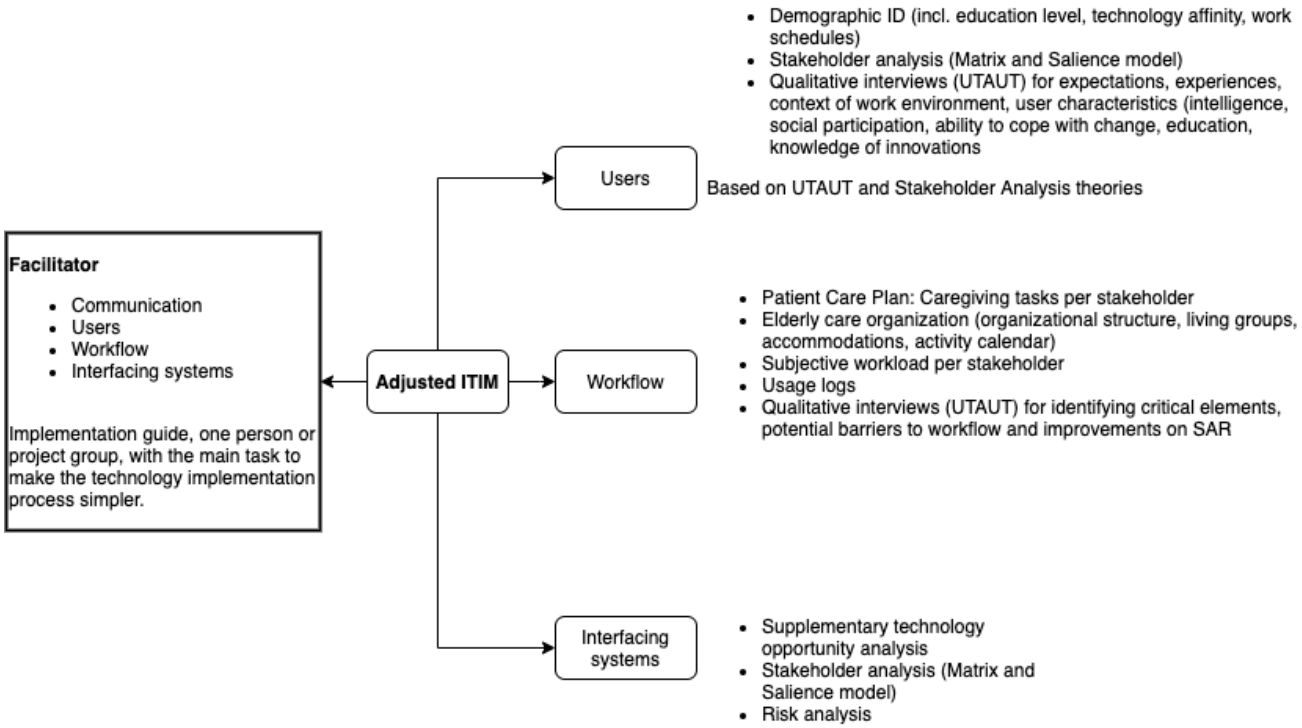

Figure 6: Adjusted ITIM with CIF developed by this current study for SAR implementation

In order to apply ITIM for SAR, the adjusted concepts must be applied and aligned in a specific order over time. While Schoville (2015) has provided a complete model, ITIM does not specify any sequential steps which have to be taken and possibly repeated over the time of the implementation of SAR. The Adjusted ITIM aims to consider the timeline of SAR implementation by highlighting decision-making by stakeholders which influence the implementation and facilitator-role. The Adjusted ITIM is based on an organizational approach where the choice for SAR as innovation spending by an elderly care organization in the Netherlands is the starting point for this framework.

First, the elderly care organization chooses to innovate in order to stimulate change and facilitate the elderly care delivery needs. As the organization is in the Netherlands, it must comply with the country's regulatory requirements. Also, it must secure its economic capabilities through the form of government policies and subsidies regarding innovation in healthcare organizations or through its own funds.

Further, the organization is subject to the availability of the SAR market, which is analysed in section 2.8.

The adjusted ITIM can be applied once the leadership of a Dutch elderly care organization have selected a SAR which suits the organizational needs to change and innovate and fits the care delivery needs of the organization. Also, the type of SAR regarding its taxonomy and the required level of implementation facilitation play a crucial role in the leadership's choice. Once the organizational leadership and the SAR vendor have agreed on terms and implement the SAR within a closed elderly care facility of the organization. This entails that the outer context-concepts are based on regulations for elderly care organizations in the Netherlands, which stimulate robot innovation for long-term care environments, and that the organization has the economic means to acquire a SAR with the necessary additional costs for services and implementation.
After initial agreements, the leadership can discuss the implementation trajectory with the vendor and facilitator which may be similar but do not have to be as the implementation facilitator may as well be an external consultant or an employee of the elderly care organization. Further, the implementation trajectory can be determined based on the specific needs of the organization, the stakeholders and eventual goals of both the elderly care organization as the vendor.

The main goal of the Adjusted ITIM is to improve the implementation of the SAR within the elderly care organization and optimize the adoption of the SAR by the caregivers in the closed elderly care facilities. By focusing on the Users, Workflow and Interfacing Systems, the implementation of the SAR can be optimized according to the needs of the most important stakeholders, fitted within the existing workflow of the elderly care facilities in order to minimize the effort required to experiment with and adopt the SAR, and collaborate with existing technologies through integration with SAR functionalities. See Figure 6 for the Adjusted ITIM. As adoption increases over time due to implementation efforts, it is suggested by the Continuous Improvement Framework that the facilitator guides the stakeholders through the various phases of the CIF in cycles over a determined time period (Victores et al., 2010).

3.8 DATA COLLECTION

The necessary inputs of data for applying the Adjusted ITIM are collected through a variety of methods as shown in the Adjusted ITIM image in section 3.7.3. For the stakeholder analyses, the facilitator must aggregate the right stakeholders depending on the needs and expected deliveries of the SAR implementation project which have been determined in the pre-implementation phase negotiations. Additional information on the elderly care organization like demographic ID of caregivers, the patient care plan, work environment, and supplementary technologies can be requested at the leading stakeholder from the organization by the facilitator.

Data on workload can be collected through surveys based on the NASA Task Load Index described in section 2.6. Also, the usage logs that describe the usage of the robot by the elderly care organization can provide a variety of information on robot use. This is further described in section 3.8.2.

Information on the SAR, its functionalities and other relevant information depending on the goals of the implementation can be gathered through stakeholder meetings, online surveys and interviews. The interview questions are based on the UTAUT model by Heerink et al. (2010) and are adapted for information gathering with the focus on the facilitating conditions-concept as this concept is most relevant for implementation purposes. The next sub-section further describes the UTAUT questionnaire for SAR implementation based on the concept of facilitating conditions.

3.8.1 UTAUT questionnaire for SAR implementation

The unified theory of acceptance and use of technology (UTAUT) is a TAM formulated by Venkatesh which aims to explain the intentions to use an information system and related usage behavior. UTAUT is applied by Heerink et al. (2010) to develop a questionnaire for qualitative interviews which aided the development of the Almere adoption model (Dwivedi, Rana, Chen, & Williams, 2011; Heerink, Kröse, Evers, & Wielinga, 2010; Venkatesh, Thong, & Xu, 2012). The Almere adoption model, see Figure 7, developed by (Heerink et al., 2010) and adjusted by (Verelst, 2018), has provided this current study with a selection of questions based on the Almere adoption model for the semi-structured, qualitative interviews. The full list of questions is provided in Appendix D.

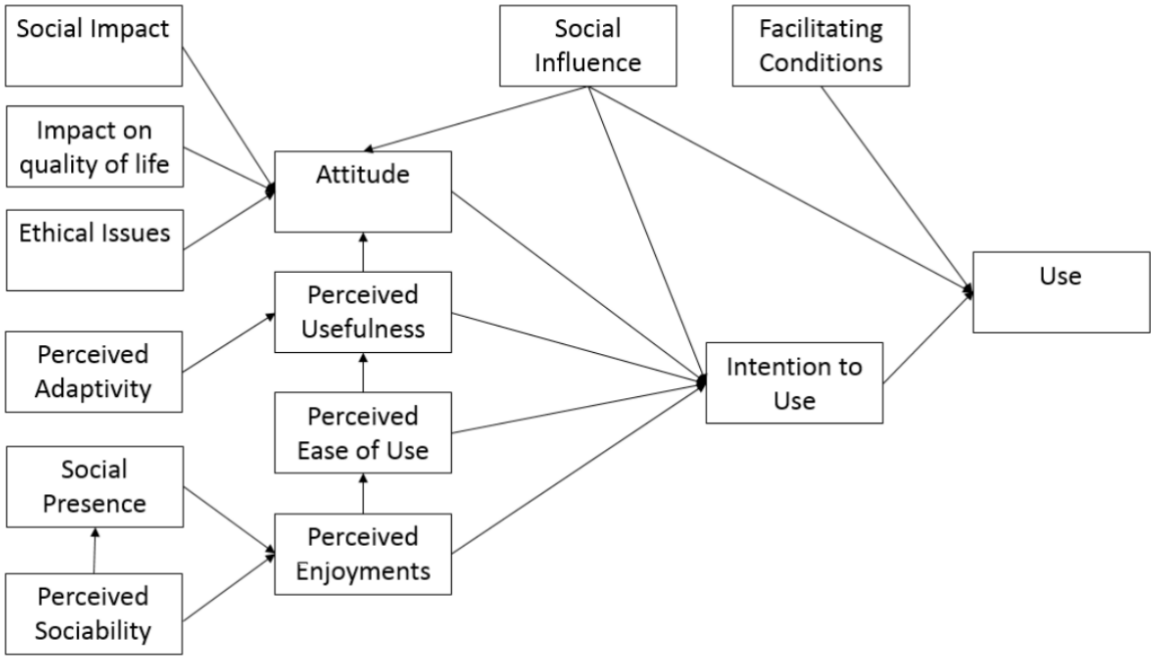

Figure 7: Almere adoption model based on Verelst, 2018

As this current study is focused on the implementation of SAR and aims to optimize the usage through *Facilitating Conditions* which are directly related to *Use*, various questions have been developed according to the coding tree presented in Verelst (2018). Especially, questions regarding the dialogue with developers, project group interests, and infrastructure are important in the scope of implementation. Economics and regulation are out of scope for the interviews as these outer context-concepts of ITIM are determined and not relevant once implementation has started. See Figure 8.

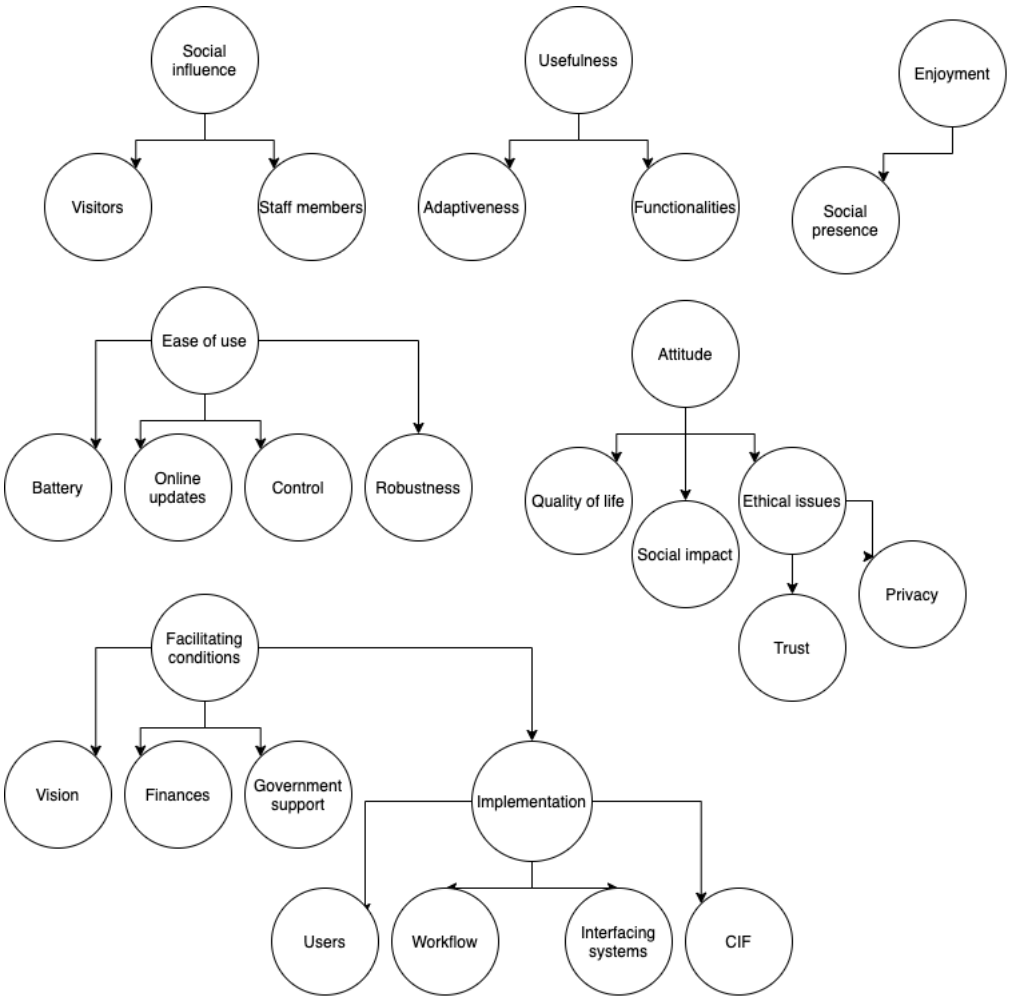

Figure 8: Coding tree developed by this current study based on adjusted Almere adoption model by Verelst, (2018)

3.8.2 Usage logs

Analysis of usage logs which are created through SAR usage can be analysed using timestamp information on usage specifics, like types of interactions during the day, which can be combined with the daily care routine calendar of the elderly care facilities.

By combining usage data with organizational planning data, clear insights can be provided on the amount of interactions each day and during which part of the day considering the care routine. This data is visualized and used in feedback sessions with caregivers in order to provide useful insights and promote discussions on the types of circumstances the SAR is mostly used by caregivers. This allows caregivers to share their experiences which can be backed up by data in an easy and clear manner. Also, this allows the facilitator to manage the implementation through combined analyses of experiences of caregivers and usage logs.

3.9 Reflection

In order to apply ITIM for SAR implementation, it is essential to determine which concepts are relevant for the SAR technology and make necessary adjustments to these concepts. Also, the facilitator role needs to be determined in the context of the implementation in order to define its powers and boundaries. By adjusting these concepts and defining their limits, a clear guide for applying the adjusted

ITIM for SAR implementation was developed. Further, this stepwise process allowed to combine the adjusted ITIM with the continuous implementation framework through the selection of similar steps and the integration of repetitive measures to raise the adoption of SAR.

3.10 Hypotheses

This current study has researched the implementation of a SAR at two closed elderly care facilities through the Adjusted ITIM combined with the CIF as novel functionalities were introduced on a monthly basis during the three-month case studies. Feedback on SARA and its functionalities has been gathered through semi-structured qualitative interviews based on UTAUT questionnaires by (Heerink et al., 2010; Verelst, 2018) with a focus on the effect facilitating conditions on use of SARA and online surveys with open-ended questions on caregiver preferences and experiences during usage. Also, workload measurements have been conducted on a weekly basis in order to monitor the workload of several caregivers during the implementation period. Finally, the usage logs of SARA were analysed in combination with the daily care routine of the two closed elderly care facilities in order to provide information on situational usage of SARA.

In order to answer the research questions of this current study, six hypotheses have been formulated based on the implementation efforts and effect of SARA on the workload of caregivers.

First, it is expected that the application of the Adjusted ITIM has a positive effect on the adoption of SAR by caregivers in elderly care facilities in the Netherlands. This can be analysed and confirmed through a combination of caregiver interviews and data analyses of the usage logs.

Second, it is expected that training sessions for caregivers on SAR usage, organized by the facilitator and the vendor have a positive effect on the adoption of SAR by caregivers in elderly care facilities in the Netherlands. This expectation is based on the CIF method, which stipulates that training sessions on how to use SAR in elderly care facilities are beneficial for adoption of SAR.

Third, it is expected that recurring feedback sessions with caregivers where they share their experiences and provide feedback on usage have a positive effect on SAR usage. This expectation is based on the CIF method, which stipulates that feedback sessions on usage experiences are beneficial for adoption of SAR.

Fourth, it is expected that contact between caregivers and the developers of the SAR vendor has a positive impact on the adoption of SAR. During this contact, experiences, questions and ideas can be shared which stimulates knowledge transfer between developers and caregivers. This has been suggested by the CIF method and in the recommendations for future research by Verelst (2018).

Fifth, it is expected that providing and sharing insights in SAR usage logs to caregivers has a positive effect on the usage of SAR. Especially, insights on the usage of SAR during specific times of day which are specified in the care routine calendar of the elderly care facilities, are expected to stimulate use during the same parts of the day.

Finally, the adoption of SAR in elderly care facilities is expected to have a positive effect on the decrease of workload of caregivers. As discussed in the theoretical background, SAR application in elderly care facilities is suggested to decrease the workload of caregivers as it might alleviate some care

burdens and time pressure. The perceived workload is measured through NASA TLX surveys and backed up through interviews with the respective caregivers.

3.11 SARA

The SARA robot or Social Autonomous Robotic Assistant is a SAR project that started in 2018 as a European Institute of Technology-funded program (Figure 9). The SAR robot has hardware provided by the Chinese robotics producer Sanbot and its software is developed by Bright Cape in an Android-based environment. Based on the SAR taxonomy and market analysis conducted in section 2.8, SARA is described in Table 7.

SARA is part of the Commercial Product Offering category, specifically a Social Health Assistant-type SAR which is offered with software updates including open software platform support for customization demands by clients. Also, product and software subscription plans are offered in the form of co-innovation trajectories where the client leases the robot and pays a monthly premium for the customized software. Another premium is payed for continuous implementation support in the context the Adjusted ITIM which includes the CIF cyclical methodology.

Figure 9: SARA hardware depicted (Sanbot Elf by Sanbot)

Feature	**Description**
Embodiment	Caricatured
Emotions	Artificial emotions, emotions as control mechanism, speech, facial expression and body language
Dialogue	Non-verbal and natural language
Personality	Artificial being
Human-oriented perception	Passive
User modelling	Pre-defined features for elderly care
Socially-situated learning	Not included in current version
Intentionality	Attentional and expressive
User populations	Elderly
Task examples	Physical therapy, daily life assistance and emotional expression
Sophistication of interaction	Speech and direct input
Role of the assistive robot	Support of caregivers through quality of life maintenance of elderly, increasing work efficiency and reduction of workload

Table 7: Taxonomy of SARA

3.12 Case studies

The case studies focus on the longitudinal implementation of a socially assistive robot, called SARA, within closed elderly care environments for the elderly with dementia. SARA is developed by Bright Cape B.V., a Dutch data science consultancy located in Eindhoven. The goal of the implementation is to stimulate the adoption and therefore the usage of SARA by the caregivers during routine, daily caregiving tasks. Due to the limited time provided for this study, longitudinal three-month long case studies were conducted at two elderly care facilities. During this period, three client entertainment functionalities have been introduced and tested in both closed elderly care facilities. Entertainment in closed elderly care facilities often is unscheduled and can be in various forms depending on the interests of the elderly and availability in the closed facilities. This includes board games, listening to the radio, watching television and reading the newspaper. In these activities there is minimal to no interaction required and caregivers tend to monitor the elderly and stimulate them to focus on the type of entertainment provided. More information and detail on these entertainment functionalities is provided in the following sub-sections regarding each specific case study.

As SARA is under development by Bright Cape, the elderly care facilities and Bright Cape have signed co-innovation agreements which specify a one year-long collaborative project during which every month a new functionality for SARA is tested in the closed care environments of the elderly care facilities. The functionalities were divided in four segments: Client Entertainment, Autonomy & Interaction, Motivation & Stimulation, and Personalization of Interactions. Each co-innovation project exists out of two phases: Quick Scan and Co-innovation.

It should be noted that the Quick Scan phase took place several months before the start of this current study and is analysed through existing documentation, additional information by Bright Cape consultants working on the SARA project, and semi-structured interviews with employees from both elderly care organizations.

The first phase, Quick Scan, was conducted for both closed elderly care facilities by Bright Cape implementation consultants before this current study had begun. Various meetings between Bright Cape and the elderly care organizations were conducted regarding the selection of functionalities which would be implemented and agreements on implementation facilitation and service during each co-innovation trajectory. After these meetings, initial analyses were conducted following with a focus on specific stakeholders, the workflow of caregivers and technologies already in place which might be supplementary to SARA's functionalities. These analyses were conducted in order to determine the organizational readiness for the implementation trajectory, determine the timeline of the implementation trajectory, select the most important stakeholders, select interfacing systems, gather information on routine workflow of caregivers and select the types of data to be collected, processed and used by the facilitators of the implementation in order to aid implementation and boost adoption. The conducted Quick Scans have been analysed by this current study in the context of the Adjusted ITIM concepts; Users, Workflow and Interfacing Systems.

As discussed in section 3.7.3, the outer context-concepts of ITIM like Regulation, Economic Environment and Vendor, are already determined as both the elderly care facilities and vendor are in the Netherlands and are subjected to Dutch regulatory and economic policies. This indicates that both Dutch innovation regulations for elderly care organizations and the economic environment of these elderly care organizations permit the elderly care organizations to commence the co-innovation projects

with Bright Cape, the vendor of SARA. That is why the case studies focus on selected inner context-concepts of ITIM specified the Adjusted ITIM.

The implementation during the three month-period is based on the proposed Adjusted ITIM combined with the CIF. The monthly implementation cycles are part of the second phase of the co-innovation projects.

The second phase, Co-innovation, the actual implementation of SARA based on the Continuous Improvement Framework for the Adjusted ITIM. Each month a new functionality was introduced to the caregivers and other stakeholders of each elderly care facility alongside with a training session. During each training session, feedback on the new functionality and future desires were gathered through open-ended questions in group setting. During the month of usage, feedback on the usability of the SAR functionalities was collected through surveys and semi-structured qualitative interviews, and usage logs of SARA and workload measurements of selected caregivers were analysed. At the end of each monthly cycle, the feedback and data were presented to the stakeholders of the elderly care organization in order to evaluate the latest functionality. After the evaluation, a novel functionality was introduced, and the new cycle started. See Figure 10 for the monthly implementation loop presented in a figure used in the implementation guide for SARA.

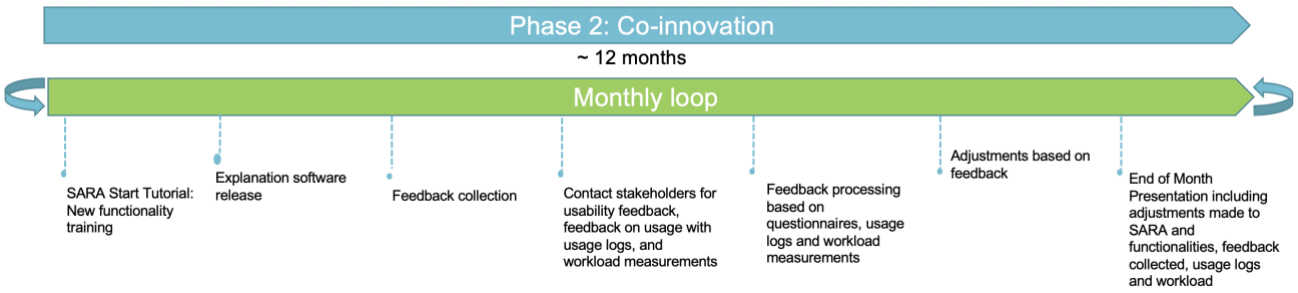

Figure 10: Monthly implementation loop of Phase 2: Co-innovation; Developed by this current study for SAR implementation

3.12.1 Case Study 1: tanteLouise

tanteLouise is an elderly care organization located and operating in the municipalities Bergen op Zoom, Woensdrecht and Steenbergen in the Netherlands. The organization is financially healthy, is a market leader and has a high employee satisfaction score. Also, it is the leader in innovation of Dutch elderly care institutions. The choice for SARA was based on the need to innovate and willingness to co-develop a SAR beneficial for elderly clients in closed environments and caregivers.

There are two SARAs implemented in a closed elderly care institution called ‘De Bosgaard’ located in Bergen op Zoom, Netherlands. There are 16 elderly living in the closed facility in separate rooms and share two living rooms. Each SARA is placed in one living room of a closed facility for elderly with high-level care needs due to progressing dementia. Each living room is designed for approximately 8 clients who are cared for by a team of 13 caregivers who work part-time in shifts (N=13), including living attendants, activity attendants, wellbeing employees and nurses. The caregivers all work exclusively in this closed elderly care facility and work in shifts caring for all 8 elderly and so visit both living rooms.

During the Quick Scan, a stakeholder analysis was conducted in order to form a project team including relevant stakeholders from both tanteLouise and Bright Cape. This stakeholder analysis is shown in

Table 8. Also, a workflow analysis of caregivers and their routine, daily tasks in the closed, elderly care facilities was done through interviews based on section 3.8.1. Responses regarding the workflow analysis are displayed below.
Further, an analysis for interfacing systems was conducted in order to select potential interfacing systems for the three entertainment functionalities. As the closed elderly care facility did not have any other relevant technologies which could benefit from a connection to the three entertainment functionalities of SARA, interview questions related to the selection of interfacing systems was made for future applications which would be beneficial for more primary care-related functionalities were added.

During the Co-innovation phase, the chosen three entertainment functionalities, *music*, *storytelling* and *event calendar*, were developed by Bright Cape and tested at the closed elderly care facility of tanteLouise. The first month, SARA was introduced to the caregiver staff and several other important stakeholders through a presentation and training session during which the basic controls of SARA through the touch screen were introduced. Also, the first functionality, music, was introduced and initial feedback and desires from the stakeholders was gathered. Further, the online surveys for general feedback were provided and two caregivers were selected to measure their workload on a weekly basis. During this first month, feedback was gathered from caregivers and a second information session was given in order to stimulate more caregivers to use SARA. At the first evaluation session, the feedback gathered from the stakeholders through interviews, written and verbal comments and online surveys was categorized in relevant categories and presented. Also, workload measurements and usage logs were discussed. Finally, the new functionality, storytelling, was presented combined with a quick workshop. This cycle was repeated, following the CIF, for the other two entertainment functionalities, storytelling and physical movement therapy.

3.12.2 Case study 2: Maasduinen

Maasduinen is an elderly care organization located and operating in the municipality Kaatsheuvel in the Netherlands. The organization is financially healthy and is described as an innovative organization which cares about employee satisfaction. The choice for SARA was based on the strategic vision of the organization towards improving care and technology with a focus on robotics. The co-development of SARA was chosen to be the first robotics implementation in the organization which would contribute towards its vision.

There is one SARA implemented in a closed elderly care institution called ‘Kompas’ located in Kaatsheuvel, Netherlands. There are 8 elderly living in the closed facility in separate rooms and one living room. SARA is placed in the living room of a closed facility for elderly with high-level care needs due to progressing dementia. This living room is designed for approximately 8 clients who are cared for by a team of 13 caregivers who work part-time in shifts (N=13), including living attendants, activity attendants, wellbeing employees and nurses. The caregivers all work exclusively in this closed elderly care facility and work in shifts caring for all 8 elderly.

During the Quick Scan, a stakeholder analysis was conducted in order to form a project team including relevant stakeholders from both Maasduinen and Bright Cape. This stakeholder analysis is shown in Table. Also, a workflow analysis of caregivers and their routine, daily tasks in the closed, elderly care facilities was done through interviews based on section 3.9. Responses regarding the workflow analysis are displayed below.

Further, an analysis for interfacing systems was conducted in order to select potential interfacing systems for the three entertainment functionalities. As the closed elderly care facility did not have any other relevant technologies which could benefit from a connection to the three entertainment functionalities of SARA, interview questions related to the selection of interfacing systems was made for future applications which would be beneficial for more primary care-related functionalities were added.

During the Co-innovation phase, the chosen three entertainment functionalities, *music*, *storytelling* and *braingames*, were developed by Bright Cape and tested at the closed elderly care facility of Maasduinen. The first month, SARA was introduced to the caregiver staff and several other important stakeholders through a presentation and training session during which the basic controls of SARA through the touch screen were introduced. Also, the first functionality, music, was introduced and initial feedback and desires from the stakeholders was gathered. Further, the online surveys for general feedback were provided and three caregivers were selected to measure their workload on a weekly basis. During this first month, feedback was gathered from caregivers and a second information session was given in order to stimulate more caregivers to use SARA. At the first evaluation session, the feedback gathered from the stakeholders through interviews, written and verbal comments and online surveys was categorized in relevant categories and presented. Also, workload measurements were discussed. It is interesting to mention that Maasduinen did not want to discuss the usage logs as they felt it would have a negative effect on their employees' experience regarding SARA. More information on this topic is discussed in the Results section. Finally, the new functionality, storytelling, was presented combined with a quick workshop. This cycle was repeated, following the CIF, for the other two entertainment functionalities, storytelling and brain games.

3.13 Concluding remarks

The development of the Adjusted ITIM with CIF has resulted in a model and an accompanying guide which describes the necessary steps for SAR implementation within closed elderly care facilities through elaborating on its concepts, including a cyclical methodology which allows continuous improvement during the implementation process, and describing the necessity of qualitative and quantitative data which is useful for analysing the implementation progress. Also, this adjusted model encompasses the full scope of SAR implementation as is described in the case studies where SARA is implemented in two closed elderly care facilities for an extended period.

4. Results

The results of the application of the implementation guide based on the Adjusted ITIM with CIF are presented with a focus on the concepts of Users, Workflow and Interfacing Systems. These are analysed through stakeholder analyses, usage log analyses, workload analyses and semi-structured qualitative interviews based on the adjusted UTAUT model. The results of the analyses are presented in the following section. The results are discussed according to a structure which is consistent with the structure of the methodology.

4.1 Stakeholder analyses

The stakeholder selection is based on the Quick Scan analyses of both elderly care organizations and follows the ITIM guidelines presented by Schoville (2015). The stakeholders include members of all levels of the elderly care organizations and the implementation facilitators. The relevant stakeholders and their powers and interests are presented in Table 8.

Stakeholders	**Power/Interest**
Facilitator (Bright Cape consultants)	Implementation of SARA
Team manager	Responsible for team guidance and management
Location manager	Implementation of SARA for benefit of elderly care organization's innovation vision
Innovation advisor	Implementation of SARA for benefit of elderly care organization's innovation vision
Caregivers	Responsible for client wellbeing
IT department	IT infrastructure
Clients	Quality of life
Family, relatives and acquaintances	Client wellbeing
Physiology/psychology coaches	Client physical and mental wellbeing

Table 8: Stakeholder analysis

The wellbeing and quality of life of elderly clients in closed elderly care facilities is the most integral part and main goal of implementing SAR. All management and advisory positions within elderly care organizations can heavily influence the implementation of SAR as they occupy leadership capacities within the organizations and function as the decision makers regarding the project planning and implementation of SAR. Also, they are responsible for managerial and operative decisions that caregivers are not allowed to make.

The caregivers are essential in the implementation process and provide the most useful feedback as they have long-term hands-on experience of working with SAR during the implementation trajectory. Their trust and effort are a complete necessity for a successful integration of SAR within their routine, daily work.

The IT department and coaches are important to consider as they provide necessary connections for internet, implementation within existing systems and advice regarding functionalities which influence the elderly client's physical and mental wellbeing.

The approval of family and relatives is required as elderly with progressed dementia are often not capable nor allowed to sign over approval for third party healthcare technology application in their home environment, data collection and privacy measures.

4.2 Usage logs

As SARA records all interactions that have been performed, these records are analysed in order to provide useful insights regarding the use of SARA. These records are combined with data on routine, daily care tasks and schedules of the closed elderly care organizations. The resulting data shows during which moments of the day SARA is being used most frequently and which interactions are performed. This data allows the implementation facilitator and the elderly care organizations to review how and when SARA is deployed, which can be used to train caregivers and review the implementation and adoption progress. It should be noted that the ability to log interactions and therefore analyse the usage of SARA was only technically possible after more than one month after the first implementations of SARA. This means that the analyses cannot entirely account for the novelty effect as the SAR was already in use for a period longer than a month, which would diminish the effects of novelty. Also, the initial use of the SARA's was not possible to record in any way which is a limitation to this study and therefore the analyses performed below start to describe the usage of the robots at different dates during the second implementation loop.

The records of SARA exist out of three variables: date, time and type of interaction. This allows this study to analyse how long SARA is turned on every day and how long each interaction took place. By combining this information with data on the routine, daily schedule, analyses provide insights on which interactions are performed during the various care and non-care related activities. Below, an example of usage log files which are entered in Excel for analytical purposes is provided in Figure 11. Also, the routine, daily time schedule which was mentioned before in section 2.4 is required to analyse the usage logs. See Table 1 for the routine work schedule in closed elderly care facilities.

Date	Time	Function	Activity count	Type of activity	Part of day
[26-feb.-2020	14:56:31]	/hls/audioStory3_nl_000.ts	1	Story	Free time 2
[26-feb.-2020	15:00:23]	/hls/audioStory1_nl_000.ts	1	Story	Free time 2
[26-feb.-2020	15:00:28]	/hls/audioStory1_nl_000.ts	1	Story	Free time 2
[26-feb.-2020	15:43:54]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[26-feb.-2020	15:45:47]	/hls/MyBonny_000.ts	1	Music	Free time 2
[26-feb.-2020	15:48:13]	/hls/m/OpDeGroteStilleHeide_000.ts	1	Music	Free time 2
[26-feb.-2020	15:52:20]	/hls/m/Catootje_000.ts	1	Music	Free time 2
[26-feb.-2020	15:59:28]	/hls/m/EenKarretjeOpDeZandwegReed_000.ts	1	Music	Free time 2
[26-feb.-2020	16:03:09]	/hls/m/DaarBijDieMolen_000.ts	1	Music	Free time 2
[26-feb.-2020	16:07:46]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[26-feb.-2020	16:10:45]	/hls/NederlandseFeestdagen_000.ts	1	Story	Free time 2
[26-feb.-2020	16:12:15]	/hls/m/AlsIkTweemaalMetMnFietsbelBel_000.ts	1	Music	Free time 2
[27-feb.-2020	11:42:38]	/hls/m/AlsDeKlokVanArnemuiden_000.ts	1	Music	Free time 1
[27-feb.-2020	11:46:24]	/hls/m/Catootje_000.ts	1	Music	Free time 1
[27-feb.-2020	13:03:40]	/hls/audioStory3_nl_000.ts	1	Story	Lunch
[27-feb.-2020	13:05:22]	/hls/audioStory3_nl_000.ts	1	Story	Lunch
[27-feb.-2020	13:09:25]	/hls/audioStory2_nl_000.ts	1	Story	Lunch
[27-feb.-2020	13:15:05]	/hls/audioStory1_nl_000.ts	1	Story	Lunch
[27-feb.-2020	14:37:04]	/hls/m/hersengym/Dequiz_000.ts	1	Hersengym	Free time 2
[27-feb.-2020	14:38:35]	/hls/m/hersengym/Dierengeluidenspel_000.ts	1	Hersengym	Free time 2
[27-feb.-2020	14:39:31]	/hls/m/hersengym/Gezegdespel_000.ts	1	Hersengym	Free time 2
[27-feb.-2020	14:40:53]	/hls/m/hersengym/Samenzingen_000.ts	1	Hersengym	Free time 2
[27-feb.-2020	14:42:41]	/hls/m/hersengym/Voorwerpenspel_000.ts	1	Hersengym	Free time 2
[27-feb.-2020	14:49:31]	/hls/m/ShoenEnLeerIndustrie_000.ts	1	Story	Free time 2
[27-feb.-2020	14:57:54]	/hls/m/andre/AveMaria_000.ts	1	Music	Free time 2
[27-feb.-2020	15:37:01]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[27-feb.-2020	15:40:02]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[29-feb.-2020	13:38:21]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[29-feb.-2020	13:40:46]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[29-feb.-2020	13:42:21]	/hls/MyBonny_000.ts	1	Music	Free time 2
[29-feb.-2020	13:44:19]	/hls/m/AlsIkTweemaalMetMnFietsbelBel_000.ts	1	Music	Free time 2
[29-feb.-2020	15:39:03]	/hls/m/TussenKeulenEnParijs_000.ts	1	Music	Free time 2
[29-feb.-2020	15:40:13]	/hls/m/AllesInDeWind_000.ts	1	Music	Free time 2
[29-feb.-2020	15:41:49]	/hls/KleineCafe_000.ts	1	Music	Free time 2
[29-feb.-2020	15:46:07]	/hls/m/AlsDeKlokVanArnemuiden_000.ts	1	Music	Free time 2
[29-feb.-2020	15:49:57]	/hls/m/DaarBijDieMolen_000.ts	1	Music	Free time 2
[29-feb.-2020	15:53:56]	/hls/LonelyShepherd_000.ts	1	Music	Free time 2

Figure 11: Part of usage logs of SARA in Maasduinen including the analysis of type of interaction and part of day

Descriptive analyses of the usage log data have been performed to count and classify the data. Counting the data provided an overview of the overall usage during the case studies of the three SARA's in both elderly care facilities. By defining what type of interaction took place and during which period of a routine day in a closed elderly care facility, various insights can be provided. First, the amount of interactions of each robot divided over the five time periods describes the most effective time periods to apply SARA based on the nature of its functionalities. Second, the popularity of every type of interaction can be defined based on usage.

The SARA robot at Maasduinen seems to be used more frequently in comparison to SARA 1 and 2 at tanteLouise. SARA 2 at tanteLouise seems to be used in a very limited capacity while SARA 1 is used quite regular. These differences can be explained by the different locations of all three robots and the motivation of caregiver staff to use the robot in their routine workflow. The Maasduinen facility seems to have very enthusiastic caregiver users while the staff at tanteLouise responsible for SARA 2 seems to neglect the robot entirely. The music functionality is the most popular overall. Further, the story functionality is more popular at the Maasduinen closed elderly care facility. It could be that the elderly in Maasduinen are more interested in the stories or that the caregivers prefer to use the story functionality more in comparison to the tanteLouise caregivers. Also, the brain games functionality, which requires the presence of a caregiver in most occasions, is used almost 10 percent of the time. This suggests that caregivers take the time during their work routine to actively involve SARA.

	SARA 1 tanteLouise	SARA 2 tanteLouise	SARA Maasduinen
Total interactions	234	24	369
Story	22	1	97
Music	212	23	242
Brain games	NA	NA	30
Days of usage logging	68	68	53
Average amount of interactions per day since start usage logging	**3.4 interactions per day**	**0.4 interactions per day**	**7,0 interactions per day**

Table 9: Amount of interactions per SARA since logging availability

The total amount of interactions is plotted per week since the moment that the ability to log interactions was implemented in SARA 1 at tanteLouise (see Figure 12). The amount of interactions is low in March which seems to be due to the corona-virus measures which were installed during that period. It is not clear if the usage increased in February as there is no usage log data available before that period. However, it was expected that usage would increase after every monthly implementation loop, which ends with an 'End of the loop'-presentation at the end of the month, as a new functionality is introduced, bug fixes are implemented, feedback from stakeholders is incorporated, and analysed data on usage and workload is shared with stakeholders.

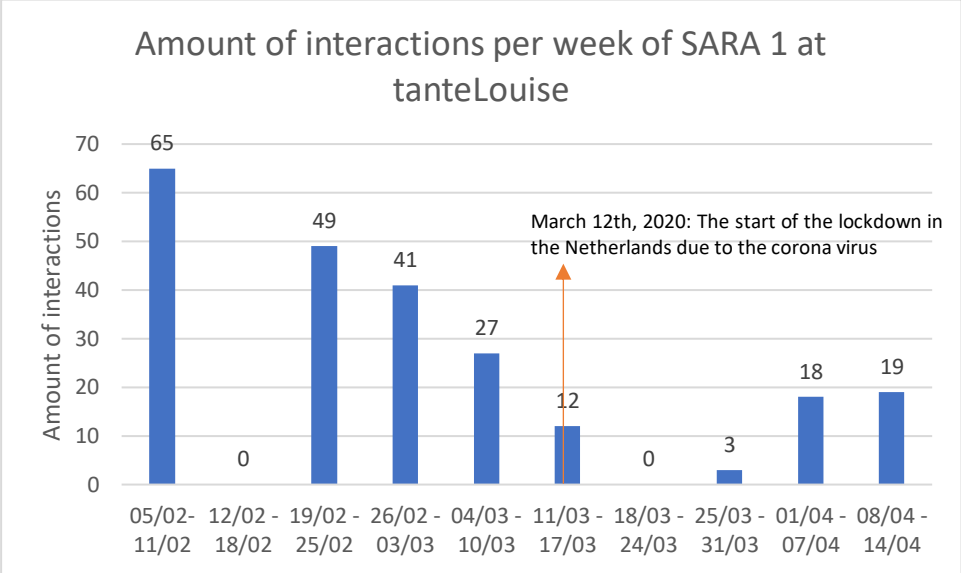

Figure 12: Amount of interactions plotted per 7 days since start usage logging

SARA at Maasduinen does show the expected usage increase after every 'End of the loop'-presentation as the amount of interactions reaches its local peak in the week of the new implementation loop. This is seen at both [04/03 – 10/03] and [01/04 – 07/04] of Figure 13. Further, a relative decrease of interactions is noticed as a result of the corona-virus measures of the Netherlands which were installed during this period [11/03 – 17/03]. It is noticeable that the effect of these measures seems to have a far lower effect on SARA usage in comparison to the usage of SARA 1 at tanteLouise. SARA 2 at tanteLouise has so few logged interactions that its usage logs do not provide any useful information after analysis. See Figure 14. The negligible amount of interactions is discussed in the qualitative interviews in section 4.4.

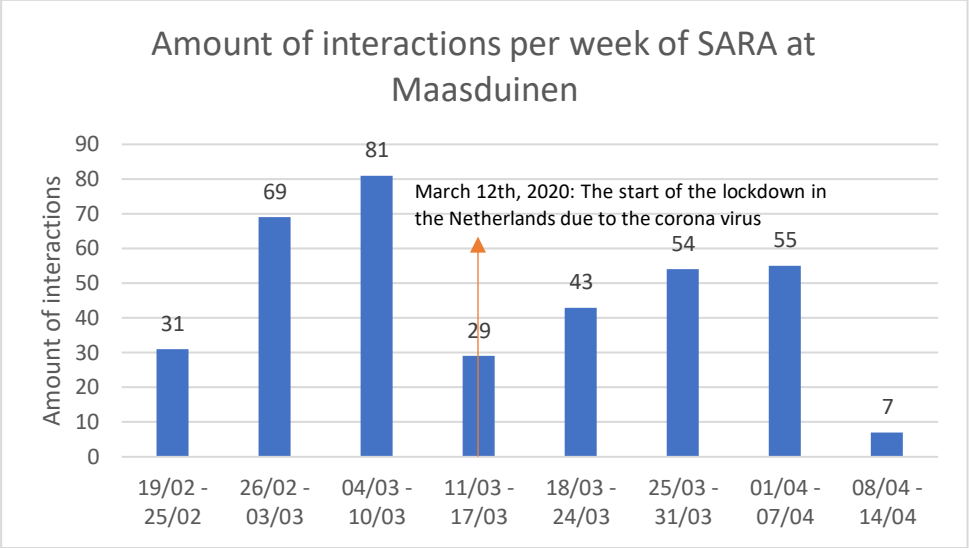

Figure 13: Amount of interactions plotted per 7 days since start usage logging

SARA at Maasduinen does show the expected usage increase after every 'End of the loop'-presentation as the amount of interactions reaches its local peak in the week of the new implementation loop. This is seen at both [04/03 – 10/03] and [01/04 – 07/04] of Figure 13. Further, a relative decrease of interactions is noticed as a result of the corona-virus measures of the Netherlands which were installed during this period [11/03 – 17/03]. It is noticeable that the effect of these measures seems to have a far lower effect on SARA usage in comparison to the usage of SARA 1 at tanteLouise. SARA 2 at tanteLouise has so few logged interactions that its usage logs do not provide any useful information after analysis. See Figure 14. The negligible amount of interactions is discussed in the qualitative interviews in section 4.4.

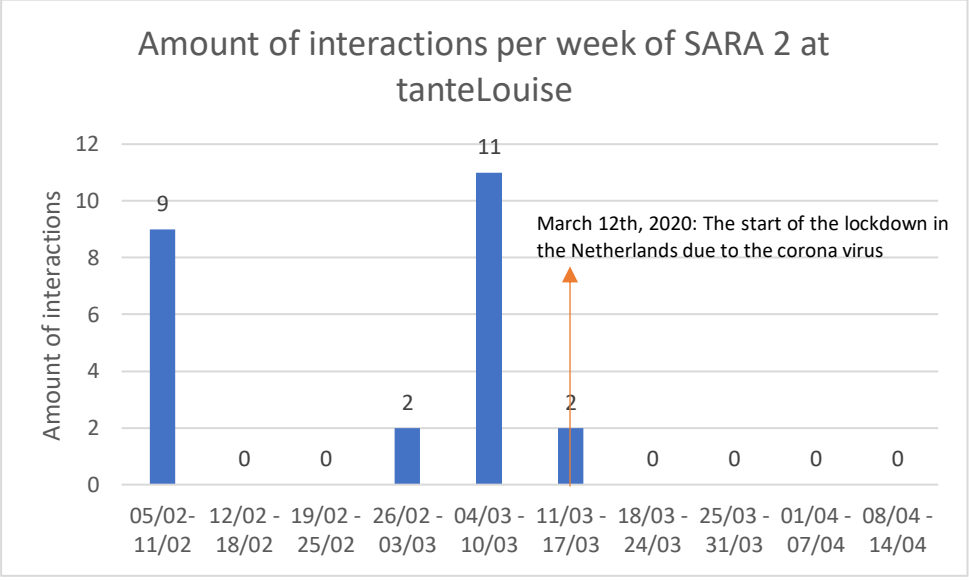

Figure 14: Amount of interactions plotted per 7 days since start usage logging

Figure 15 and Figure 16 describe the usage logs per part of day over a 68-day period at tanteLouise. The music functionality is most popular over every time period. Also, the music functionality is very often used in the morning in the case of SARA 1. This suggests that caregivers have applied SARA to entertain or distract one or several elderly clients in order to perform primary care tasks like medicine delivery. This data and reasoning behind this assumption is discussed in the qualitative interviews with caregivers at tanteLouise in section 4.4.

SARA 2 seems to be used in a very limited capacity, but its usage logs also suggest that the entertainment functionalities are mostly used during free time periods and the evening to entertain elderly clients and possibly distract them during evening care.

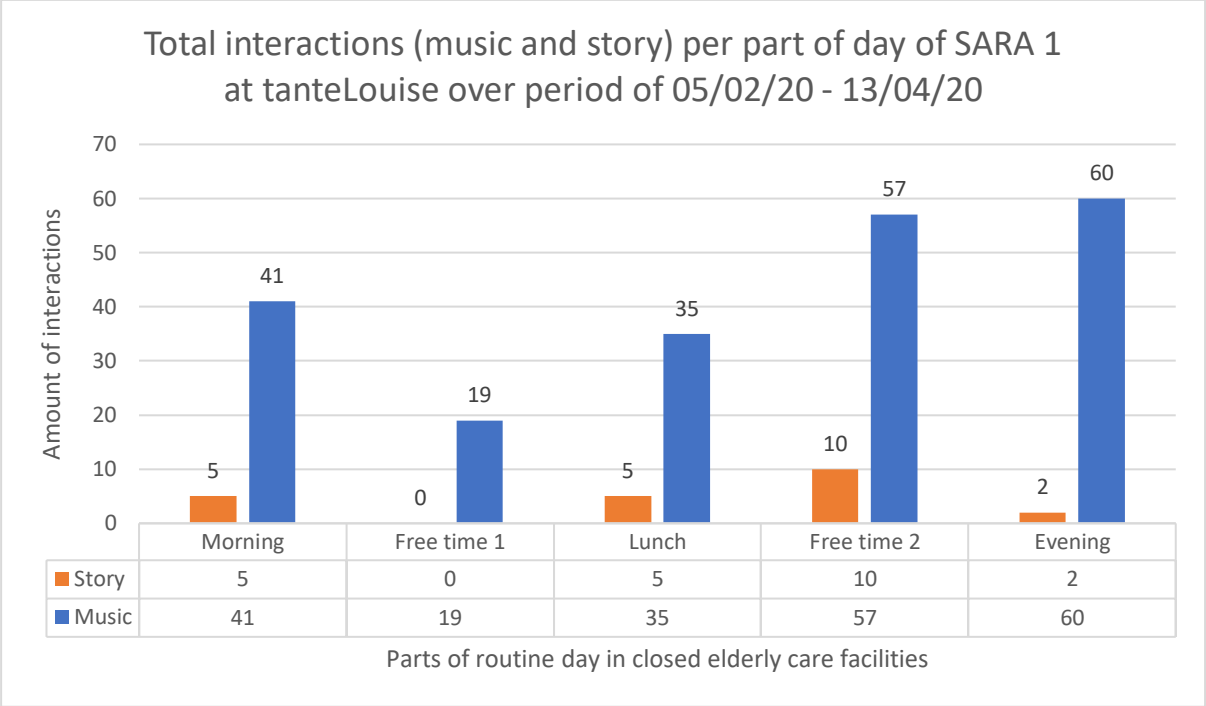

Figure 15: SARA 1 Usage Log analysis at tanteLouise over the period of 05/02/20 - 13/04/20

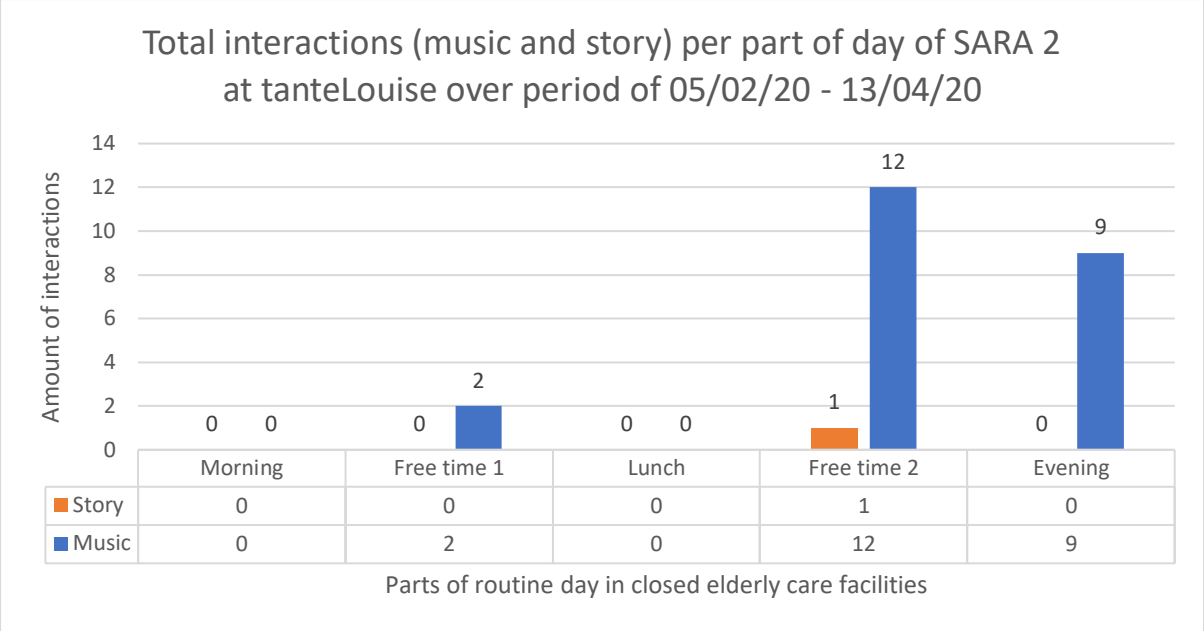

Figure 16: SARA 2 Usage Log analysis at tanteLouise over period of 05/02/20 - 13/04/20

Figure 17 describes the usage logs per part of day over a 68-day period at Maasduinen. The music functionality is most popular over every time period except the first free time-period where the story functionality is slightly more used. The brain games which often require the presence of a caregiver, are used most often during the second free time period and in the evening. This suggests that caregivers tend to take more time to entertain clients by accompanying SARA in the later periods of the day.

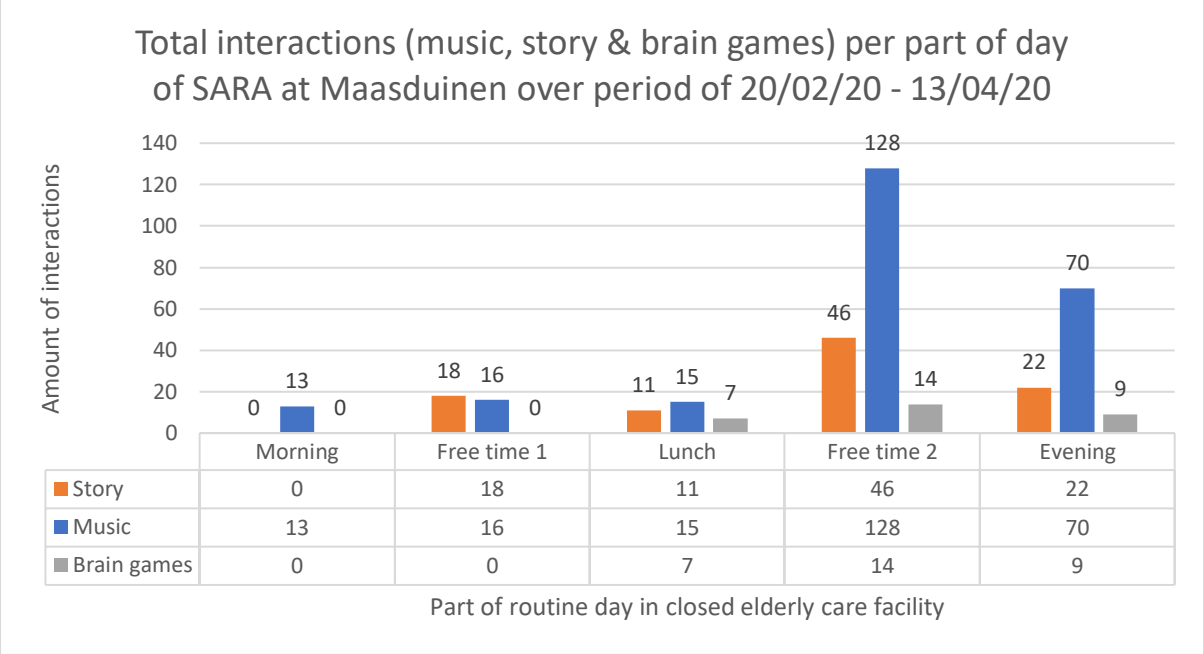

Figure 17: SARA Usage Log analysis of SAR at Maasduinen over the period of 20/02/20 - 13/04/20

The visualized data shows clearly that each SARA is used most often during the free time moments, before and after lunch, and in the evening in both closed elderly care environments. The main reason for this usage pattern is due to the entertaining nature of the available functionalities as these do not contribute towards elderly care directly and entertainment functionalities are most often used during the

free time moments. The most popular type of interaction is music. Caregivers have noted that the reasoning behind the popularity is the non-challenging nature of the interaction. This means that the elderly clients do not have to focus fully on the music as this is difficult for them. With the stories and brain games, caregivers note that these interactions require more focus from the elderly clients and the brain games require the presence of a caregiver as most elderly find it difficult to operate and interact with SARA. The main reasons for these difficulties according to caregivers are based on the qualitative interviews conducted by this research. The full analysis of the interviews is provided in section 4.4;

"The elderly clients have trouble seeing and understanding the touch screen. Also, the speaking pace of SARA is often too fast for elderly and the robot does not repeat itself. We often repeat our questions to them several times and with different paces."

Some use of entertainment functionalities is noticed in morning and evening care situations as these functionalities may have a relaxing or distracting effect on the elderly which benefits caregivers as this helps them to perform primary care tasks like medicine delivery.

4.2.1 Reflection

The ability to measure the adoption by logging the usage of SARA and analyzing these logs is a useful tool in order to understand the adoption progress within a closed elderly care facility. Due to the limited applicability of entertainment functions, the usage log analysis in combination with the routine workflow of caregivers in closed elderly care facilities did confirm that entertainment is mostly done during the free time periods. It is very useful for further functionality development that entertainment functionalities can be used to entertain or distract elderly clients in order to allow caregivers to perform their primary care tasks more efficiently.

Once more functionalities are introduced which are developed to aid caregivers to perform their tasks more efficiently or can monitor elderly clients without the immediate presence of the caregiver, it is expected that the usage of these functionalities will be dispersed throughout the day instead of the peaks experienced during the free time and evening periods. Also, more functionalities can provide more useful insights which can be used during feedback sessions in order to better understand the interaction between a SAR and caregivers' workflow. Finally, the logs can be more detailed with respect to the exact location, e.g. living room or room of elderly client X, where they took place. Also, information of who activated the functionality and the result of the functionality, e.g. achieved score on brain games, could provide more useful insights.

4.3 Subjective workload (NASA TLX)

Workload measurements conducted through bi-weekly online surveys according to the NASA Task Load Index methodology have shown that the workload of caregivers at both elderly care facilities has not made any significant changes due to the implementation of SARA. See Figure 18 for the average workload per caregiver for each bi-weekly measurement since the start of the implementation. All caregivers have missed a measurement, but they all have provided eight over a three-month time period and at least two weeks apart from the previous one. Caregiver 1 is from tanteLouise and the other caregivers are from Maasduinen. Another caregiver from tanteLouise participated in this study on workload but due to too high workload and overall stress experienced by this caregiver, the caregiver went on sick leave and dropped out of this study in the beginning. These results were omitted from this study.

It is noticeable that the average workload experienced by all caregivers seems to stay relatively on the same level throughout the measurement period. This suggests that the implementation of SARA did not have any impact on their workload. Also, the Corona-virus measures did not result in a significant impact on the caregivers' subjective workload. This suggests that externalities which do not directly impact their routine, daily work entirely but only result in some additional tasks or processes in their work, like working with SARA during free time periods or taking into account additional hygienical measures, do not have an significant impact on their experienced workload. Also, the usage log results presented in Figures 12, 13 and 14 in section 4.2 do not provide any explanation for the relatively constant perceived workload as the use of SARA changed significantly during the same period that the workload measurements were completed. Further, caregivers have commented that they have not experienced any changes in their perceived workload.

"I think that at this stage SARA does not contribute to the reduction of workload as can be seen in my workload measurements. But I feel it might happen in the future."

There are various reasons that support these results. These reasons have been constructed based on the responses of stakeholders from both case studies and conclusions drawn by this current study; First, the functionalities of SARA are limited to entertainment which cannot be applied during care tasks such as medicine delivery or cleaning. Second, the implementation of SARA has resulted in additional tasks and workload for caregivers which counteracts the perceived benefits of SARA. Third, the corona-crisis has resulted in additional pressure on elderly care organizations as the elderly are in the increased risk category and caregivers must take many additional measures to practice safe caregiving.

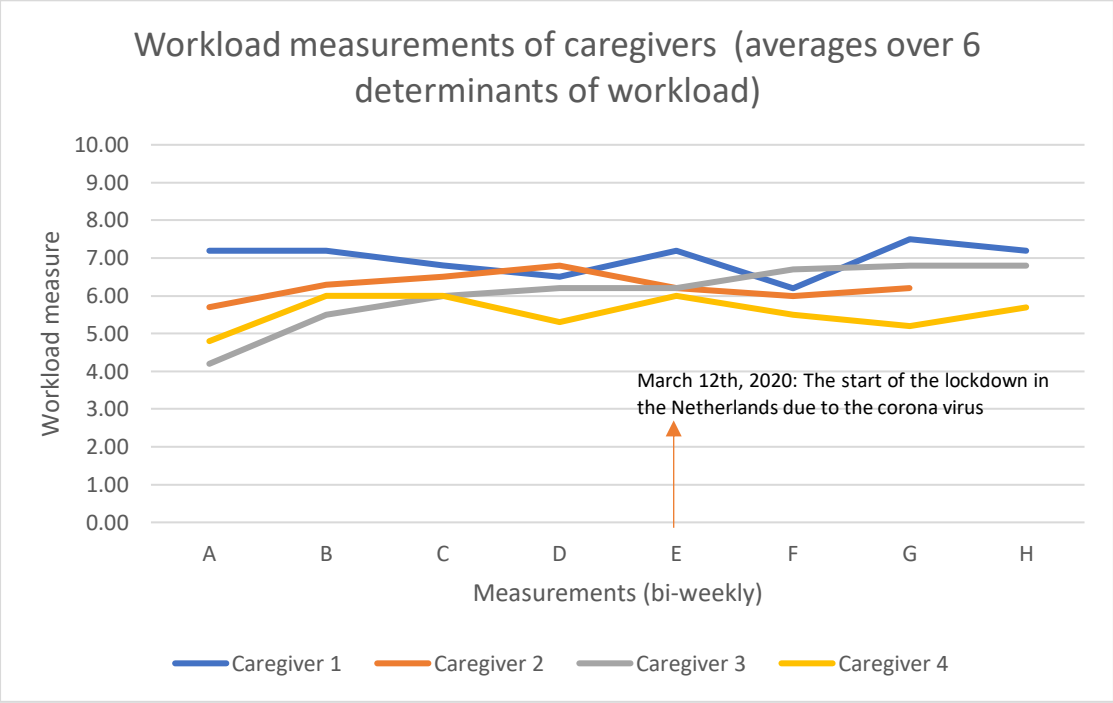

Figure 18: Workload measurements of caregivers (Case studies 1 & 2)

4.3.1 Reflection

Due to the limited use for the entertainment functionalities, a SAR cannot be applied to the benefit of caregivers throughout their entire workflow. Once functionalities can contribute towards primary care tasks, like medicine delivery, or other care tasks including mobility assistance, personal supervision, home organization and administration, the perceived workload of caregivers is expected to be affected. The workload measurements show that the experienced workload by caregivers does not respond to externalities like the implementation of SARA or additional measures due to coronavirus.

This measurement faces some limitations; First, it is not clear how often these caregivers applied SARA during their routine workflow as all usage logs are anonymous, so it is not clear to what degree their perceived workload was affected by SARA which might explain the steadiness of the workload measurements. Second, the measurements could have been repeated too often, which could incentivize caregivers to report the same experienced workload every measurement. Finally, the caregivers could have been observed for a longer time period during their routine workflow in a non-disruptive capacity to assess the caregivers' tasks, experienced stress and changes in their work environment. These factors could provide more context and should relate their reported workload more carefully.

4.4 Qualitative interviews

The qualitative study analysed using Atlas TI software has led to a final coding tree shown in section 3.8. The results of the various concepts from the UTAUT model that influence the implementation and adoption of SAR in the elderly care organizations are discussed according to the main constructs of the adjusted Almere model; Usefulness, Attitude, Facilitating conditions, Ease of use, Enjoyment and Social influence. The responses are provided by personnel in various organizational levels of the two elderly care organizations in the case studies regarding the implementation of SARA. A total of 8 transcribed interviews is used to present the results including translated quotations. The total list of interviewees is presented in Appendix C and the transcripts are presented in Appendix D.

4.4.1 Usefulness

The interviewees of both closed elderly care facilities regard SARA as a tool for entertainment of the elderly. Caregivers, team- and location managers, and innovation advisors agree that SARA is great to amuse the elderly and has a positive effect on the mood of elderly and their environment. But all interviewees agree that the functionalities of SARA are still very limited and predominantly use SARA in free time situations. Two specific constructs can be distinguished regarding the usefulness of SARA: functionalities and adaptiveness.

Functionalities

The three functionalities of SARA are mainly designed for entertainment purposes. Especially, music and storytelling are used during the free time moments where the elderly have no specific routine and can do whatever they like. Caregivers tend to use SARA to stimulate elderly to sing together or amuse elderly that appear to be bored or lonely. Caregivers know when to apply the music and storytelling functionalities as they resemble the application of other entertainment technologies like the television. A caregiver at Maasduinen explains;

"SARA is used to entertain our people, to make them smile, laugh or just distract them. Sometimes they want to sing. They love the songs."

The music and storytelling functionalities are sometimes used when the elderly get restless in the evening and the caregivers are busy with providing evening care like medicine delivery and bringing the elderly to bed. This happens one by one, so the caregivers trust SARA to play music and stories for the remaining elderly while they are not in the living room. The caregivers acknowledge that it took some time to trust SARA and not react to every noise coming out of the living room. Nowadays, they know which elderly they can put to bed first, as they do not trust them unsupervised, while they can leave others alone in the living room with SARA without any hesitation.
The team manager at tanteLouise confirms:

"My staff uses SARA more in the evening as now they have the feeling that once they are busy with evening care and are not present in the living room, they can use SARA for that exact purpose. I think that is very good."

The brain games are less liked by the caregivers and elderly because the SARA interface is not easy to use for all the elderly and it requires a caregiver to play the brain games with the elderly. Due to the lack of time, caregivers tend to not play the brain games. Also, caregivers mentioned most elderly find it difficult to focus for such a long time due to their dementia progression.

Adaptiveness

In order for SARA to adapt to the needs of the caregivers in closed elderly facilities, according to the science practitioner of tanteLouise and innovation advisors of both elderly care facilities, the functionalities need to be centered around three main topics: Enhancement of the quality of life of the elderly, enhancement of the efficiency of the performance of caregiving tasks by caregivers, and decrease of the care demanded to the caregivers by the elderly.

The quality of life of elderly has proven to be maintained and enhanced in various papers on SAR adoption and is recognized by all interviewees (Feil-Seifer, Skinner, & Matarić, n.d.; Kachouie et al., 2014; Khosla et al., 2012; Shukla et al., 2019; Tapus et al., 2007). While a caregiver did acknowledge that in the beginning of the implementation of SARA, she did not see the benefits of SARA for the elderly, she did get used to applying SARA more often and noticed various benefits of SARA in comparison to the television or radio.

"In the beginning, I had the feeling that I did not know what to do with that robot. But not I see the fun benefits that the robot brings to the care environment."

There are various opinions on whether SARA enhances the efficiency of the performance of caregiving tasks by caregivers. Some caregivers have seen in which situations SARA can be applied in order to entertain or distract the elderly while they can perform other tasks. They acknowledge that it took some time to see in which aspects of work and during which moments applying SARA could be beneficial for their work and increase their efficiency of performing some caregiving tasks. A fitting example is the application of SARA's music functionality during the evening care routine of one elderly lady as she gets distracted and more relaxed. This way the caregiver can perform the evening care routine without any disruptions.

Other caregivers, managers and innovation advisors of both organizations strongly advice that efficiency of caregiving task performance can only be enhanced once the functionalities will directly contribute towards physical caregiving tasks. Also, functionalities that enhance information sharing, reporting, and integration with existing communication systems would be beneficial for enhancing care efficiency. Further, functionalities that allow SARA to operate autonomously and allow personalized interactions with elderly without any involvement of caregivers, are regarded to be efficiency enhancing.

Finally, functionalities that fulfill caregiving tasks with minimal or no attention of caregivers are required in order to decrease the demand for care by elderly. These functionalities need to be intertwined with existing interfacing systems and should function automatically during the routine care day.

4.4.2 Caregiver attitude

The caregiver's attitude towards the use of SARA is essential in the implementation of SARA. Once staff members accept SARA in their working environment and recognize the benefits of the application of SARA during their work, adoption of SARA is achieved. At both Maasduinen and tanteLouise, there is a division between caregivers that accepted SARA and apply the functionalities during fitting moments of the day and caregivers that are not yet convinced of the benefits of SARA towards the elderly and their own work. A caregiver of tanteLouise who already implemented SARA in his work routine explains;

"First, you need to see the added value of applying SARA during the daily work. If they don't see it yet, it is our responsibility to handle that."

Interviewees acknowledge that these types of products are used once they see the added value of applying the functionalities in order to make their work more efficient. Applying the storytelling functionality to calm down an elder client in order to perform the evening care routine is a good example of such situations. Another caregiver from Maasduinen explained the shift in her attitude over time during the implementation of SARA;

"I found it very difficult because you think about the added value of such a robot. I thought that a radio was always good enough, but now I notice that the longer I work with SARA, the more I start to like it."

The interviewees agree that they all have been informed well on the potential impacts of SARA by the facilitators of the implementation trajectories. The consequences of SARA adoption on the quality of life of the elderly, the social impact and ethical issues are presented in the following subsections.

Quality of life

All interviewees agree that SARA provides benefits to the quality of life of elderly as its functionalities are designed to entertain the elderly. Sometimes the songs and stories trigger distant memories of the residents which they can share vividly while they smile and look happy. This is a major benefit according to caregivers from both elderly care facilities and has a positive impact on their quality of life. As a result, the interviewees acknowledge that their own work becomes more enjoyable if their clients have a high quality of life. Of course, this happiness is only partly a result of the adoption of SARA.

Social impact

The interviewees agree that the assistive capabilities of SARA may have some positive effect on their working environment but due to the limited features, it does not yet fully promote the independence of elderly. Also, working alongside SARA took some time and various adjustments in the workflow as now a new tool was available. This did have an impact on workload and stress in the beginning as the caregivers were given the assignment to try and experiment with SARA during their daily working routine. As the caregivers got information and training by facilitators, it was expected by the managers and innovation advisors that adoption would go smoothly while it took some time to adjust to this innovation. This turned out to be not enough as caregivers did not have enough time during their routine daily work, according to the innovation advisor of tanteLouise;

"Employees are embedded in their current working routine and are busy all day, thus they do not have enough time to think about how they could use SARA to their benefit. As innovation advisors, it is our goal to contribute to the implementation as well and provide some time for our employees to experiment and get used to the innovation."

Ethical issues: trust and privacy

Some caregivers tend to use SARA more and reap more benefits regarding the efficiency of their work as they already trust SARA and know in what situations they can use the robot. The examples of applying SARA to entertain the elderly in the living room while performing evening care and medicine delivery to the elderly one by one, is only feasible if the caregiver trusts SARA to maintain order in the living room and not cause any negative situations.

All interviewees share the same opinion on the privacy aspect as SARA does not record any personal or privacy sensitive information, it cannot harm the elderly and caregivers. Also, future functionalities with some personalized content could be accepted if privacy concerns would be mitigated through agreements with the vendor of SARA regarding data collection and storage.

4.4.3 Facilitating conditions

The conditions that aid the implementation of SARA in order to ensure the adoption of SARA by the full caregiver staff are reviewed according to various aspects of the Adjusted ITIM. First, the vision of the elderly care organizations and adhering goals regarding innovative technologies plays a huge part in the success of the implementation of SARA. Second, the financial support available for the acquisition of SARA is an important factor for elderly care organizations as financing SARA is expensive and regarded as experimental without any direct financial benefits for the organizations. Third, Netherlands' government support plays a decisive factor regarding the implementation of SARA as these types of innovative projects must abide by various regulations. Finally, the implementation support provided by Bright Cape consultants according to the Adjusted ITIM with CIF methodology is discussed.

Elderly care organization's vision

According to the science practitioner of tanteLouise, the organization's vision regarding innovation for closed elderly facilities has always been to research and experiment with innovations that provides opportunities that other technical solutions do not offer. If an innovation promises to enhance the quality of life, enhance the efficiency of performing caregiving tasks and decrease the care demand, it is selected and researched by the organization.

"We have to try a lot of innovations. I am still skeptical regarding the benefits of socially assistive robotics as it does not do much yet. But we find that innovation is crucial to tackle the future elderly care demand. So, this is one of the possibilities we research and experiment with."

The innovation advisors of tanteLouise and Maasduinen both recognize that SAR has been a big topic for a while within the innovation boards of the organizations. The innovation advisor of Maasduinen specifies that the organization's goal is to keep experimenting with innovative robotics solutions as robotics will become very relevant in elderly care in the future.

"We want to keep our eye on the ball regarding the field of robotics for elderly care. The offering of the market should be aligned to the issues we as an organization want to tackle. If we can define which issues we want to tackle and where we want to be within five years with robotics in our organization, it is essential that we introduce various forms of robotics in our organization. We do want to already gain some experience in working with robotics in order to create awareness of its possibilities among our staff."

Further, the innovation advisor of tanteLouise specifies that robotics is going to be very involved in the workflow of caregivers and will contribute to primary care tasks like medicine delivery instead of providing entertainment or distractions for elderly so caregivers can perform tasks more efficiently. At this moment, the development of SAR is still in its infancy.

Financing of SARA

The financing of SARA is the full responsibility of the elderly care organizations according to the managers and innovation advisors of both organizations. They specify that a part of the financing is done from their innovation budget which is meant for costs related to staff and monthly subscription of SARA updates, which is common for elderly care organizations in the Netherlands, and the other part is obtained from subsidies provided by local, regional and national organizations that provide financial support for innovative projects in healthcare surrounding robotics. tanteLouise applied for the Meeussen fund, a local fund in Bergen op Zoom, meant for projects which support wellbeing and improve health of residents of the city.

The organizations themselves oversee the applications for these subsidies and they tend to prefer locally organized subsidies as these are easier to apply for and have a smaller number of applicants which increases the chance of receiving the subsidy. Also, the innovation advisors stress that it is crucial for elderly care organizations to collaborate with the assistive robotics market in order to be able to experiment with robotics.

Government support

According to the science practitioner of tanteLouise, the government offers very limited support for experimenting with innovative robotics and innovations in general. Some subsidy and funding operations are supported by the government, but the organization's motivation and effort are key in achieving successful innovation projects.

"The government should provide more support and guidance regarding innovation in healthcare. Especially with the tremendous workload were experiencing right now and the expected wave of elderly that will need care in the near future. Robotics could definitely help us but at this

moment the implementation of robotics like SARA is very limited as socially assistive robotics is still in its infancy."

4.4.3.1 Implementation

The methodology based on the Adjusted ITIM with CIF that guided the implementation in both elderly care organizations was well structured and clear. The monthly cycles that included the information and training sessions for the caregivers and team managers, feedback gathering, sharing of usage log data and workload measurements, while maintaining the agreed-on timeline of the project, was reviewed as very positive by all interviewees. In the following section, the various elements of the Adjusted ITIM, users, workflow and interfacing systems are discussed. Also, the monthly implementation loop is reviewed based on the experiences of the interviewees.

Users

According to the managers and innovation advisors of both elderly care organizations, all relevant stakeholders have been present and accounted for from the start of the planning of the implementation projects. The facilitation of the consultants of Bright Cape has been helpful in analyzing which stakeholders are should be gathered in the project, some of which were not accounted for by the organization themselves like the IT department, psychologists and physical therapists. The interviewees agree that gathering these specific stakeholders had a positive effect on the implementation process of SARA as a great variety of employees felt included and wanted to contribute towards the implementation process.

The caregivers themselves felt that they have been notified too late and some did not even hear of SARA until the robot arrived at their closed elderly facility. A caregiver at Maasduinen provided the following statement:

"The robot just appeared out of nowhere. Most of us [caregivers] just got to know about SARA on the first day of the implementation."

This caregiver acknowledges that she was not present at the first information session and the first training, but she stresses that as most caregivers work part-time at their facility, multiple information and training sessions should have been planned at various hours. Also, the provision of flyers and other reading material would have helped in order to prepare the caregivers. Another caregiver at tanteLouise feels that there has been enough information provision on SARA before the project and notes that the initial introduction of SARA and the first training session was more than enough to get started on working with SARA.

Managers from both organizations suggested that due to the variety in caregivers as every caregiver has a different age, background and affinity with technology, multiple information and training sessions should be provided in order to capture the biggest part of the personnel which will benefit the implementation and adoption of SARA. They do acknowledge that it is mainly their responsibility to make sure all caregivers are provided with equal amounts of information and training.

"We need to motivate our caregivers to join the information and training sessions. Even if they don't have a shift that day, we should provide them with some incentive to join or facilitate multiple sessions with the SARA team."

This statement suggests that the facilitators should notify managers in advance of the difficulties surrounding engaging caregivers to join information and training sessions, so the managers can think of ways which could boost engagement with the implementation project. The science practitioner notes that there are always caregivers who tend to not cooperate with innovative projects and mentions that even within a small, closed elderly care facility there are open-minded early adopters and closed-minded laggards.

In general, the stakeholder selection and communication, regarding their power or interests, towards these stakeholders has been to satisfaction of the managers at the elderly care organizations.

Workflow

The routine daily work schedule of caregivers in closed elderly care facilities combined with the fact that all caregivers work part-time and in shifts, makes it difficult to allow the whole staff of a facility to come together. According to the team and location managers of both organizations this is a continuous struggle in elderly care. The location manager of tanteLouise elaborates:

"I know how difficult it is to get everyone together for a meeting. As some are scheduled to be working and you cannot afford to miss them, while others have their day off, it is a challenge to bring them together."

According to all interviewees, the best time to schedule a meeting without disturbing the workflow too much is during the afternoon shift change around 2pm or 3pm. During this time, the transfer of the shifts take place and essential knowledge on the status of the elderly is shared by caregivers. Before or after this shift change, a meeting of a half hour should allow more caregivers to be present, but not all of them. General team meetings are scheduled up to two months in advance to allow everyone to adjust their schedule and be present. Interviewees advise the facilitators to schedule information, training and evaluation sessions way in advance and during aforementioned hours.

The workflow of caregivers does not allow them to take much time to consider the optimal ways to apply SARA. That is why the facilitators should provide suggestions on how and when to apply SARA's functionalities and during which moments of the day SARA should not be used. Some caregivers have taken time, when they are not at work, to figure out themselves during which moments of the day and which care tasks, they could benefit from SARA. This type of caregivers is scarce, and it cannot be expected from caregivers to figure out SARA in their own time, according to the interviewees. Managers acknowledge that it is their responsibility to allow caregivers some time during their shifts to figure out when SARA could be applied to their benefit. Managers also ask the facilitators to provide more practical suggestions regarding the use of SARA during routine, daily care tasks.

The nature of entertainment functionalities is suggested to have a relation to the routine, daily work schedule of caregivers, as reflections on usage logs show that the application of SARA tends to be highest during free time and evening care moments. Caregivers agree and note that the entertainment functionalities are mostly use to entertain elderly and sometimes distract them during completion of primary care tasks like medicine delivery. A caregiver of Maasduinen elaborates:

"We cannot use SARA the whole day as we have to perform important care tasks and SARA does not make it easier for us to do so. We like to use SARA for fun and entertainment. Only with specific elderly, SARA might distract them which allows us to quickly finish the evening care routine."

Interfacing systems

While the elderly care organizations have stressed that the functionalities of SARA need to be integrated with the existing systems and technologies they use, most interviewees recognize that there is only a very limited number of technologies that they apply on daily basis which could benefit from compatibility with SARA.

Considering the existing entertainment functionalities, the interviewees suggest to allow family, friends and volunteers to provide media in the form of pictures, music and stories that they have made or collected themselves and use these media to provide customized material to the elderly that is related to their place of birth, their living environment and heritage.

When asked if the interviewees could suggest technological systems in their work environment that should be compatible with SARA, most of them do not now directly which systems could be integrated. But some suggested to connect SARA to their communication and reporting technologies which would allow elderly to signal caregivers through the interface of SARA. Also, this would allow caregivers to provide care reports together with the elderly using SARA through speech or a built-in interface based on their existing reporting software.

CIF

All interviewees agreed with the content of and cyclical approach to the implementation of SARA. The caregivers liked the monthly information and training sessions which benefitted the adoption of SARA. Also, they liked to be involved in the general process of evaluating their progress based on feedback, usage logs and workload measurements. Especially, the dialogue with the facilitators of Bright Cape made them feel very involved.

"The insights are very useful, and it provides some clear data which allows my colleagues to see how often they use SARA. It improves everyone's awareness and makes everyone feel more involved in the project."

By evaluating the feedback on functionalities and usability, the caregivers find themselves to be connected to the project and tend to be more engaged in the implementation of SARA. Also, by reviewing the usability logs the caregivers and managers have agreed on the relationship between the nature of the entertainment functionalities and the times of their application during the daily routine. They mention that once functionalities can contribute towards primary care tasks, SARA will also be used during care moments like morning and evening care.

The managers and innovation advisors agree with the cyclical approach which enhances the awareness to use SARA to grow. This approach to continuously review the progress of the project and adjust where necessary. They stress that it keeps the focus of the project close to its main stakeholders, the caregivers and the elderly. Also, they agree that by scheduling various information, training and evaluation sessions, all employees tend to be more connected to the project.

One important aspect of the implementation using CIF is the timeline. As elderly care organizations have limited time to allow for general team meetings, it is essential that the facilitators consider the long-term scheduling that is common in the elderly care industry. It was noticed by the managers and innovation advisors that the schedules proposed by the facilitators of Bright Cape was often too short term and not applicable for the elderly care organizations.

4.4.4 Ease of use

Most caregivers found SARA easy to use through the touch screen interface. Some did have to get adjusted to the possibilities but that was not considered as an issue. Also, the charging of SARA was found to be quite easy but there were some malfunctions during the charging sequence which was not understandable for caregivers. Eventually, this issue was fixed as a quick start guide was provided by the facilitators to allow all caregivers to operate SARA easily. Most caregivers acknowledge this while some remain skeptical as they find the technology somewhat difficult. Further, the online updates that took place at night were considered as good. Finally, the overall robustness of SARA was found to be good as well as there were minimal malfunctions.

4.4.5 Enjoyment

There have been various opinions on the social presence of SARA in the living rooms of the closed elderly care facilities. Some caregivers still question its purpose while others find SARA very useful. Also, due to the high workload experienced in the industry, some caregivers tend to regard SARA as an extra burden instead of a solution. But this are the opinions of a few. In general, caregivers and elderly tend to enjoy the presence of SARA and those who don't find it easy to ignore SARA which alleviates their burden.

4.4.6 Social influence

The presence of SARA in the elderly care facilities is positively accepted by family, friends and volunteers. They find the robot interesting to play with and like to see how the elderly interact with and through SARA. Some start singing along with the elderly, while others take the time to play brain games while the caregivers are busy with care tasks.

There have been some critical comments of family members that don't want their parents to be cared for by robots, but the caregivers and other staff of the organizations could provide them with clarification on the purpose of socially assistive robotics.

4.4.7 Communication and the facilitator role

According to all interviewees, the implementation support was provided to satisfaction by the Bright Cape consultants. It is stressed that continuous communication between all relevant stakeholders was essential to manage expectations and provide accurate information on organized events like training and evaluation sessions.

4.5 Concluding remarks

The results presented in this section provide a clear and thorough overview of the various qualitative and quantitative analyses conducted based on the Adjusted ITIM with CIF and the adjusted UTAUT. These results present the findings on the first longitudinal case studies on SAR implementation in closed elderly care facilities in the Netherlands. Also, the combination of usage logs and workload measurements with qualitative data from interviews presents a unique approach for analysing the progress of SAR implementation.

5. Discussion and conclusion

This thesis focusses on the implementation of SAR in closed elderly care facilities to achieve the adoption of SAR within the daily, routine workflow of caregivers. This is achieved through the application of a developed implementation model based on the ITIM called Adjusted ITIM with CIF and mixed method analyses of usage logs, workload measurements and semi-structured interviews with relevant stakeholders. This final section presents the conclusions with regards to the research question in section 5.1 and stresses the effects of SAR implementation on caregiver workflow and the importance of collecting and analysing usage log and perceived workload data. Further, it offers a discussion on the theoretical and methodological contributions in section 5.2. Also, a reflection upon the limitations of the conducted research in section 5.3 is provided. Finally, recommendations for further studies are proposed in section 5.4 and policy implications are discussed in section 5.5.

5.1 Answers to research question

The research question guiding this thesis is how can socially assistive robots be implemented in elder care work environments using the Integrated Technology Implementation Model in order to reduce workload of caregivers in routine, daily tasks? A division is provided following the five sub-questions specifying essential steps to answer the main research question; (1) Determination of applicability of the Integrated Technology Implementation Model for long-term implementation of socially assistive robotics in closed elderly care, (2) Development of an adjusted implementation model based on the 12 concepts of ITIM including the incorporation of CIF, (3) analysis of the effect of SAR implementation on the workflow of caregivers, (4) analysis of workload measurements of caregivers from both elderly care organizations, and (5) analysis of usage log data in order to measure the progress of adoption. For each of the sub-questions conclusions are presented, followed by a reflection.

5.1.1 Applicability of the ITIM-framework for SAR implementation

To determine the applicability of the Integrated Technology Implementation model for long-term implementation of socially assistive robotics in closed elderly care, three main types of research were conducted. First, the status and relevant developments in the closed elderly care industry were analysed which resulted in an overview of the rising demand for care by elderly and its consequences for the industry which include high workload and increased turnover and sick leave among caregivers. Also, the frequency of dementia cases among the elderly was discussed and the caregiver routine, daily work schedule including care tasks was examined. See section 2.1 – 2.4. Second, the SAR market was analysed through the literature review of academic literature on SAR development and online research of SAR availability in the market according to the taxonomy of SAR and various features relevant for the competition aspect of the SAR market. This thesis suggests adding sensorial capacities as a feature to the SAR taxonomy list designed by Fong (2003) as multiple SAR's offer this feature nowadays. This market analysis, provided in section 2.8, resulted in a division of three main types of SAR that are commercially offered: Plug and play bots, Social Health Assistants, and Multi-Industry Robots. The main differences between the three types are the availability of software updates, degrees of implementation support and customization options in terms of hardware and software. Third, a variety of models regarding the implementation of technology were researched and compared. The main difference was the focus of the implementation as Technology Acceptance Models are developed for adoption by users while Implementation Science models are developed for adoption by organizations. ITIM appeared to be a suitable model for SAR implementation in closed elderly care as it combines the

concepts of TAM and IS models and focusses on the implementation of healthcare technologies in care environments. Section 2.9 elaborates on the limitations of previous studies concerning SAR in elderly care environments.

5.1.2 Development of an adjusted implementation model with CIF

Adjustments needed to be made to the concepts of ITIM in order to achieve concepts that are fully applicable for the implementation of SAR. In section 3.7, the various adjustments to the concepts are described. This process was followed by the distinction between fixed and variable concepts as the nature of the technology is predetermined to be SAR and the outer concepts regulation, economic environment and vendor are predetermined once a choice has been made to implement a specific SAR in a specific elderly care organization, with predetermined financial means, that is located in a country which determines the regulatory and economic concepts. The inner concepts of users and leadership have been combined as these concepts both specify stakeholders and their powers and interests. The result of this distinction is the Adjusted ITIM consisting out of variable concepts: users, workflow, interfacing systems and facilitator role. Further, the Continuous Improvement Framework is described and its repetitive cycle feature that ensures a cyclical approach towards implementation of SAR allowing for improved feedback gathering on capabilities and usability. The resulting Adjusted ITIM with CIF is presented in section 3.9 and accompanied with a guide on how to apply the adjusted implementation model.

The Adjusted ITIM with CIF has been applied in two separate case studies where fixed concepts like type of SAR, vendor, and regulatory and economic environments were described. The variable concepts have been determined by applying various analyses. First, users have been determined through stakeholder analyses and semi-structured qualitative interviews based on the questionnaires used by Heerink (2010) and Verelst (2018), which resulted in a selection of relevant stakeholders for SAR implementation. This whole selection and description of the power and interest of each stakeholder is provided in section 4.1. Second, the workflow analyses using information on patient care plans, information on both closed elderly care facilities, analyses of usage logs, and semi-structured qualitative interviews, resulted in the understanding of the relation between specific functionalities and their preferred application during the routine, daily work schedule of caregivers. Finally, interfacing systems were determined mainly through semi-structured interviews where it was suggested to integrate SAR in the existing communication and reporting technologies, but this has not been attempted nor implemented due to the limited time and scope of the case studies. It is concluded that there is a very low presence of technologies in closed elderly care facilities and caregivers mostly work without any other technologies except a portable radiophone for communication and alerts, and a laptop to type client reports.

5.1.3 SAR implementation effects on workflow

It has been strongly suggested by interviewees that a relation exists between the type of functionality and the routine, daily work schedule of caregivers. Specifically, that entertainment functionalities are best applied during free time moments to entertain the elderly and that these functionalities can sometimes be applied for specific care tasks in order to distract the elderly in order to increase the efficiency of the performance of the care task by the caregiver. Also, the results suggest that functionalities that could contribute towards the efficiency of primary care task performance like medicine delivery, would boost efficiency of caregiver workflow.

Further, the implementation is suggested to have negatively impact the workflow of caregivers as they have an additional task to experiment and use the SAR during their routine, daily work schedule. Also, the implementation efforts based on CIF, especially the information, training and evaluation sessions take up a lot of time for the caregivers as they work part-time shifts and the scheduling of these sessions is not fully compatible with their work schedules. Finally, due to the experienced high workload and predetermined schedule of work meetings, caregivers do not have time to consider useful applications of SAR if management does not provide them with this time.

Based on the results presented above, this thesis suggests providing caregivers some additional time during which they partake in a workshop on effective and efficient application of SAR. This would benefit their understanding of the benefits of SAR, allow them to brainstorm during which moments in their routine workflow they can apply SAR for the benefit of the elderly and the caregiver team, and have time outside of their work environment to apply SAR in teambuilding games.

5.1.4 Caregiver workload measurements

The results of the workload measurements show that the workload of caregivers has not made any significant changes. This suggests the following; First, due to the nature of functionalities which are limited to entertainment, the usability of a SAR with these solely entertainment functionalities is also limited. While some caregivers that were part of the case studies have found ways to improve the efficiency of their work by applying SAR and acknowledged that they felt a decrease in workload, the measurements of their workload have not shown similar effects on their workload. Second, the implementation of SAR results in additional tasks for caregivers which does not decrease workload. Third, events unrelated to the implementation of SAR have an impact on the routine, daily work schedule which in turn affects the workload of caregivers. It is apparent that the implementation of SAR cannot decrease the workload by itself as overall workload of caregivers is subject to many factors outside the scope of SAR implementation and adoption. This thesis concludes that investigating workload of caregivers is only relevant to determine the workload itself and is not useful to analyse the workload during the implementation of SAR.

5.1.5 Usage log data to measure adoption

The application of usage log data allows to track the adoption progress of the implementation of SAR as the usage log data provides information on date, time, type of interaction and duration of interactions. In the case studies, the usage log data also allowed the facilitator to analyse the usage of the SAR in order to provide feedback to the elderly care organizations based on metrics. This allowed them to reflect on why the SAR is used during particular times of day and resulted in useful analyses which were shared among stakeholders to raise awareness and boost adoption. It is important to note no personal and privacy-sensitive information was collected during the case studies as the SAR did not have any personalized options. This thesis concludes that by gathering and analysing usage logs and combining these results with calendar data, work schedules, and information on daily routine and activities, it allows stakeholders of the implementation to understand why the SAR is used and propose suggestions to increase the use of SAR and boost adoption.

5.1.6 Reflection

This thesis has provided and tested an easy-to-use model and guide for future SAR implementations in healthcare environments that can be adjusted and improved upon based on prospected requirements. The exploration of implementing socially assistive robots in closed elderly care work environments using an adjusted implementation model based on ITIM and CIF to achieve a reduction in caregiver workload resulted in an initial guide towards the implementation of SAR in elderly care organizations. The analyses show that the implementation of SAR can be achieved if managed properly with all relevant stakeholders and if the facilitator accounts for the existing workflow of the closed elderly care facilities. The most important aspect of the implementation is continuous communication without any obstacles as it allows stakeholders to debate on intermediary results, evaluate feedback and adjust the implementation schedule.

The results show that by analyzing usage logs and perceived workload combined with qualitative feedback useful insights are generated which allow the stakeholders to effectively evaluate the progress of implementation of SAR. The results of the explorative case studies show that the expected workload reduction for caregivers is not achieved. As the vision of elderly care organizations regarding SAR implementation is often limited and its derived key performance indicators which are used to measure the success of a SAR implementation are not updated since the arrival of SAR, additional metrics to determine the added benefits of SAR need to be identified and introduced within healthcare organizations who are willing to adopt SAR. The varieties in vision and measures applied to measure performance and success, allow for a great deal of subjectivity.

Further, additional research is needed to study the implementation of SAR as there are very limited studies conducted this topic to the knowledge of the author. Also, additional research is needed to apply the Adjusted ITIM with CIF for other SARs, in other closed elderly care facilities, and in other countries with other regulations and economic environments, in order to validate the developed SAR implementation model.

The methodology, analyses and results presented in this thesis provide opportunities for further research and contribute to the understanding of SAR implementation in closed elderly care organizations. The analyses performed on the implementation of SARA in the two case studies illustrate varied perspectives on SAR functionalities, usability, purpose and acceptance of SAR. Due to the limited availability of SARA, additional research with a larger sample is required to explore the various aspects implementation in a variety of closed elderly care organizations and explore more metrics to measure the adoption progress. This can be achieved by further developing the Adjusted ITIM with CIF based on future SAR features and future requirements of healthcare organisations and review the implementation progress consistently throughout the implementation.

5.1.7 Practical use of the implementation guide for SARA by Bright Cape

The resulting Adjusted ITIM with CIF developed by this thesis has been used to develop a thorough implementation guide for SARA. The goal of this implementation guide is to incorporate the elderly care organisation’s vision and implement SARA in order to contribute towards that vision. The guide features a structured timeline and methodology to follow in order to successfully implement SARA within closed elderly care facilities. Also, it features an adaptable stakeholder matrix based on the functionalities included with SARA and the wishes of the adopting elderly care organization. Further,

it describes the necessary data to collect and various applications for this data which includes the analyses of usage logs, workload measurements and qualitative feedback processing. At the moment of writing, it is applied in the third closed elderly care facility and a SARA robot has successfully been implemented since a month.

5.2 Theoretical and methodological contributions

Sections 2 to 3 reviewed the theoretical and methodological foundations of this research by reflecting upon previous studies and positioned this thesis. In this section, the contributions towards theory and methodology of the discussed field and studies are reflected upon.

5.2.1 Theoretical contributions

The literature review of section 2 specifies that there is currently no existing research that has analysed the SAR market based on its taxonomy and commercial offerings. This research has proposed an initial market analysis which can be built upon by future research. Also, this research has suggested the addition of sensorial capacities like tactile gestures to the SAR taxonomy list designed by Fong (2003) and elaborated by Feil-Seifer and Matarix (2005).

Further, the division of SAR offerings in the market based upon commercial aspects into Plug and play bots, Social Health Assistants, and Multi-Industry Robots. The main differences between the three types are the availability of software updates, degrees of implementation support and customization options in terms of hardware and software. This differentiation can aid future research to clearly analyse the distinctions between SAR market offerings and describe market differentiation.

5.2.2 Methodological contributions

The methodology review of section 3 specifies that the novel ITIM is at the cross section of TAM and IS models but has not yet been tested in the case of SAR. This research has contributed towards the development of an adjusted implementation methodology fitted for SAR implementation within closed elderly care facilities. There has not been any similar research conducted for implementation of SAR in general and especially not for the implementation of SAR in the elderly care industry. The clarifications and additions to the original ITIM concepts have provided a basis for concepts for SAR implementation in elderly care which might aid future studies that want to further develop a SAR implementation model based on ITIM.

Further, the addition of the Continuous Improvement Framework to the adjusted implementation methodology accounted for the missing factors in ITIM by Schoville (2015). The addition of cyclical measures over time, including feedback sessions on capabilities and feedback, has given the adjusted implementation methodology for SAR an extra dimension as implementation progress can now be effectively reviewed by relevant stakeholders and changes can be made during the implementation in order to continuously improve the implementation efforts of projects for SAR implementation in elderly care. This addition might inspire future studies to apply this framework for SAR implementation purposes.

Finally, a guide has been provided in order to assist future studies in SAR implementation. There have not been any studies that have provided a guide which includes various analysis tools to enhance

implementation efforts and measure implementation progress. The proposed cyclical method of introducing SAR and its functionalities, gathering and analysing qualitative and quantitative feedback through interviews, usage logs and workload measurements, and sharing the results with relevant stakeholders, allows future studies to further investigate the implementation of SAR and make adjustments to the adjusted implementation model, measure implementation progress through the proposed methods and add novel methods.

The concept of facilitating conditions of the Unified Theory of Acceptance and Use of Technology has been further developed by proposing the addition of the implementation concept which includes sub-concepts users, workflow, interfacing systems and CIF. These concepts have not yet been validated with the UTAUT model for SAR by Heerink et al. (2010) and future studies might check which of the proposed concepts can be validated.

5.3 Limitations

This study has several limitations that are discussed in the following paragraphs. These limitations provide more background for the choices made by this current study and put the results and conclusions into perspective.

First, there have not been any previous studies which have been frequently cited and validated regarding the topic of SAR implementation in healthcare. Due to the exploratory nature of the study and limitation to one specific SAR, no similarities or parallels could be followed during the execution of this research. Caution is advised for such exploratory studies as this thesis shows the implementation of SAR in closed elderly care facilities in very specific contexts.

Also, the gathering of data has been very limited due to the limited availability of SARA robots and limited time and scope of the implementation. Therefore, this data cannot be validated as the sample size is too small. Further, responses of interviewees are limited to two elderly care organizations and the findings in no way reflect the findings, experiences and opinions of the staff of other elderly care organizations in the Netherlands.

Finally, as the SARA robot is the result of development efforts by the data science consultancy Bright Cape, various decisions regarding implementation and data gathering were made which the researcher had to follow. Also, the demands and limitations proposed by the elderly care organizations might have influenced the gathering and analyses of data. Some demands might have affected the implementation process, but this research has aimed to minimize these effects.

5.4 Recommendations for further studies

This section outlines various recommendations for future research on the topic of SAR implementation in healthcare organizations.

First, it is recommended to analyse the implementation of multiple similar SARs at a bigger sample of healthcare organizations in order to be able to provide more generalizable results and be able to do more quantitative analyses which in turn will benefit data gathering and analyses, and decision-making during the implementation process. This allows for minimizing the uncertainties and random results of the implementation.

Second, all data gathered has been anonymized due to the strict privacy regulations surrounding healthcare in the Netherlands which is based on Europe's GDPR legislation. It would be interesting to analyse the usage log data if you know who has created the logs through interacting with the SAR. This will allow you to select users based on their experience in order to ask deeper and more specific questions regarding the functionalities, usability and implementation process. Also, the personal information will allow your analyses to be more detailed and complex, which would benefit the results. Finally, this will allow you to select users that barely use and interact with the SAR, which allows you to find out the reasoning behind that behavior, analyse the data and adjust the implementation in order to achieve more users and eventually a greater adoption.

Third, I challenge future researchers to study the implementation of SAR in various countries as not only outer context elements like regulation and economic environment, but also cultural elements will come into play. This will benefit the variety of data and results will indicate optimal regions for SAR implementation. These results could also have industrial applications, which benefits the free market and increases the adoption of healthcare technologies among healthcare organizations that struggle with high workload, turnover and sick leave. Finally, the implementation of SAR in various countries could increase awareness of SAR solutions and will motivate experimentation with and possibly adoption of SAR solutions.

5.5 Implications and recommendations for public policy

This section presents recommendations and implications for public policy regarding the stimulus of e-health technology implementation and adoption in healthcare environments in the Netherlands. Due to the novelty of SAR and other e-health technologies and t The Dutch government has voiced ambitions to enhance the online availability of medical records, to popularize e-health technologies and subsidize research efforts in the field of e-health innovation (Nictiz & Nivel, 2019; Rijksoverheid, 2016). The policies described have been guiding in the country's actions towards e-health technology adoption in healthcare, but the national government has delegated the tasks of defining how to popularize and subsidize e-health technologies to the provinces, decentralized institutions like private funds and local technology hubs like the High Tech Campus in Eindhoven. The government keeps up with the progress of their e-health policies through the yearly e-health monitor administered by Nictiz which concludes that the use of online inspection of medical records, video calling and telemonitoring is increasing throughout the country but the integration of many e-health applications and technologies within the existing workflow of healthcare organizations is progressing very slowly. This is due to the insufficient integration of the technologies with the existing care practices and lack of knowledge and knowhow on e-health possibilities within healthcare organizations and their staff. While healthcare organizations and staff are enthusiastic about e-health technologies, the implementation of e-health in healthcare needs to be improved drastically (Nictiz & Nivel, 2019).

As both case studies have occurred in elderly care organizations located in Brabant, the province's derived plans based on the national policy are important to consider; The Brabant province developed the Economic Program Brabant 2020, where it focusses on the development and growth of multi-organizational clusters within its region for the care economy which includes external economical and societal stakeholders. Also, it aims to connect these clusters to the labor market organizations and education. The province makes clear that business should be leading the development and implementation of e-health together with healthcare organizations while the province should have the

role of enabler as it aims to actively connect parties and provide more than financial support (brabant.nl, 2019).

So, how can healthcare organizations be guided in order to enhance the implementation and adoption of e-health technologies (1) and how can healthcare organizations increase their knowledge on e-health technologies and their applications within their existing workflow (2)?

Although this thesis has not provided an implementation model for all emerging e-health technologies, it shows a thorough and replicable approach for the adaptation of ITIM into an implementation model for SAR within closed elderly care environments which can be followed to implement other e-health technologies. Hence it is essential to define essential concepts for the implementation of an e-health technology in order to successfully develop a fitted implementation model and actively measure the progress of the implementation through qualitative and quantitative data analyses. Key Performance Indicators (KPI's) need to be defined, related measurement tools need be standardized and based on reasonable goals for every specific e-health technology. By integrating stakeholders into the implementation process and analyzing their own workflow, caregivers have gained useful insights on the implementation and adoption of SAR which can now benefit them in their future work with e-health. Also, some direct educational activities have taken place during this process where caregivers have learned about technological possibilities and experienced working together with an e-health technology provider. These experiences have required them to approach their work environment from different perspectives and investigate how SAR can be applied to benefit them in their existing workflow.

Here recommendations are made for policymakers. The recommendations encapsulate efforts for enhancing collaboration between healthcare organizations and e-health providers and the increase of knowledge sharing on e-health application within existing healthcare workflows.

I. To advance healthcare organizations in their knowledge, technical understanding, and application possibilities of e-health, it is advised to develop policies on national and provincial level that stimulate e-health providers to offer active implementation support for healthcare organizations. This can be done through co-innovation subsidies that allow collaborating organizations to apply and allocate the funds for implementation of the e-health technology and enhance the development of the technology based on their findings from the implementation support. The presented thesis offers an approach to manage such a co-innovation project. Subsidy allocation could be controlled through a division of funds based on efforts from both parties and reception of a part of the funds can be based on the achievement of adoption KPI's. It is advised that the KPI's are defined and measurement tools for the KPI's are researched. Further, efforts need to be undertaken to control the compliance of both parties to the subsidy standards and regulations.
II. Healthcare organizations' management have long been interested in the benefits of e-health and often described the desire to improve their care offering through e-health (Nictiz & Nivel, 2019). The adoption of e-health is often described as a trend that all healthcare environments will have to adhere to. Unfortunately, healthcare organizations are often not able to allocate time and resources to educate and train staff on emerging e-health technologies, how to sustainably incorporate e-health technology in the existing workflow of caregivers, and experimenting with and learning to effectively apply e-health technologies (Cresswell & Sheikh, 2013; Nictiz & Nivel, 2019). It would be possible to allow caregivers to learn on the job through knowledge sessions and training accompanied by implementation and workflow experts. This allows caregivers to spend minimal time

away from the job while having full accessibility to information and advice on effective e-health application. In addition, this allows experts to record e-health implementations, gather and analyse data from various e-health technologies and healthcare environments, develop standardized models and increase the speed of spreading e-health among healthcare organizations. Policymakers can further examine the changes in quality of life for clients and caregivers, in efficiency of caregiving task completion, and in reduction of care demand from to caregivers, and consequently develop policies which allow for time and resource allocation to further educate and train caregivers.

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Appendix A – SAR analysis

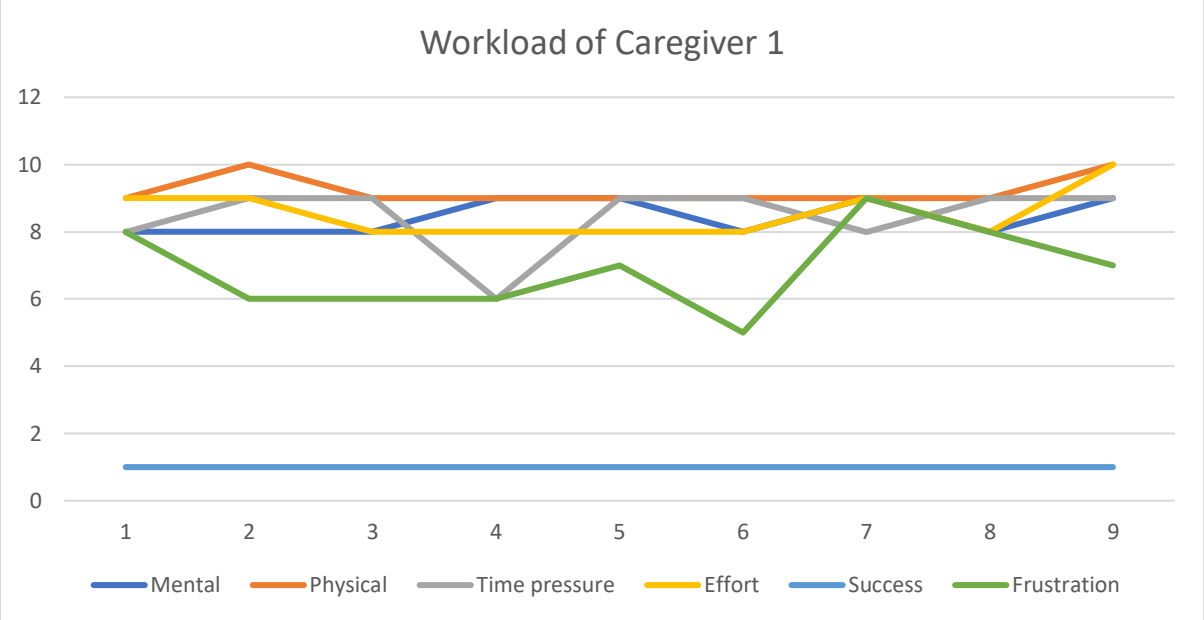
See additional Excel file which includes the SAR market analysis file with name “SAR market analysis.xlsx”. This file provides a complete and detailed overview of the total number of SARs analysed according to 39 variables based on the SAR taxonomy of Fong (2003) and Feil-Seifer and Matarix (2004) and additional variables in order to determine the market offerings of the SARs as described in section 2.8.

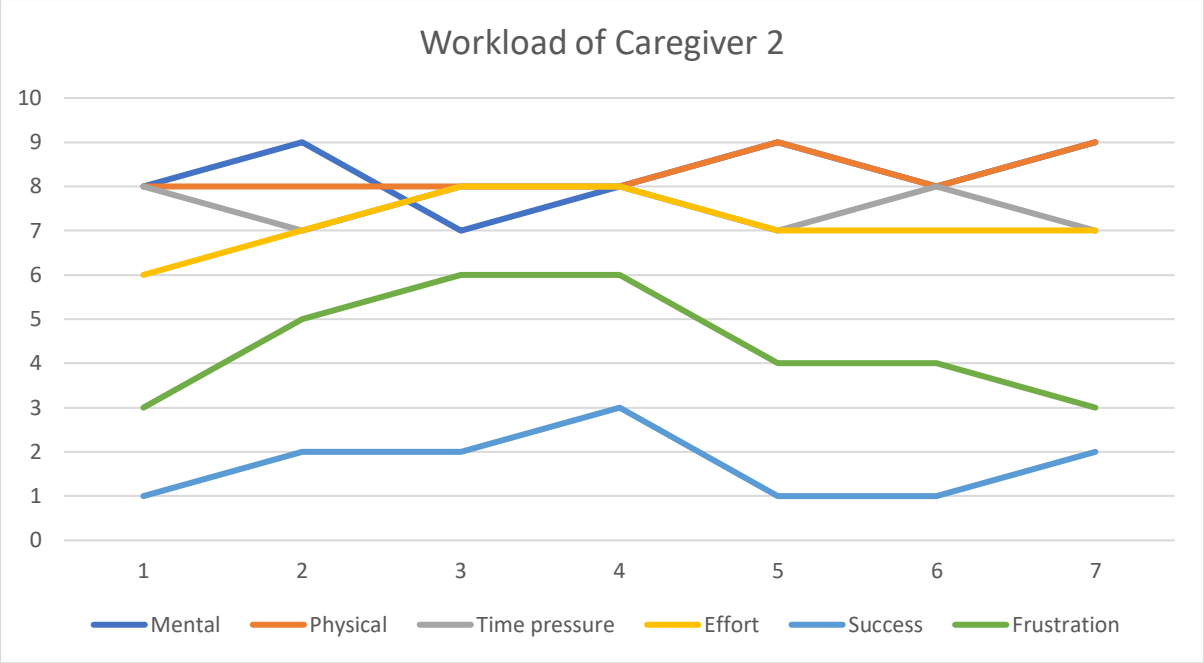
Appendix B – Usage log analysis

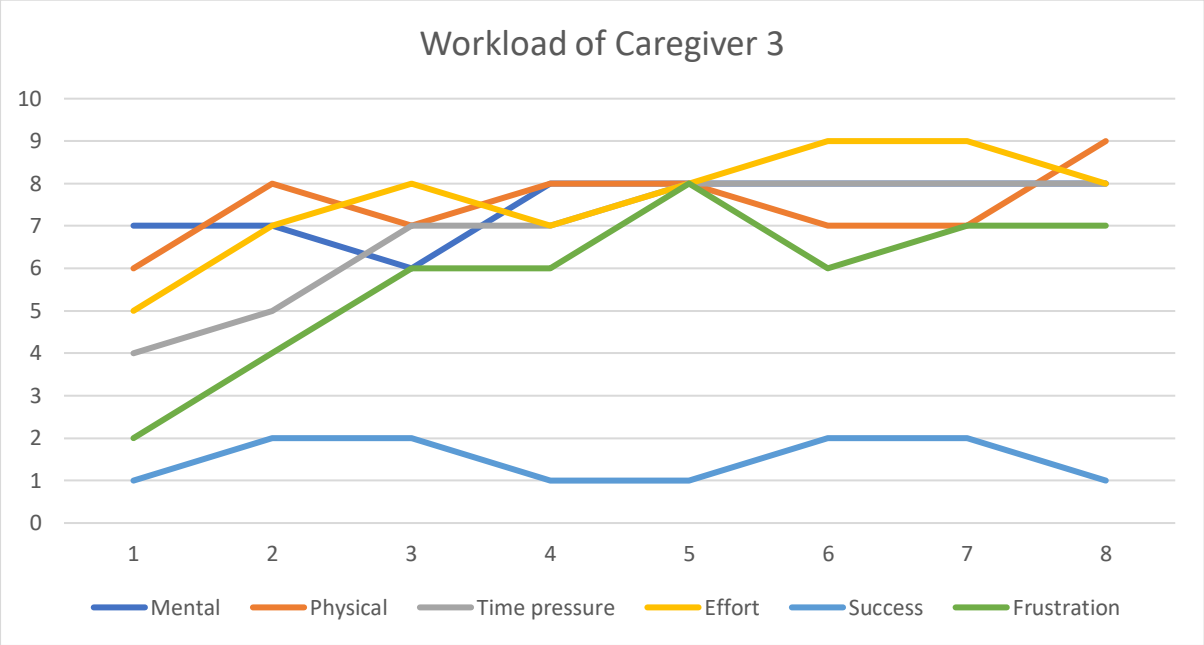
See additional Excel file which includes the usage log analysis of the SARA robots in both case studies with the name “SARAlogs.xlsx”. Each tab presents the filtered and analysed usage logs including the descriptive graphs for visualization purposes.

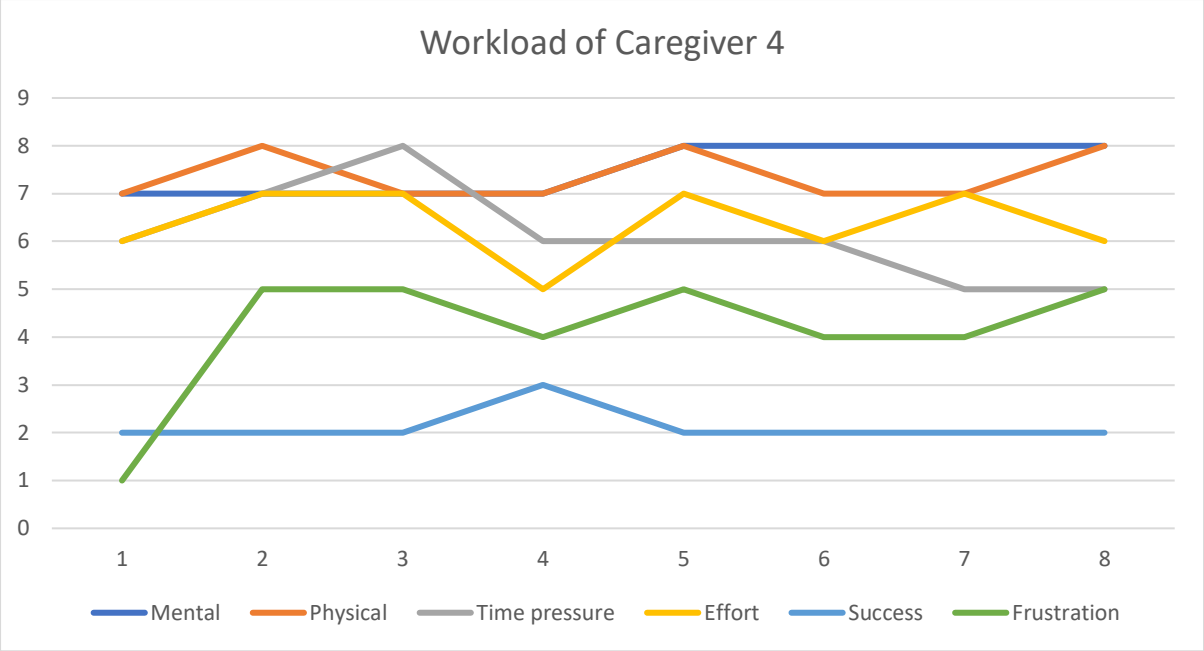
Appendix C – Workload analyses

Workload measurements of the four participating caregivers are provided below. The workload measurements are depicted in the six workload determinants of workload according to the NASA TLX methodology. The measurement of success was conducted based on an inverted scale (1 = very successful and 9 is not successful) (Hoonakker et al., 2011). Caregivers have been anonymized.




Workload of Caregiver 2
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
Mental
Physical
Time pressure
Effort
Success
Frustration


Workload of Caregiver 3
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
Mental
Physical
Time pressure
Effort
Success
Frustration



Appendix D – Questionnaire for semi-structured, qualitative interviews based on adjusted UTAUT model by Heerink et al. (2010)

The questionnaire below is provided in Dutch as the interviewees were based in the Netherlands.

- Leeftijd, opleidingsniveau, functie, ervaring in de zorg, ervaring met robotica

Perceived ease of use & perceived usefulness:

- Waar wordt SARA momenteel voor gebruikt? Wordt SARA gebruikt voor gezelschap or ook fysieke en/of cognitieve assistentie?
- Op wat voor momenten wordt SARA gebruikt? (Rekening houdend met de algemene dagindeling in de gesloten zorgomgeving)
- Draag SARA bij aan efficiënt werken bij de zorgmedewerkers? Op wat voor manier wel/niet?
- Draagt SARA bij aan het afnemen van de zorgvraag van de ouderen aan zorgmedewerkers? Op wat voor manier wel/niet?
- Hoe gaat u/het personeel om met het werken met de robot?
- Is SARA makkelijk te gebruiken?
    - Opladen batterij
    - Online updates
    - Besturing SARA via touch screen
    - Robustness

Attitude & perceived enjoyments:

- Is de robot makkelijk te gebruiken voor het zorgpersoneel?
- Gebruikt iedereen van het personeel SARA even vaak? Wat zorgt ervoor dat zorgmedewerkers SARA gebruiken? Wat houdt zorgmedewerkers tegen om SARA te gebruiken?
- Geniet het zorgpersoneel van het gebruiken van SARA?
- Wat voor invloed heeft de robot op de sociale werkomgeving van het zorgpersoneel?

- Verbetert SARA de kwaliteit van leven van ouderen? Verbetert SARA de kwaliteit van leven van de zorgmedewerkers?
- Hoe ervaren de zorgmedewerkers het werken met SARA? In wat voor werkomstandigheden maken zij gebruik van SARA? In welke werkomstandigheden maken zij geen gebruik van SARA?

Social influence:
- Hoe gaan bezoekers zoals familie en vrienden om met SARA/de aanwezigheid van SARA?
- Hoe ervaren de medewerkers (zorg/welzijn/vrijwilligers) SARA/de aanwezigheid van SARA?

Facilitating conditions:
- Waarom is besloten om te investeren in sociaal assistieve robotica als innovatie? Waarom is voor SARA gekozen?
- Hoe is SARA bekostigd?
- Op wat voor manier stimuleert de overheid innovatie in de ouderen zorg? Wordt de nadruk op robotica gelegd?
- Hoe staat de adoptie van robotica bij de zorgorganisatie op de planning?
- Wat vindt u van het contact met Bright Cape? Wat vindt u van de implementatie begeleiding?
    - Nieuwe functionaliteit trainingen
    - Kort cyclische feedback en aanpassingen (ophalen via gesprek, interviews, online surveys)
    - Inzicht gebruik SARA dmv logs
    - Inzicht werkdruk gedurende implementatie proces SARA
    - Aanstellen SARA-ambassadeur
    - Aantal contact momenten (face-to-face/digitaal)
    - Betrekken van medewerkers in het implementatie proces
    - Dragen de maandelijkse feedback sessies, trainingen en inzichten in gebruik bij aan de adoptie?
- Adjusted ITIM
    - Wat vindt u van de ondersteuning van de verandering? Wat helpt bij de verandering? Wat kan er beter?
    - Users
        - Zijn de juiste stakeholders betrokken?
        - Wordt er op de juiste manier met stakeholders gecommuniceerd?
    - Workflow
        - Wat vindt u van de implementatie van SARA in het werkproces van de zorgmedewerkers? (Rekening houdend met de algemene dagindeling in de gesloten zorgomgeving)
        - Draagt de implementatie SARA bij aan de verlaging van werkdruk van zorgmedewerkers? Denkt u dat SARA in de toekomst bij kan dragen aan de verlaging van werkdruk?
        - Denkt u dat inzichten in gebruik van SARA dmv usage logs bijdragen aan de adoptie van SARA? Op wat voor manier wel/niet?
        - Is de werkomgeving geschikt voor de adoptie van SARA?
    - Interfacing systems
        - Welke technologische systemen moeten met SARA interacteren?

- Hoe belangrijk is het dat SARA samen met de overige technologische systemen werkt?

Appendix E – Interviewees

Names of interviewees can be retrieved upon request.

Caregiver at tanteLouise
Caregiver at Maasduinen
Team leader at tanteLouise
Location manager at tanteLouise
Innovation advisor at tanteLouise
Innovation advisor at Maasduinen
Innovation advisor assistant at Maasduinen
Science practitioner at tanteLouise