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SpeakOut – A digital platform for orientation and self-help for personal and social problems of students at university

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Abstract. This work presents the development of an online platform (SpeakOut) which follows a user-centered participatory design approach considering students' interests. It was investigated how the graphical user interface of the application should be designed to provide a positive user experience. By involving individual interest groups, both improvement potential and requirements for the system are identified, adapted and transferred into a final prototype in several design iterations based on workshops, heuristic evaluation, a user evaluation, interviews and guerrilla testing. More and more students are struggling with e.g., fears or depression during their studies. Therefore, prevention work through low threshold university offers is becoming increasingly important. Our results show that a university platform for students requires simple structures, short precise texts, and a visual language. SpeakOut is promising as a profitable instrument in the mediative process of conflicts. It offers a preventive approach to orientation and self-help for students' personal and social concerns.

Introduction

Motivation

Even before the outbreak of the Corona pandemic, students represented a vulnerable target group. In 2017, almost 100,000 students sought help from the German Student Services[1]. Covid-19 and the restrictions that have accompanied it socially since the beginning of 2020 represent additional stressors. In various surveys, the Federal Statistical Office (2021) recorded a stress perception of ‘rather strong’ to ‘very strong’ among 68% of all international students surveyed and 69% among those with German university entrance qualifications[2], whereby the personal perception of stress was of an individual nature and differentiated according to vulnerability[3]. According to 62% of all respondents, coping with learning material had become ‘rather more difficult’ to ‘more difficult’ during the pandemic. Likewise, structuring the day. 58% of them find it more difficult to follow online events than live events before. 57% find exam requirements more burdensome at these times, again based on the vulnerability of the individual (e.g., those with impairments 67%; Covid-19 risk group 61%, students with child 61%). 61% also say that communication with teaching staff is now more difficult. Interaction in study groups is even more difficult for 77% of respondents, and 86% report less contact with fellow students. Psychological impairments have increased massively because of Corona[4].

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[1]Deutschlandfunk: https://www.deutschlandfunk.de/psychologischer-beratungsservice-immer-mehr-studierende-100.html (Last accessed: 2nd of August, 2023)

[2]statista: https://de.statista.com/statistik/daten/studie/1237385/umfrage/studierende-mit-psychischer-beeintraechtigung-nach-faechergruppen/ (Last accessed: 2nd of August, 2023)

[3]statista: https://de.statista.com/statistik/daten/studie/1237304/umfrage/pruefungsbewaeltigung-von-studierenden-nach-vulnerabilitaet/#professional (Last accessed: 2nd of August, 2023)

[4]statista: https://de.statista.com/statistik/daten/studie/1237316/umfrage/stressempfinden-von-studierenden-nach-vulnerabilitaet/ (Last accessed: 2nd of August, 2023)

Problem and objective

A lack of anonymity can have a discouraging effect and thus make it difficult to address serious problems, especially in very sensitive conflict zones, such as bullying, fear of failure, and depression but also circumstances such as financial struggles or loneliness. Through a combination of stigmatization and lack of privacy, the path of the natural self-help that every person disposes of can disappear. As a result, 'seeking help' can prove complicated for those affected (Bauer et al., 2005). Therefore, our contribution is focused on this. Because of the lower stigma due to anonymity when using eHealth products, the inhibition threshold in 'seeking help' is reduced, leading to increased autonomy of the affected person (Bauer et al., 2005). Also, an important factor to expand eHealth services in Germany is that increased mobility can ensure a significant improvement in patient accessibility in terms of service use, regardless of time and place (Gigerenzer et al., 2016).

Students represent a large target group of effect carriers, among whom symptom carriers are often found. Therefore, the overall project aim of SpeakOut was to create a private digital space that strengthens the advocacy of students in general and minorities, such as the LGBTTQQIAP+ community or students with disabilities, in particular. In this way, stigmatization is counteracted by promoting a stronger perception of interpersonal interaction and mutual acceptance. The generation of knowledge in the thematic focal points of the platform would intend to help users achieve more self-determination. However, since SpeakOut was only a one-year project, the development focus was initially on the graphical user interface (GUI) as well as good user guidance to help students find competent support in the university context, where information and contact persons are often difficult to find due to the high density of the first.

In this study the students' expectations of such a platform are investigated to avoid a negative reaction of the target group. Given the current developments in the business domain, two questions are posed for further action: 1) How must a virtual assistant be integrated into an eHealth-based platform? and 2) What interaction elements must this platform offer to create a good UX? Following these questions in the course of this work a user-centered concept for the SpeakOut platform is developed. In order to ensure this a Participatory Design (PD) approach has been followed, so the needs and requirements of students as well as other stakeholders, such as the Central Student Counseling Service and usability experts (HCI MA students), have been taken into account.

Research background

Mental health challenges of university students and university counselling

Studying at universities and colleges can be a positive and enjoyable experience. It can help build self-confidence, increase performance and improve mental health. However, it can also be challenging and stressful. Attending university is associated with lifestyle changes and increased autonomy in personal life. As many young adults move from the parental home to shared or single apartments, the social environment changes.

A study (Auerbach et al., 2018), part of a World Health Organization (WHO) initiative, examined the prevalence of mental disorders including major depression, mania, generalized anxiety disorder, panic disorder, alcohol use disorder, and drug use disorder among first-year students at 19 universities in 8 developed countries. The surveys found that 1 in 3 first-year students reported symptoms of mental illness.

According to the 2016-2017 Healthy Minds Study, there is a perceived stigma among college students against publicly admitting to a mental health condition. Just over half of the students surveyed agreed with the statement that most people think less of a person who is receiving mental health treatment (Eisenberg et al., 2017). Thus, they describe a sense of social isolation associated with the stigma of mental illness, which is why they are often unwilling to seek help (Megivern et al., 2003). Mental health problems have further far-reaching implications for all aspects of campus life: at the individual, interpersonal, and institutional levels (Kitzrow, 2003).

Diverse study findings suggest an unmet need for internal university counselling services (Auerbach et al., 2018). Timely and effective treatment is important. However, the number of students who need it due to personal challenges and mental illness far exceeds the resources of most counseling centers. This results in a significant unmet need for mental health treatment (Auerbach et al., 2018; Unbehaun et al., 2021). The need to provide counseling to such a wide range of students and issues including multicultural as well as gender issues, career and developmental needs, life transitions, stress, violence, and serious psychological problems is one of the greatest challenges facing college counseling centers (Kitzrow, 2003). Grobe (2018) particularly advocates low-threshold offers that students can take advantage of at an early stage. A potential is seen in anonymous online offers that take into account the “smartphone generation” (Grobe et al., 2018). In their recent study, Williams et al. (2021) highlight the importance of providing navigational support to facilitate clear and efficient navigation of resources. In particular, they note that participants in their study “consistently expressed difficulty in locating resources and had limited knowledge of the resources and services available to them on campus" (Williams et al., 2021, p. 3). This finding emphasizes the challenges individuals face in finding and understanding the resources available to them. In a related study, Motahar et al. (2020) investigated the ways in which international graduate students seek support. They found that their participants frequently used social media platforms, such as Facebook and Twitter, to obtain information and network support. This use of technology highlights a modern approach to seeking support and highlights the role of digital platforms in contemporary support seeking behaviour.

EHealth

Health information and programs are made available to the general public on the Internet. This is of particular benefit to people who, due to physical or mental disabilities, have difficulty accessing personal services (Ertl et al., 2019, 2020). Internet access is available around the clock and from almost everywhere. By presenting texts and other information in a variety of formats, languages, and writing styles at different educational levels, the presentation can be customized to the user. With the help of specific functions, technology-based interactivity between different people, such as the people concerned, psychologists, doctors, etc., is made possible (Taylor & Luce, 2003; Unbehaun et al., 2018, 2019, 2020).

Internet-based innovations and technologies are rapidly expanding the reach of psychological interventions around the globe. A Bertelsmann Stiftung population survey of 1.074 German Internet users aged 18 to 80 on "Searching for health information online" (Marstedt, 2018, p. 1) found that 46 percent of respondents use the Internet for health-related questions (Marstedt, 2018). Thus, it represents an essential first point of contact for patients. In this context, the term computer-assisted therapy is defined as psychotherapy that uses a computer program to deliver a significant portion of the therapy content, or the use of a computer program to assist the therapist. Because of its strong standardization, structuring, and many psychoeducational elements, cognitive behavioral therapy (CBT) is usually best suited for eHealth approaches (Klein & Berger, 2013). CBT is a widely used, effective form of therapy used for a variety of mental disorders (Kiropoulos et al., 2008) and, with reference to the APA (American Psychological Association), described by the authors as "'gold standard' psychological treatment approach" (Kiropoulos et al., 2008, p. 1273). Its "set of techniques in which there is a combination of a cognitive approach and behavioral procedures" (Chasqueira et al., 2022) offers a good diversity for designing an eHealth platform.

In a different study by Harrison et al. (2022), the authors took a closer look at post-graduate students and their risk of experiencing mental health concerns. Their prototype helped to connect students for in-person meetings, which had a positive impact on their stress levels and raised their awareness for selfcare. However, the authors conclude that these “technologies must be utilized carefully, and are not a replacement for other sources of student support in universities” (Harrison et al., 2022, p. 10:2). Lederman et al. (2014) also examined in their study the importance to pair up moderation and consultation, where they conclude “that the unique combination of peer interaction, clinician support, and online therapy provided a level of support that built on the success of previous health-based applications that provided either one or two of these features” (Lederman et al., 2014, p. 5:23). Here the authors stress out that the specific target group needs to be acknowledged with their specific characteristics.

Conversational agents

One of the most important forms of communication in our society is language. It is attractive as a natural, flexible, and efficient means of communication, especially for interpersonal communication (Zue & Glass, 2000). Chatbot technology provides a way for humans to interact with computers in natural language (spoken human language) (Clark et al., 2019). Chatbots are often designed to convincingly simulate the behavior of a human counterpart.

However, chatbots are not a new development. The first measurement of artificial intelligence (AI), known as the Turing Test, dates back to the 1950s. It measures whether a human can distinguish a machine from another human as a conversational partner. Attempts have been made since then to develop an intelligent machine that can pass the test (Hettige & Karunananda, 2015). So-called ELIZA was the first program that did. With her the first chatbot was developed in 1966 at the MIT AI Laboratory by Joseph Weizenbaum. ELIZA simulated a simple text-based conversation between a human user and the computer pretending to be a therapist (Weizenbaum, 1966). Originally, chatbots responded only to written texts, but in the last decade they have become more versatile and include speech synthesis and recognition as well as affective state detection and responses (Hussain et al., 2019).

Positive computing and design for well-being

In the HCI community, interest in promoting mental health and well-being has led to new areas of research and development in recent years to integrate scientific principles of well-being into the design of interactive systems (Calvo et al., 2016). One of these principles is positive computing (Botella et al., 2012). Calvo and Peters (Calvo & Peters, 2015) define positive computing as the design and development of technologies to support psychological well-being and human potential.

According to Diefenbach et al. (2017), activities can influence well-being by increasing positive emotions, behaviors, thoughts, and fulfilment of important psychological needs. Deci and Ryan's (2000) self-determination theory (SDT) assumes that basic needs drive the goal-setting process. Intrinsic ambitions - personal growth, belongingness, and intimacy – are set according to need fulfilment and thus contribute to one's well-being, community, and physical health. For Deci and Ryan (2000), three basic needs are a critical prerequisite for psychological growth: autonomy, competence, and relatedness. The fulfilment of needs is therefore seen as a natural goal of human life that describes many of the meanings and purposes underlying human action (Deci & Ryan, 2000). The practice embedded in an experience is understood to be an important level of design because it provides the activity in context to fulfill a particular need. This in turn provides positive impact and meaning (Hassenzahl et al., 2013).

Positive computing strives to incorporate scientific knowledge from well-being psychology and neuroscience into everyday technological experiences (Gaggioli et al., 2017). Therefore, creating a good user experience (UX) when using a technological artifact can support positive computing. In this regard, it can also promote the user's mental health and well-being (Calvo et al., 2016), making positive computing a good approach for a user-centered design of an eHealth platform.

Methodology

SpeakOut is guided by the Design Case Study approach. This user-centered research approach focuses on the cultural and social context (Wulf et al., 2011). It is defined by the interaction between a particular technology and a social practice within a particular socio-technical framework. In the Design Case Study, the use and development of technology is observed within a socio-technical framework (Rohde et al., 2017; Stevens & Pipek, 2018). In application, qualitative approaches are preferably ethnographically grounded (Aal et al., 2016, 2018; Rohde et al., 2017; Rüller et al., 2022; Wulf et al., 2011).

The goal of this user-centered research approach is to develop interaction possibilities to support the user group with their social problems (Wulf et al., 2011). This is made possible by a three-phase design consisting of (1) an empirical pre-study, (2) prototyping (participatory) IT-design, and (3) evaluation/appropriation. In this way, the Design Case Study allows us to understand the relationship between the social practices, the students seeking help, and the design of the SpeakOut platform (Rohde et al., 2017).

In the present Participatory Design study, users, HCI experts, and the university's Central Student Counseling Service are involved in the creative process through various testing methods as well as workshops, thus assuming the role of active design agents. In this process, the ideas and perceptions of each stakeholder group are incorporated into the iterative concept. The step-by-step development of user interfaces involves continuous design improvement based on user testing and other evaluation methods (Nielsen, 1995). The overall 21 participants divide themselves among the different design steps as follows:

First, three participatory design workshops took place where one male person (head of Student Services Department) with fifteen years of professional experience and two female persons (department head of Central Student Counseling Service and psychologist from Psychological Counseling Service) with twelve and two years of professional experience participated.

Second, a heuristic evaluation took place. Here three HCI-MA students were involved. They were between 24 and 28 years old and had good usability skills due to their degree program and practical experience.

Third, a user evaluation took place. The participants could be recruited through personal contact. Due to the importance of both genders for the usability tests, both male and female students were considered. The five participants were exclusively students at the university for which SpeakOut was developed. During the tests, they were between the second and tenth semesters. All of them had German citizenship. Only one of the respondents indicated French as their native language, the others German. In the area of age structure, an age between 20 and 27 years was given. None of the respondents suffered from physical or mental limitations. Represented were students from the study programs architecture, media studies, literature, culture and media, and elementary school teaching with integrated remedial education. Two of the participants indicated that they were not particularly familiar with the use of smartphones, tablets, or laptops. The remaining participants had average to good experience using mobile devices. Three of the respondents had previously sought out the university for a support option. Only one of them used the university website to find his contact person. In contrast, the other two reached their destination via Google search.

Fourth, another user test was carried out using the method of guerrilla testing with the help of a random sample (5 female and 5 male students).

The representative characteristics of the central user group that have been worked out in the pre-study on user research, which will not be in focus of this publication, are joined by problems identified as generally faced by students during their studies: inquiries about studying, being overwhelmed or underchallenged, social conflicts, financial problems, loneliness, gender issues, stresses at home, fears about the future/lack of orientation, lack of time management/procrastination, study subject doubt, relationship issues, mental challenges, physical impairments, sexism, racism, and culture shock/adaptation issues. However, as the preliminary study found, the overarching problem is that students do not know where to turn for help with their problems. With this in mind, we worked with personas and scenarios, which were often used to justify design decisions during the design process. In the context of the user evaluation/usability test, they served as the basis for generating the Use Case.

Design of the SpeakOut platform

Design implications

With the help of an eHealth platform as an information medium (Laszig & Eichenberg, 2003), students with psychological or personal concerns can find out anonymously whether there is a suitable support service for them. This can overcome an initial inhibition barrier. Subsequently, when they are assigned a contact person, they can decide whether and by which method of contact (synchronous/via chat by using audiovisual media or asynchronous/via email) they would like to use the offer.

Through the principle of a chatbot, such an eHealth platform can be realized. Students receive support for problem solving and self-help. A task-oriented chatbot communicates to them the right contact person for university or personal concerns in short conversations.

In this work, in line with the usability of SpeakOut, it is first decided to test relatively simple rule-based approaches for chatbots. By having the bot provide students with response options, a fluid dialogue can be facilitated. Asking for symptoms is one way to assign a contact person. In this context, it is important to provide the user with a safe comfort zone. For this reason, the concept development of the SpeakOut platform should address the needs and requirements of the user following the approach of positive computing (Botella et al., 2012; Calvo & Peters, 2015).

The application of the platform should generate a positive UX and thus promote general well-being (Calvo et al., 2016). Based on this, the system should, according to SDT, be designed to promote three needs: autonomy, competence and connectedness (Deci & Ryan, 2000). By enabling users to help themselves through easy access to information, both the need for autonomy and competence can be satisfied. By influencing one's own situation through independent action and exploration of the system, the impression of autonomy can be reinforced. Through such self-determined action, well-being is also promoted (Diefenbach et al., 2017). Users can decide for themselves how to access their information. Connectedness is created on the one hand by the support of the contact persons of the different advice centers and on the other hand by the interaction with the chatbot. In this way, the bot can be implied as a kind of person, thus creating a feeling of support.

Following a participatory design approach with iterative design elements, several prototypes were tested and revised based on the feedback. The following visual insights correspond to an exemplary presentation.

Participatory Design Workshop 1 and 2: Design of the user interface

For the conception of the SpeakOut platform it is important to integrate all relevant support centers for students. The main categories psychological counseling, studying with family, financing, housing, work and career, and those affected by disabilities are defined in a tree structure for the platform together with the Central Student Counseling Service. In addition, a brainstorming session was conducted to define other requirements for the prototype. Based on the design implications from the literature and the collected needs and requirements of the target group (pre-study/user research), the prototyping phase was then initiated.

The goal was to help users with personal or mental health challenges through a virtual chatbot by delivering messages according to the principles of CBT (Kiropoulos et al., 2008; Klein & Berger, 2013) and taking into account design-oriented principles of positive computing (Botella et al., 2012; Calvo & Peters, 2015).

As a first draft, a basic framework of the platform was created in form of a wireframe based on the personas and scenarios. Using possible Use Cases, it was examined how the platform represents the best possible solution for a user query. The wireframe, after agreeing on all conditions and needs, served as the design basis of the SpeakOut platform (SpeakOut 1.0) and thus the basic framework for the first prototype (Figure 1).

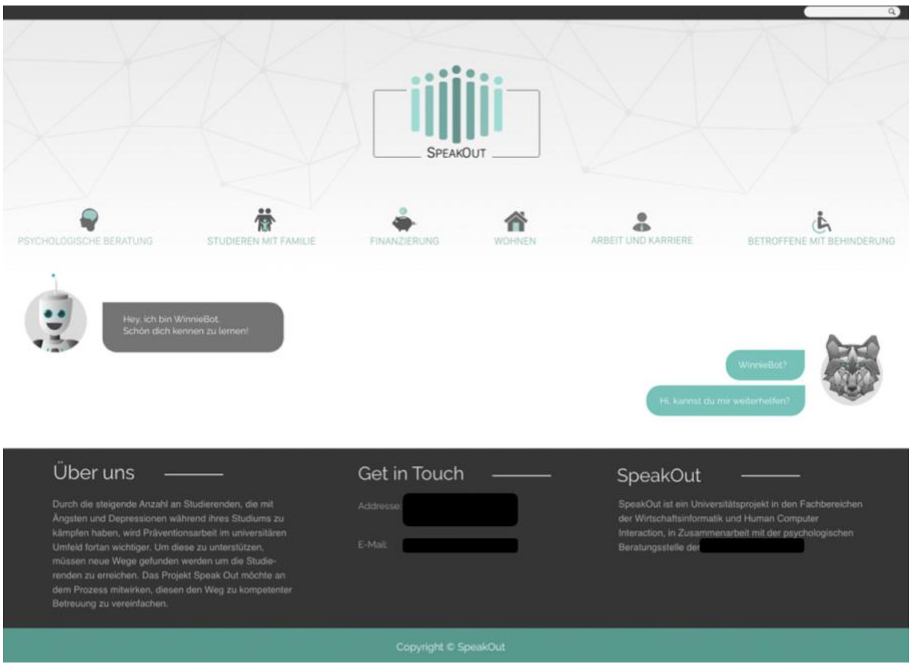

Fig. 1. SpeakOut 1.0: Start page

In a first Participatory Design workshop, the existing concept and screen designs (see Figure 1) were tested and evaluated. Notebooks with the Adobe XD program were available for testing the prototype. It was examined whether the interface concept is understandable and whether the design works convincingly. For this occasion, three employees of the Central Student Counseling Service participated in the workshop. The participants included the head of the Student Services Department with fifteen years of professional experience (male), the department head of the Central Student Counseling Service (female) with twelve years of professional experience, and a psychologist from psychological counselling who has been working in this field for two years (female).

In this first test phase, the aim was to find out whether the participants understood the platform, the design, and the interaction elements. As key stakeholders, they were integrated into the design process with the help of a subsequent discussion round. In the discussion, the participants identified some points of criticism as well as usability problems while exploring the system and made suggestions for the design optimization. The critiques in the PD workshop have been implemented in the next iteration step in the form of a revised prototype (SpeakOut 2.0, Figure 2) which was then re-evaluated and revised during a second PD workshop (SpeakOut 3.0, Figure 3) with the same participants:

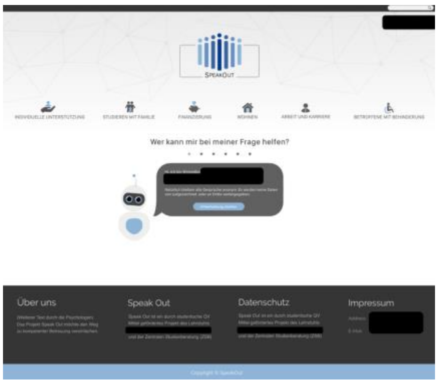

Fig. 2 and 3. Revised prototype of SpeakOut 2.0 (left) & re-evaluated and revised prototype SpeakOut 3.0: Start page (right)

The design of SpeakOut 3.0 was then shared written with the workshop participants, with renewed feedback resulting in SpeakOut 4.0. The design status obtained then formed the basis for the heuristic evaluation with the usability experts (HCI-MA students).

Heuristic evaluation

Regardless of the technology, interface, or medium, users prefer one product over another when good usability is provided. According to ISO 9241-11, usability is the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency, and satisfaction in a particular context of use (International Organization for Standardization, 1998). Different methods can be used to measure the usability of a product, the most commonly used one being Jacob Nielsen's heuristic principles (Molich & Nielsen, 1990). The results are assigned by the experts according to severity from zero (no usability problem) to five (usability disaster) according to Nielsen (1995).

Before the prototype was tested by the target group, a heuristic evaluation by usability experts first uncovered potential usability problems that users may encounter. The heuristic evaluation of the SpeakOut interface design involved three HCI-MA students who were between 24 and 28 years old and had good usability skills. Likewise, each of them was given a list of Nielsen's 10 heuristics (Nielsen, 1995).

The heuristic evaluation resulted in initial optimization suggestions. Forty-nine usability problems were identified, forty-three of which could be attributed to the platform and six to limitations caused by the Adobe XD prototyping tool. The majority of the usability problems found could be classified as severity levels one and two (Nielsen, 1995). The results were examined and analysed in more detail and possible solutions were then developed and transferred to a new prototype version (SpeakOut 5.0) which has been further evaluated during the upcoming usability tests with users from the end-target group.

User evaluation

Usability tests serve to find out how the target group experiences the concept and design of the SpeakOut platform. The aim is to find out whether interaction elements such as navigation, icons, buttons as well as the conversational interface are easy to use for the user group. The UX fundamentals for designing chatbots are partly the same as for a platform. The difference is that buttons, switches, and tabs in conversational design are replaced with content and chat elements. With the help of the platform, the target group examined whether a UX that was as intuitive, natural, and pleasant as possible could be created. In addition, it was to be examined whether the needs and requirements of the students for the platform were met.

For the user test, an execution sheet was developed that already contained all questions and tasks as well as the complete test procedure. This included an introductory questionnaire to collect demographic data and to verify that the respondents belonged to the target group. The five male and female participants, students of the university in focus here, were then asked to perform various tasks without support and to describe how well they got on with the platform. This was done using the Thinking Aloud method, in which participants speak their thoughts aloud while working on a task (Masthoff, 2006). Finally, a semi-structured interview took place (Wilson et al., 2014). Thus, subjective feedback from the users could be obtained (Masthoff, 2006).

The bot was viewed positively and described as an attractive alternative to reach their contact. Participants who had indicated in the initial questionnaire that they had already looked for a contact person in the past were asked whether they had wished for this platform at that time. The participants concerned answered the question unanimously affirmatively. One participant drew a direct comparison to the university website:

> "Yes, because I actually also criticize the site of the university, that there are so many sub-items [...]. Because just to read through all the subsections and if you are under stress, then you already despair [...]. That's why I think it would be nice if there was a separate page for these kinds of problems."

From the beginning of the scenario until the respondent left, the test was videotaped and recorded using audio for adequate back-up.

Participatory Design Workshop 3 and Guerilla Testing: Creating a final prototype

The last prototype used (SpeakOut 5.0) as well as the results of the heuristic evaluation and the user evaluation were evaluated in another round of discussions with the participants of the Central Student Counselling Service who had previously taken part in the PD workshops.

In addition, another user test was carried out using the method of guerrilla testing with the help of a random sample (5 female, 5 male students) in the university canteen. Three different designs for the 'Individual Support' icon were presented, with results of 70%, 20% and 10%, indicating a clear preference (see Figure 4, tree structure left).

The findings from both, PD-Workshop 3 and the guerrilla testing, were transferred into a final prototype (SpeakOut 6.0, Figure 4):

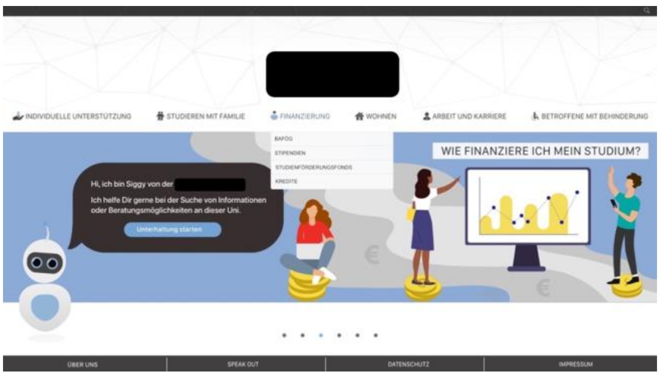

Fig. 4. SpeakOut 6.0

From the results of the various tests and discussions, it can be deduced that a university platform for students needs simple structures, short precise texts and pictorial language. Long content and complicated user paths discourage the user, especially when under stress. Through icons and simple interaction surfaces as well as graphics, the user feels addressed and is thus more motivated to explore the application.

Reflections about the study

Limitations and future prospects

The results from this work cannot be generalized, as only small numbers of cases were used due to the limited time and resources available. Besides, this is a case study and generalizability is not the aim. Thus, the small number of participants in the usability tests should be noted. A higher number of people from the end user group would be desirable in order to identify further needs and requirements for the system. Despite this, the final interviews in the user evaluation/usability tests showed that the participants were satisfied with their results and after achieving their goal of finding a contact person. Moreover, they felt more comfortable on the SpeakOut platform than on the university website. Whether the well-being of the user group ultimately increases, could not be determined in this work. Thus, only the well-being goals were used when designing the concept. In a long-term study it could be tested whether the application has a positive influence on the well-being of the students, especially for students with mental illnesses, who were not part of the sample in this work.

Making the chatbot an invaluable experience for the target group takes time. This will require developing more use cases and looking closely at what kind of dialogue leads to user satisfaction and engagement. It is important to identify how they can help users achieve their goals effectively and use them to that end. The chatbot provides highly task-oriented information based on selectable responses. Thus, there is more of a guided dialogue than a conversation. However, based on the developed chatbot, a conversational AI solution can be developed that provides more value to the end user through natural communication.

Conclusion

With the aim of helping university students with personal or mental health problems to find the right contact person when seeking help, this paper presented the development process as well as the UX-oriented design of an eHealth platform called SpeakOut, which includes a virtual chatbot designed to facilitate the search for support through dialogue. The design process was based on the principles of CBT (Kiropoulos et al., 2008; Klein & Berger, 2013) and took into account design-oriented principles of positive computing (Botella et al., 2012; Calvo & Peters, 2015).

Since the concept of the platform was approved by the different stakeholders, SpeakOut can be called as beneficial tool in the mediative process of personal challenges. The user group responded positively to the platform when testing the prototype. It can be concluded that the application is user-centric and meets the needs and interests of the students. Matching the principles of both – positive computing (Botella et al., 2012; Calvo & Peters, 2015) and CBT (Kiropoulos et al., 2008; Klein & Berger, 2013) – it can promote the mental health and well-being of the users (Calvo et al., 2016). The SpeakOut platform can therefore potentially be a useful extension of the university website and serve as a complementary information medium. This was the result of the positive evaluation of the user group as well as the good feedback of the usability experts and the Central Student Counseling Service.

These results point to a successful addressing of the key factors: autonomy, competence and connectedness (Deci & Ryan, 2000) through enabling students to help themselves via independent action and easy access to the information needed and offering the opportunity to connect with the chatbot and the human actor searched for. Well-being is therefore promoted through self-determined action (Diefenbach et al., 2017).

After a possible implementing the platform, the next step would be to test it in a long-term study within the real university context (Müller et al., 2015, 2019). Another step would be to expand the contact options within the platform, as currently there is only communication with the bot, but not with the contact person, who is pointed out as an appropriate contact via bot conversation. In addition, the platform should be filled with more information relevant to the different student groups to help them act in a more self-determined way. CBT could be increasingly integrated here. The described extensions of the platform inevitably lead to questions about data security, e.g., those regarding storage, (regulated) accessibility, anonymization, as well as about corresponding formats and devices. For the prospects described, however, additional funding of the project is imperative.

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Mediating Personal Relationships with Robotic Pets for Fostering Human-Human Interaction of Older Adults

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Abstract. Good human relationships are important for us to have a happy life and maintain our well-being. Otherwise, we will be at risk of experiencing loneliness or depression. In human-computer interaction (HCI) and computer-supported cooperative work (CSCW), robotic systems offer nuanced approaches to foster human connection, providing interaction beyond the traditional mediums that smartphones and computers offer. However, many existing studies primarily focus on the human-robot relationships that older adults form directly with robotic pets rather than exploring how these robotic pets can enhance human-human relationships. Our ethnographic study investigates how robotic pets can be designed to facilitate human relationships. Through semi-structured interviews with six older adults and thematic analysis, our empirical findings provide insights into how robotic pets can be designed as telerobots to connect with others remotely, thus contributing to advance future development of robotic systems for mental health.

1. Introduction

The importance of relationships for mental health and social well-being has been studied in well-established research. Long-term isolation and the loss of social connection can negatively impact mental health, often reported as loneliness and depression (Hawkley & Cacioppo, 2010; Van Tilburg et al., 2021). Older adults, in particular, often face mental health challenges such as loneliness or depression due to increased isolation and lack of social connections (Cotten et al., 2014; Krause-Parello et al., 2019; Tkatch et al., 2021).

By 2050, the global population of individuals aged 60 and older will reach 2.1 billion, doubling the current number, while those aged 80 and older will see a threefold increase from 2020 figures, totaling 426 million (World Health Organization, 2022). The shift in demographic changes towards an aging population has put forward technology development, also in the field of technologies for mitigating loneliness or depression. Robotics, in particular, has gained popularity in research as a supportive measure in caring for older adults as robotic companions (Hung et al., 2019; Koh et al., 2021). Robotic pets or zoomorphic robots, akin to biological pets, have gained popularity as a technological solution to reduce feelings of loneliness or depression (Melson et al., 2009; Pearce et al., 2012; Unbehaun et al., 2019; Krause-Parello et al., 2019; Hudson et al., 2020; Darling, 2021; Koh et al., 2021; Rebola & Ramirez-Loaiza, 2021). Since owning a pet would come with its responsibilities of pet care and animal restrictions (Tkatch et al., 2021), robotic pets can be easier to care for and sometimes cost less (Coghlan et al., 2021; Petersen et al., 2017; Koh et al., 2021) While AIBO, a robotic dog, and PARO, a robotic seal, represent some of the most advanced robotic pets currently available (Nelson & Westenskow, 2022), studies suggest that further enhancements can unlock the innovative potentials, using robotic pets as playful tools (Marchetti et al., 2022), telerobots (Vaziri et al., 2020; Chien & Hassenzahl, 2020; Albers et al., 2022), social robots (Kidd et al., 2006; Ahn et al., 2013; Schwaninger et al., 2022; Helm et al., 2022), etc. Therefore, robotic pet development has the potential to unlock more technological features.

While many existing studies primarily focus on the relationships that older adults form directly with robotic pets (Lazar et al., 2016; Dörrenbächer et al., 2022), research has been exploring how these robotic pets can influence human-human relationships (Šabanović et al., 2013). This includes the social networks surrounding the users, such as moderators (Carros et al., 2020) and caregivers (Carros et al., 2022; Paluch & Müller, 2022). Given the potential technological advantages and benefits of robotic pets, studying the desirable design features from a human-human relationships perspective and fostering human connection through robotic pets becomes beneficial. In this context, we aim to understand the research question: **How can robotic pets mediate older adults' relationships with others to benefit their mental health?**

2. State of the Art

In this section, we elaborate on the state of the art in relation to our empirical work on *Mental Health and Relationships of Older Adults (2.1)*, *Robotic Pets for Human-Human Relationships (2.2)*, and *Future Development of Robotic Pet Design (2.3).*

2.1 Mental Health and Relationships of Older Adults

In the discourse, older adults are particularly vulnerable to mental health problems from loneliness (Cacioppo et al., 2006), loss of social relationships (Cornwell & Waite, 2009), disabilities and illness (Bruce et al., 1994; Bruce, 2001). Healthy relationships can positively impact mental health conditions (Rook & Ituarte, 1999; Reis & Collins, 2004; Umberson & Karas Montez, 2010; Thomas et al., 2017; Krause-Parello et al., 2019; Van Tilburg et al., 2021; Tkatch et al., 2021). As the benefit of healthy relationships for older adults' mental health is well-established, it is evident that interventions to support healthy human-human relationships of older adults can benefit their mental health.

2.2 Robotic Pets for Human-Human Relationships

Research indicates that the use of robotic systems should not neglect the complex human-human relationships that exist between older adults, these technologies, and the individuals in their social networks (Hornecker et al., 2020; Wengefeld et al., 2022). Paluch and Müller (2022) investigated the views of care attendants and nursing home residents on robotic pets, revealing how these pets can be integrated into care practices and the ethical considerations that arise during their use. Fogelson et al. (2022) conducted a study to investigate the impact of robotic pets on older adults and their caregivers. The results showed that robotic pets not only benefit older adults' mental health but also enhance their relationships with caregivers. Hudson et al. (2020) surveyed older adults to investigate the effectiveness of robotic pets in reducing loneliness. They examined participants' experiences and perceptions of interacting with a robot and the outcomes related to their feelings of loneliness. The researchers found that older adults who were lonely and lacked physical activity benefited most from robotic pets. These individuals were interested in cuddling, grooming, and sleeping with the robot, and some were even willing to share their pets with others. Sharing their pets facilitated increased closeness to others, thereby reducing feelings of loneliness (Hudson et al., 2020).

2.3 Future Development of Robotic Pet Design

The future development of robotic pet design can benefit from a thorough understanding of users' needs and attitudes toward current products. Various robotic pets are available in the market, including *PARO, Joy for All cat,* and *Joy for All dog* (Bradwell et al., 2021). Despite PARO's limited functionality, including its inability to speak, older adults have expressed satisfaction with it, noting improvements in their relationships with others (Chen et al., 2022; PARO Robots, 2023). According to Bradwell et al. (2021), among the various robotic pets, *Joy for All cat* and *Joy for All dog* are preferred by care home staff, residents, and their families (Ageless Innovation LLC, 2018). Participants tend to prefer robots that resemble domestic pets, with soft fur, large eyes, and the ability to move and interact with them. Studies by Guerra et al. (2022) and Rebola and Ramirez-Loaiza (2021) also found that older adults expect robotic pets to have features similar to those of real biological pets. However, Coghlan et al. (2021) show that participants' preferences for robotic pet design vary widely, making it challenging to design a robot that can meet diverse individual needs.

3. Methodology

Our study, guided by the research question, “How can robotic pets mediate older adults’ relationships with others to benefit their mental health?” seeks to identify design elements for future robotic pets that promote positive human interactions. By integrating insights from the State of the Art and conducting a thematic analysis of our interview data, we aim to provide a comprehensive understanding of how robotic pets can be designed to bolster the mental well-being of older adults through improved interpersonal relationships.

ChatGPT 4.0, with its Scholar AI plugin, was used to assist in finding relevant research papers (Open AI, 2023).

3.1 Participant Demographics

We interviewed six German participants (five males and one female), recruited through an online forum where we requested participation in our research. All participants had prior experience relevant to our research topic and demonstrated a strong interest in aging society and technology. This made them ideal candidates for the co-design of robotic pets. The interviews were conducted via Zoom, and each interview was recorded with the participant's consent. The demographic information of the participants is provided in Table I.

Table I. Participant demography

Participant	Age	Gender	Marital status
P1	77	Male	Single
P2	75	Female	Married
P3	71	Male	Married
P4	63	Male	Married
P5	72	Male	Married
P6	67	Male	Married

3.2 Data Collection: Interviews

In our study, we followed the interview research recommendations of McIntosh et al. (2015). We conducted one-on-one semi-structured interviews to provide rich, high-quality data for social informatics research. We developed interview questions and conducted interviews with older adults to gain insight into how they communicate with their families and maintain positive relationships. In addition to exploring participants' regular interactions with family and friends, we also discussed their ideal social lives and how a robotic pet could assist or facilitate these interactions. In this context, we left it up to the interviewees to value the importance of family or friends and relate to it, since care in relationships can be very heterogeneous (Nave-Herz, 2012; Paluch et al., 2023). In order to understand comprehensively the participants' experiences, feelings, and expectations related to their social interactions and potential interactions with robotic pets, our interview structure can be broken down into several topic phases:

- **Introduction**: Briefly explain the research purpose to the participants.
- **Warm-Up Phase**: Ask everyday questions to ease into the interview. Empathy Phase: Explore participants' experiences with family and friends. For example, “Could you share some memories when you spent time with your family?”
- **Loneliness Exploration**: Probe into participants' feelings of loneliness and coping strategies when alone or unable to reach family and friends. For instance, “What would you do if your families don’t reply to you quickly?”

- **Robotic Pet Introduction**: Introduce the concept of a robotic pet and gauge participants' reactions and desired features. For example, “If a robotic pet could perform three tasks for you, what would they be?”
- **Design**: Involve participants in the design process, understanding their desired interactions with the robotic pet. For instance, “What would you like to say to your children through a voice messenger pet?”
- **Demography:** Ask demographic questions.
- **Debrief:** Inquire about participants' feelings and if there's anything additional they'd like to discuss.

Since we conducted interviews with older adults lasting between 40 minutes and 1.5 hours, it's important to offer them breaks to rest and encourage them to drink water during the interview.

3.3 Data Analysis: Thematic Analysis

Thematic analysis, a qualitative data analysis method, was used to interpret the interviewees' opinions and identify themes and patterns of meaning within the data sets (Jason & Glenwick, 2016). This analysis involves reading and reviewing the data to understand the information fully and creating categories and subcategories through coding. These codes are grouped to identify similar and distinct themes, which are reviewed and updated to ensure accuracy and given evocative names and meanings. The study objectives, relevant literature, and interview questions were used to develop themes and codes. Thereby, we followed the five phases of qualitative text analysis proposed by Kuckartz (2019), as listed below. The audio files were transcribed, notes were taken for further evaluation, and MAXQDA was used to conduct the qualitative analysis (Kuckartz & Rädiker, 2019). The codes and categories would be derived from the responses to our interview questions, and codes could be assigned to different types of memories, experiences, and suggestions shared by the participants. Here is an example of our codes for each interview topic phrase:

- **Empathize Phase:** “positive family interactions”; “negative family interactions”; “topics of conversation”
- **Loneliness Exploration:** “coping mechanisms”; “activities when alone”; “feelings of loneliness”
- **Robotic Pet:** “missed individuals”; “desired companionship”; “comfort with a robotic pet”; “preferred tasks for a robotic pet”; “desired features”
- **Design:** “desired voice messages”; “anticipated family responses”; “preferred topics of conversation”

4. Results

Our study aims to understand what fosters good relationships among older adults and their families. Specifically, we are interested in understanding how robotic pets can benefit personal relationships and care networks. In the following section, we highlight qualitative text analysis on *Family Connection (4.1)*, *Design Considerations for Robotic Pets (4.2),* and *Opinions and Expectations of Robotic Pets (4.3).*

4.1 Family Connection

Upon reviewing the results, it became apparent that family communication is important for the participants. Whether residing in close proximity or far away from each other, they make efforts to maintain contact with their families. Participant 5 shared, "*We can only communicate by phone... We use all possible communication channels depending on what we want to do or transport. We have integrated communication*." This sentiment was echoed by other participants, who use various Internet communication technologies (ICT) to connect and bridge intimacy and physical distance. Communication channels are flexible and integrated, with some preferring phone calls while others prefer video conferencing. Despite the physical distance, maintaining a connection is vital, with family relatives seeking support and advice on both ends for older adults and younger adults. However, participants also believe that such robotic pets may only augment connections rather than serve as a substitution of connection.

4.2 Design Considerations for Robotic Pets

The participants shared their insights on an appropriate design for the robotic pet. Our empirical data suggests that robotic pets should consider hygienic and cleaning features, such as easy-to-clean surfaces and self-cleaning mechanisms. Customizable features, such as adjustable voice and movement settings, were also highlighted. Additionally, participants expressed a desire for the robotic pet to have the ability to follow the owner around, providing a sense of companionship and security. Furthermore, participants expressed a desire to experience the telepresence interaction of their families through robotic pets. Participant 2 shared, "*I can feel my family gently touch me if they remotely control the pet to show me their love.*" Participant 3 stated, "*I start to feel the pet can feel like my son because he can send me voice messages and basically talk to me through the dog.*"

Participant 5 shared, "*Oh, I am thinking this pet is acting like my grandson because he is controlling it.*" The empirical data indicates that incorporating telepresence via remote control or AI automation could enhance robotic pet design.

4.3 Opinions and Expectations of Robotic Pets

Participants shared their opinions on robotic pets for older adults. Participant 1 expressed a positive opinion, stating, *"I don't know how I feel as a demented person, and maybe it will help me."* On the other hand, Participant 5 expressed enthusiasm for the concept and stated that they and their wife would consider buying one. They believed that older adults unfamiliar with technological systems could find the pet interesting. Participant 6 acknowledged that older adults might need to learn how to interact with robotic pets but held a positive opinion toward them. It could be valuable for them if older people learn to view the robotic pet as their toy and can effectively communicate with it.

Regarding the expectations from the robotic pet, Participant 3 expressed that they could have conversations with it and that it could communicate with their family members. They also stated that the pet could help them with practical tasks like sending messages and waking them up. Similarly, Participant 2 considered the pet to perform household chores, such as removing the garbage and snow beyond the expectable practices of even trained animals. Participant 4 also believed that a robotic pet could be helpful when they need assistance with practical tasks like going for a walk or sending a message. Participant 5 expressed the desire for the robotic pet to be a source of companionship and conversation, especially when alone at home. They also suggested that the pet should be able to help them with physical tasks that they cannot do themselves. Participant 6 emphasized the importance of designing robotic pets to serve the different needs of different people, stating, *"It could be all. You have to have that in all possibilities."* They also stressed the importance of the pet's voice, as it can affect how people perceive the pet. Overall, the expectations expressed by the participants suggest that robotic pets have the potential to be both helpful and engaging in daily life, serving as tools for practical tasks and companions for social interaction (see also Hassenzahl et al. 2020).

Lastly, participants highlighted the benefits of robotic pets, noting that older adults, even those less acquainted with technology, could benefit from the voice assistant and the intuitive interaction that feels similar to human-pet interaction. Participant 3 stated that, "*My mom who is much older can only call us than texting or video call.*" Participant 2 stated, *"I prefer my smartphone to be woken up, but a little pet that could snooze into my face would be much more sympathetic. / The volume would be a little tender feeling like, hey, wake up and then, like, have a little* *paw on you. That would be wonderful.*" Additionally, the participants mentioned the benefits of interacting with a robotic pet. Participant 3 explained, *"You feel more secure if you have something. We have another superhero available to save us. I think that could work through such a pet. Because what the pet can do is they can put their paws on you a little. Those tangible feelings can kind of increase. / You take it in your arms, and you look at it and hug it, giving you a different feeling as if you're talking to a phone."* These quotes illustrate that robotic pets have the potential to provide practical assistance, such as helping with tasks or monitoring safety, while also giving a sense of companionship and emotional support.

5. Discussion

The primary goal of this study was to investigate the potential of robotic pets in enhancing the interpersonal relationships of older adults, with a focus on user-centered design suggestions. The majority of participants viewed robotic pets as valuable assistive technology that could be integrated into their daily lives. They envisaged a robotic pet as a communication tool that could foster connections with others, providing a platform for conversation and telepresence interaction (Chien & Hassenzahl, 2020; Wengefeld et al., 2022). They noted the potential for robotic pets to offer tangible feedback remotely controlled by their families, adding a unique dimension to their interactions. This aligns with existing literature where the effectiveness of robotic pets in reducing loneliness has been demonstrated (Hudson et al., 2020; Tkatch et al., 2021; Fogelson et al., 2022). Furthermore, participants also suggested that these robots could serve as an alternative communication technology for older adults who are less familiar with other digital devices and applications.

Overall, the findings suggest that designing and introducing robotic pets to enhance older adults' relationships with others is a feasible approach. This intervention has the potential to offer several benefits to older adults, including improved communication with family members, reduced feelings of loneliness or depression, and an overall improvement in their quality of life.

6. Limitations and Future Work

The results of this study are limited to participants from Germany who identify as tech-savvy. The limited sample size, gender representation, marital status, and other social factors highlight the need for further research with diverse populations to generalize findings. For instance, our empirical research underscores the importance of interviewing older adults with limited technical literacy. Robotic pets, when employed as communication tools, could be particularly advantageous for these older adults by streamlining the messaging process. Furthermore, our findings indicate the value of interviewing younger adults who might utilize robotic pets for remote interactions with older individuals. This perspective gains significance as some participants highlighted the emotional strain and potential challenges younger people face when communicating with their older counterparts. Such insights suggest that automated AI systems could be integrated into the design of robotic pets. The study offers insights from a diverse group of participants, though it might benefit from a more detailed exploration of their alignment with the primary demographic for robotic pets. For instance, the marital status of five participants could influence their perspectives on loneliness and companionship. Additionally, the active professional status of individuals in their sixties, as observed in some regions, might shape their views on social engagement (Protheroe et al., 2009). Further information on participants' retirement status or potential health conditions, such as dementia, could provide a more comprehensive understanding. Future studies might consider delving deeper into these aspects to ensure that feedback on robotic pets is rooted in direct experience and relevance. Future studies should include diverse sample participants from various countries to provide a more comprehensive understanding of robotic pets' potential benefits and limitations for personal relationships.

7. Conclusion

This study highlights what maintains good relationships among older adults and their families and how robotic pets can benefit these relationships. Data were collected using interviews with six 63-77-year-old older adults. Having analyzed the data using thematic analysis, three themes have been concluded, including *Family Connection (4.1)*, *Design Considerations for Robotic Pets (4.2)*, and *Opinions and Expectations of Robotic Pets (4.3)*. The results show that connection with others is important for older adults, who are motivated to communicate through various mediums to keep in touch with their family members. This can be related to the infrastructure concept, which emphasizes practices of maintaining the interrelation of people (Karasti, 2014). The older adults interviewed suggested robotic pet designs for future development such as assisting them in their daily tasks, connecting them to their family members through sending messages or making voice calls, providing telepresence interaction, and supporting them emotionally. Thus, this study demonstrates that it is possible to design robotic pets for older adults' human-human relationships to benefit their mental health. Further research is needed to understand the impact of various robotic pet designs on fostering human-human relationships.

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https://www.pflege-und-robotik.de/en/start-page/

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Infrastructural Complexity: A Mapping of Medication Management in Norway

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Abstract. Medication is key to the effective treatment of diseases but requires careful management to avoid errors that may harm patients. This study maps the Norwegian infrastructure for medication management. This infrastructure interlinks hospitals, nursing homes, home care, general practitioners, and so forth into an increasingly integrated record of each citizen's medication. In spite of its electronic components, the infrastructure is inherently sociotechnical. Considerable human work goes into bridging the components. While cumbersome, the bridging work also introduces occasions for double checking the medication information. The constant evolution of the medication-management infrastructure seeks to reduce bridging work but must also preserve the occasions for checking quality. Doing so requires coordinated changes in technology and work practices.

Introduction

Medication is key to the effective treatment of diseases but, at the same time, errors in medication administration pose a large risk to patients. To avoid errors, the medication process must be carefully managed. Many resources are devoted to medication management, including resources for documenting a patient's current medication (Zhang et al., 2022), for coordinating clinicians' medication-related activities (Reddy et al., 2001), and for designing electronic medication-management systems (Andersen, 2013). Yet, medication errors continue to be among the leading causes of mortality and morbidity in developed countries (Makary and Daniel, 2016; Phillips and Bredder, 2002). This study explores the

Norwegian healthcare system to map the infrastructural complexity that riddles medication management. With this mapping, we aim to bring out the boundary-crossing character of this complexity.

In 2012, Norway adopted the strategy “one citizen – one record” (Norwegian Directorate of eHealth, 2018) for its population of 5.5 million people. This strategy announced the goal of establishing a nationwide electronic health record (EHR) that spanned specialist healthcare (i.e., hospitals), municipal healthcare (i.e., home care and nursing homes), and primary healthcare (i.e., general practitioners – GPs). Medication management features prominently in all three healthcare sectors and in the interrelations among them. While the user should experience one integrated record, it will not be one technical system. It will be a cross-sectoral infrastructure of intercommunicating components from multiple technology vendors (Ellingsen et al., 2022a). To investigate the complexity of medication management, we conducted an interview-based study and analyzed the resulting data from an infrastructure perspective (Aanestad et al., 2017; Monteiro et al., 2013; Pipek and Wulf, 2009). Our study is the first stage of a larger research project to understand the prospects and challenges of making medication management increasingly integrated and electronic.

Method

This study is based on a total of 27 one-hour interviews. Five interviews (in 2021/2022) were with healthcare professionals in the region of Northern Norway and concerned their individual role in day-to-day medication management. The other interviews concerned, among other things, the infrastructure for medication management. These interviews were conducted in Central Norway and consisted of four interviews with informants from municipal healthcare consortia (in 2021), three interviews with representatives of EHR vendors (in 2020/2021), nine interviews with GPs (in 2019), and six interviews with managers responsible for an ongoing and large-scale EHR implementation (in 2018). The interviews were about evenly split between onsite and online interviews.

The interviews revolved around a small set of guiding questions prepared ahead of each interview. These questions served to maintain the focus of the interviews and as starting points for the interviewees’ responses. The interviewees were encouraged to provide rich descriptions of their work practices, including the artifacts used in performing these practices and the rationale for performing them the way they did. All interviews were recorded and transcribed for analysis, which followed an interpretive approach (Walsham, 2006). The analysis focuses on the intersectoral and hospital levels of medication management.

Results

Intersectoral Level: An Infrastructure of Interrelated Components

The interviewees mention a lot of electronic and other systems that enter into medication management. For example, several national integration components are being developed to facilitate the "one citizen – one record" strategy. One of them is the *summary care record*, which has been under development since 2012. It is a digital solution for sharing patients' health information across the healthcare sector and includes, among other things, critical information, discharge letters, laboratory results, and pharmacy-dispensed medication prescribed through the Prescription Intermediary System (in Norwegian, "Reseptformidleren"). In 2017, the summary care record was rolled out to all hospitals, all emergency call-centers, and 85% of the GPs. In 2020, the first municipalites started to use it, and currently the possibilities of sharing various clinical documents from Norwegian hospitals are being tested at different locations in Norway.

Another national component is the *shared medication list*, which will become part of the summary care record. It has been pilot implemented in Norway's second-largest city, Bergen, since December 2021. Compared to the summary care record, which gives an overview of a patient's pharmacy-dispensed medication, the shared medication list gives the full list of a patient's medications, including prescription drugs, non-prescription drugs, and drugs that have been administered in a hospital, nursing home, or purchased abroad. To enable widespread use of the shared medication list, a national component called the Central Prescribing Module is also being developed and is currently in the test phase. The Central Prescribing Module is a medication and requisition module that (through integration with the EHRs in the healthcare institutions) facilitates the sharing of medication information among various EHRs. When this module becomes available to healthcare personnel, they will have a unified prescription user interface, irrespective of which EHR they use.

The interviewees from the municipal healthcare consortia considered the shared medication list particularly promising. One said that with the addition of this list "we will have a pretty good picture of the patient's health situation." However, the shared medication list, the Central Prescribing Module, the Prescription Intermediary System, and the summary care record are merely pieces in a big puzzle. To be functional, they must work seamlessly together with hospital EHRs (DIPS and EPIC), EHRs in municipal healthcare (DIPS FRONT, GERICA, and PROFIL), and the EHRs in GP clinics (CGM, INFODOC, PRIDOK, SYSTEM X, and 2-3 others). In addition, the different EHRs must bilaterally exchange further medication information whenever a patient crosses a sectoral boundary, such as a transfer from hospital back to home care. Figure 1 illustrates the multidirectional flow of information in this infrastructure. Considerable work goes into keeping the information up to date. This work includes maintaining the distinction between the medication prescribed to a patient and the medication that the patient actually takes. Several interviewees emphasized the critical importance of talking with the patient to obtain accurate information about the taken medication, because the other components in the infrastructure mainly contain information about prescribed medication.

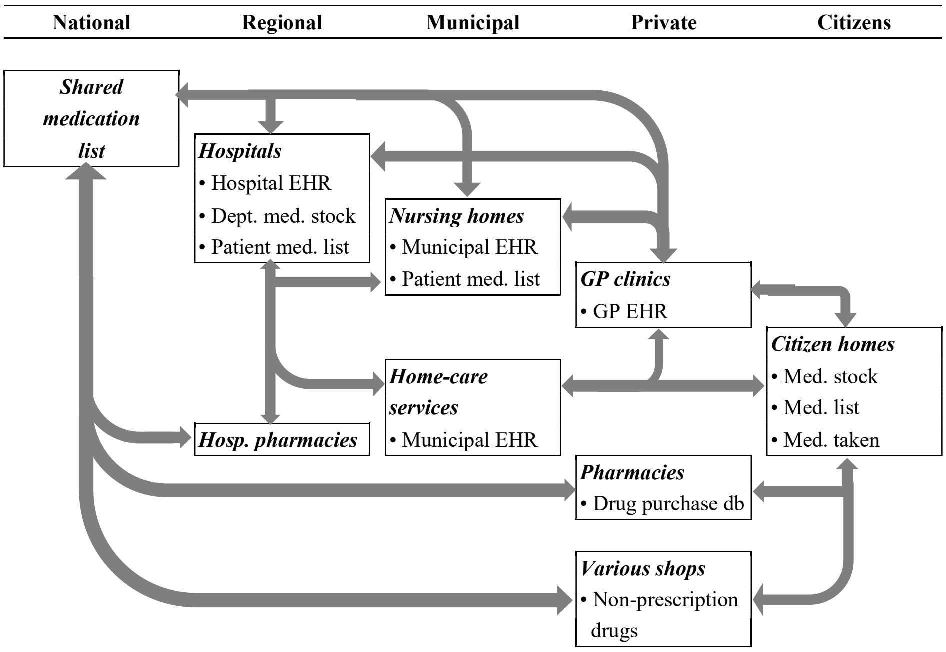

Figure 1. The Norwegian infrastructure for medication management.

Hospital Level: Working Documents vs. Electronic Documentation

Currently, the shared medication list is pilot implemented in one Norwegian city. It is still merely a vision in the rest of Norway, such as in Narvik. At Narvik Hospital in North Norway, one of the first things to do when a patient is admitted is to establish the patient's current medication. To do so, the physician must match the patient's medication list in the hospital EHR against the lists in two national components: the central prescription database and the summary care record. These three lists of the patient's medication get their content from partly overlapping sources. None of the lists can be assumed to be correct. Recently prescribed medication may not yet be on the lists; terminated medication may still be there. The physician needs to identify and remove duplicates, to determine whether old prescriptions are still in effect, and to seek additional information if left uncertain about whether something is missing from all three lists. For elderly patients, additional information may be obtained by electronic information exchange with the EHRs in home care and nursing homes. For all patients, the merged medication list is recorded in the hospital EHR and printed on paper.

During the admission, this paper printout – the paper chart – is the authoritative record of the patient's medication. Changes to the medication are written on the chart, including a reason for the change. The paper chart has preprinted fields for five days of use. If a patient stays longer, a new paper chart is printed and the changes on the old chart are manually transferred to the new chart. The paper chart is accessed repeatedly and, therefore, passed from clinician to clinician: (a) During the night shift, the nurse on duty uses the charts for all patients to dispense their medication for the next day. Patients get medication at four daily medication rounds and the nurse prepares each patient's medication for each of these rounds. (b) During the day shift, the nurses check the prepared medication against the paper chart before each medication round. This check involves adding and removing medication that has been changed by the physicians during the day. It also involves adding class A and B drugs, which for safety reasons must only be dispensed by the nurse who will be giving them to the patient. The nurses must make a separate record of the dispensed amount of these drugs. For class A drugs, the hospital pharmacy checks this record against their database of the drugs delivered to the hospital departments to discover shrinkage. For class B drugs, the record is kept by the head of department for auditing purposes. (c) During their ward rounds, the physicians use the paper chart in assessing the patient and to record any changes in medication. (d) Finally, the clinical pharmacists use the paper chart in talking with the patients about which medication and which doses they actually take, especially for the medication they also used prior to their hospital admission. The interviewed pharmacist states that these talks "almost always reveal one thing or another that does not match [the contents of the paper chart]".

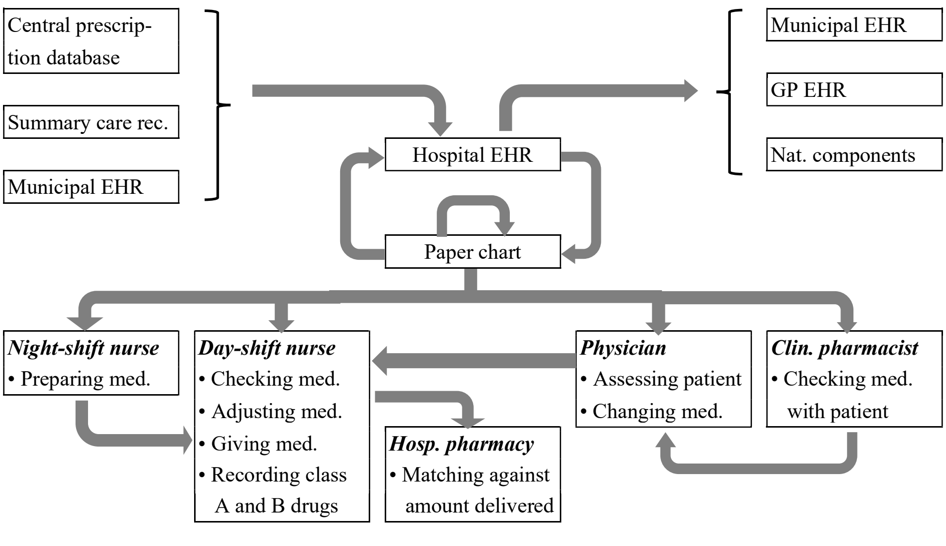

Figure 2. The process of medication management at Narvik Hospital.

At discharge, the medication list in the hospital EHR is updated with the information on the paper chart. The updated list is automatically transferred to nursing homes, home-care services, and GP clinics. However, the nursing homes often contact the hospital to verify changes in a patient's medication, especially when the reasons for prescribing it are unclearly described. Figure 2 illustrates the within-hospital medication-management process.

Discussion

Medication management is a boundary-crossing activity. As an infrastructure, it operates at multiple organizational and temporal scales, thereby connecting heterogeneous entities across various boundaries. It crosses boundaries between healthcare sectors (e.g., hospitals and nursing homes), between within-sector departments (e.g., medical wards and intensive care units), between professional groups (e.g., nurses and pharmacists), between artifacts (e.g., EHRs and paper charts), between work shifts (e.g., day and night), between vendors (e.g., DIPS and EPIC), between tasks (e.g., administering medication and recording class A drugs), and between technology and people. Any within-boundary activity is merely a component in the larger infrastructure for medication management. The complexity of this infrastructure defies automation but calls for extensive technological support to assist the healthcare professionals in spanning the boundaries. The many troubled EHR implementations documented in the literature attest to the challenges involved in supplying such support (e.g., Aarts et al., 2004; Greenhalgh et al., 2011; Hertzum et al., 2022).

In Norway, initiatives are currently ongoing to supply technological support in terms of nationwide integration components and regionwide EHRs. At the municipal level, there are also initiatives to stimulate technological innovation by increasingly opening the current infrastructure to add-on components from third parties (Ellingsen et al., 2022a). All these initiatives should strike a delicate balance between reducing bridging work and preserving quality:

- *Bridging work*: While many components in the infrastructure for medication management are electronically connected, the flow of information among the components involves considerable human work. This bridging work is cumbersome and increasingly prone to errors with more degrees of separation between the involved healthcare professionals (Hertzum, 2010).
- *Quality checks*: At the same time, the bridging work introduces multiple occasions for double checking the correctness of the medication information. These repeated checks lead to the correction of many errors. A more technologically integrated process might appear more efficient but in effect do away with these quality checks, which show that some redundancy may be useful (Cabitza et al., 2019).

Currently, suboptimal technological integration necessitates considerable bridging work and quality checks. However, the infrastructure for medication management is constantly evolving – at multiple levels. At the national level, the central prescription database and the summary care record are recent technological initiatives to integrate otherwise fragmented information. At the regional level, the new EHR in Central Norway comes with the expectation of increased cross-sectoral collaboration, but the GPs express concerns about the accompanying increase in their workload (Ellingsen et al., 2022b). At the hospital level, the clinical pharmacists are taking on new responsibilities, thereby causing task drift in the division of labor between physicians and clinical pharmacists. These initiatives wrestle with the installed base, which merely evolves slowly because of its long history and many interdependencies (Aanestad et al., 2017). The paper chart is a prime example.

The paper chart is in widespread use at Narvik Hospital and, probably, hard to replace due to its tight integration in daily practices (Figure 2). Paper has valuable qualities that are acknowledged in research but sometimes not in design efforts, as illustrated by the discussion of paper flight strips in air traffic control (Mackay, 1999). For the paper chart, the valued qualities include flexibility, portability, and at-a-glance overview. However, the paper chart also comes with the risk of manual transfer errors and information loss when the chart is full and must be replaced with a new one after five days. In addition, the paper chart precludes technology support such as automatic drug-interaction warnings when hospital physicians prescribe new medication to admitted patients. Unless the clinicians are prepared to let go of the paper chart, the support they get from their EHR will remain limited when it comes to managing medication. At the same time, changes to the infrastructure should be made cautiously because abrupt changes may cause uncertainty and perceived complexity that detracts from the intention to streamline medication management.

Pipek and Wulf (2009) advocate an integrated perspective on the design and use of information technology. A key proposition in this perspective is to get beyond the traditional design-method focus on developing individual products, because users accomplish their tasks by combining multiple products. The boundary-crossing character of medication management shows the inadequacy of a design focus on individual products. Medication management extends across many systems, each merely a component in the overall infrastructure for medication management. To meet the strategic goal of "one citizen – one record", it must be a principal design objective to bring the components together in a unified user experience. This requires a consistent focus on evolving the infrastructure, rather than solely on designing the individual component products.

This study has investigated medication management at the intersectoral and hospital levels. We envisage that including municipal healthcare and GP clinics will add further complexity. For example, nursing homes provide long-term care, which entails different conditions for medication management than the acute care administered at hospitals. Home care supports and follows up on medication management in the citizen's home, which is a less controlled environment than hospitals and nursing homes. And GP clinics are private businesses that must generate an income from their contributions to medication management, whereas hospitals and municipal healthcare in Norway are funded via taxes. In future work, we will also investigate medication management in municipal healthcare and GP clinics.

Conclusion

The infrastructure that is in place to support medication management is far-reaching and inherently sociotechnical. It spans all levels of the healthcare system, diverse technological components, and various healthcare professionals. This study has mapped the intersectoral and hospital levels of the Norwegian infrastructure for medication management. While this infrastructure supplies an increasingly integrated record of each citizen's medication, considerable human work goes into bridging the technological components of the infrastructure. Ongoing initiatives seek to reduce the need for such bridging work through increased technological integration. However, the bridging work also creates occasions for double checking the correctness of the medication information. These occasions must be preserved unless we can be certain that the increased integration makes the double checking superfluous. At each step in the evolution of the medication-management infrastructure, coordinated changes in technology and work practices are required.

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Designing for Health, Engagement and Social-Interaction: A Multimodal and AR-based Sport System to facilitate digital Connectedness over Distances

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Abstract. This work presents a prototype for a multimodal and augmented-reality (AR) based system designed to facilitate individual and social activities, promote health and well-being and support participation for various people. A practice-based design and research approach was used to explore requirements, to conceptualize, design and develop AR-based activities for a multimodal interaction. We have interviewed members from seven different sports associations and conducted design workshops to understand how to design AR-applications to promote an active lifestyle and at the same time to build a bridge for new sustainable societies and active communities. The prototype and approach presented here will serve to discuss and reflect future research activities, methodological concepts, and experiences in the field of HCI, sports, and AR.

Introduction

Physical activity (PA) has multiplicative health, social and economic benefits, can create connections in many ways, and plays an essential role in the everyday life of many people: physical activities have a positive impact on physical and mental health and make a valuable contribution to social participation and individual mobility (Cooper et al., 2015; Guthold et al., 2018). Therefore, promoting PA, social interaction and participation is directly in line with Sustainable Development Goal from the United Nations, which is focusing on *ensuring healthy lives and promote well-being for all at all ages* (Aal et al., 2016; United Nations, 2022). There are multiple direct and indirect pathways to promote PA through, e.g., walking, cycling, sport, active recreation, and play support. However, for the last 20 years, there has been a concerning worldwide trend in insufficient PA (Cooper et al., 2015; Guthold et al., 2018; Hallal et al., 2012) due to an increasingly sedentary lifestyle (Hallal et al., 2012). This favors a visible increase in overweight and obesity in the populations of industrialized nations (Reilly et al., 2018) and a related increase in chronic diseases such as diabetes type 2 or various cardiovascular diseases (Chen et al., 2012). The use of health-related information and communication technology (ICT) such as exergames (Smeddinck et al., 2015; Unbehaun et al., 2019, 2020; Unbehaun, Vaziri, Aal, Li, et al., 2018; Unbehaun, Vaziri, Aal, Wieching, et al., 2018), health applications and wearables (Vaziri, 2018), as well as digital games and training programs (Brown et al., 2022; Vaziri et al., 2017) in different domains, shown to improve activity levels and offer valuable potentials. Recently, virtual and augmented realities (VR and AR) are becoming increasingly visible in the field of health-related ICT and Human-Computer-Interaction (HCI) (Janßen et al., 2021; Janßen & Prilla, 2022; Raß et al., 2023; Taugerbeck et al., 2019; Unbehaun et al., 2019, 2021; Yoo et al., 2020). Our work presents an AR-based system to foster physical activity, facilitate social interaction, and create an innovative interface to access and promote health and active participation across all ages and abilities. In this work, we identified individual and organizational requirements, designed and developed an AR-based System aiming to adapt sports activities and combine them with AR approaches and multi-user applications to create new multimodal scenarios in individual and social outdoor interactions. The system was contextualized, designed, and developed with actors (athletes and clubs) and additional stakeholders (associations and multipliers). By exploring system requirements and implementing the system in sport-communities, the goal is to enable an innovative and active social lifestyle for various social groups and establish a socio-technical "*innovation space*" (Edwards-Schachter et al., 2012), which transfers innovations from academia and various industries into individual and institutional practices. Thus, the project explored how AR-based exercises and activities need to be designed to enable participation across distances as well as how they may foster participation, communication and social interaction across generations. The presented results and prototype will therefore serve as a platform to discuss and reflect upcoming research activities, methodological concepts, and experiences in the field of HCI, CSCW, and augmented reality.

Related Work

Physical Activity and Interactive Technologies

A sedentary lifestyle, stress at work, and omnipresent availability of industrialized food – collateral consequences of today's civilization and economic growth – create new enormous challenges to the state of health of many people. PA decreases, whereas obesity, diabetes, heart diseases and other related health problems increase almost worldwide (*Obesity and Overweight*, o. J.). One of the major approaches for developing an active population and tackling common lifestyle diseases is implementing PA in people's everyday lives. The WHO defines PA as "any bodily movement produced by skeletal muscles that require energy expenditure. PA refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work" (*Physical Activity*, o. J.). Technologies have been used in the context of sports before for several purposes. Very acquainted are the traditional step counters, which use pedometers to detect daily step counts to assess and motivate PA behaviors (Tudor-Locke & Bassett, 2004). The 10,000 steps/day goal gained popularity with the media and in practice because it appears to be a reasonable goal to benefit health (Kang et al., 2009). With digital games being among the most popular leisure activities, the lack of PA, time spent outdoors, and possible social isolation of players are critically discussed (Wulf et al., 2004). However, the supposedly challenging games and technologies could also be used to work against this trend. Under the impression that people indicated a lack of enjoyment and preferred to do other things as barriers to PA, they offer considerable potential (Hoare et al., 2017). Recently, there have been many attempts to combine the motivational benefits of digital games with exercising, forming the new term "exergaming". Famous examples of the genre are games such as Dance Dance Revolution, Wii Fit, Kinect Sports, and Ring Fit Adventure. Researchers found that these interactive technologies could increase individuals' PA, self-efficacy, perceived social support, and enjoyment (Gao & Chen, 2014). They benefit several physiological parameters like energy expenditure, oxygen consumption and heart rate (Biddiss & Irwin, 2010; Peng et al., 2011). A well-known example of that genre is "Pokémon Go," which is exceptionally well received and cited by the media (Aal & Hauptmeier, 2019; *Pokémon Go Revenue and Usage Statistics (2021)*, 2017). Studies report that more than half of the active Pokémon Go users agreed that playing the game changed their walking habits, motivated them to go outdoors more often and made them walk to a destination (Merrimack College, School of Health Sciences, North Andover, MA, United States et al., 2020). The game also influences social behavior: Studies show that it can increase the time spent with family, which improves the bonding between parents and children (Sobel et al., 2017) or the number of friendships and leads to an intensification of friendships (Bonus et al., 2018).

Augmented Reality in HCI and Computer-Supported Collaborative Sports

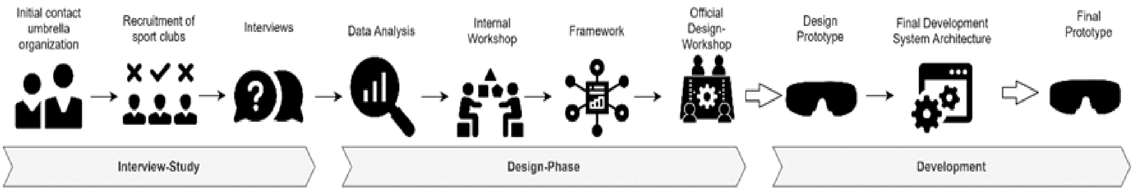
Tieing in with new hybrid forms of exercise as seen in the genre of Exergames and the example of Pokémon Go, the field of Computer-supported collaborative sports tries to make use of new technologies by expanding sports experiences through Visual Augmentations (Aal & Hauptmeier, 2019; Unbehaun, Aal, Vaziri, Wieching, et al., 2018; Wulf et al., 2004). Those augmentations differ depending on the grade of virtuality. While there are Virtual Reality (VR) applications that completely replace the real world with virtual content, they are less common in sports contexts. Most augmented sports activities instead rely on either Augmented Reality (AR) which enhances the real world by providing additional input or (MR) which combines real and virtual elements to create new immersive surroundings. These approaches lead to the user feeling like a part of their environment while still allowing them to see their actual movements and surroundings, rather than a completely virtual environment. Thus, AR and MR are more suitable for sports activities compared to VR technologies.

As Wulf et al. already argued in 2004, an augmented collaborative environment will lead to newly designed sports with entirely new game ideas (Wulf et al., 2004). In this vein, a newly emerging field focusing on recreational implications of MR technology is called "Superhuman Sports" (Eichhorn et al., 2020; Kunze et al., 2017). Superhuman Sports aims to create new sports experiences with enhanced human abilities through technological human augmentations (Kunze et al., 2017; Numan et al., 2019). Through Superhuman Sports, new sports such as "Hado" (Kunze et al., 2017), "Star Tag" (Numan et al., 2019)," League of Lasers" (Miedema et al., 2019), and "Catching the Drone" (Eichhorn et al., 2020) already emerged. Through AR, users of sports games, for example, can receive additional information in real-time and in real-life environments during gameplay and experience a range of innovative forms of activity through augmented reality and mixed reality technologies. AR glasses are already available in cycling, in areas such as movement training and rehabilitation (Anderson et al., 2013) in billiard and table tennis (Yeo et al., 2019), or sport climbing (Kajastila et al., 2016). Similarly, MR has been used to create complete environments for sports such as Basketball (Pai et al., 2018; Santoso, 2018). Future research interests refer to the opportunity to use AR/MR more commonly on a recreational level, such as making sports more challenging by designing visual obstacles (Yeo et al., 2019) or enabling the users to manually set their training as already the case in Augmented Climbing (Kajastila et al., 2016). The related research stresses the importance of motivational, social, and acceptance factors to support individual and social sports activity (Wulf et al., 2004). Similarly, social collaboration and competition prove to have a significant effect on motivation as well as acceptance and desirability of the device (Kunze et al., 2017).

Methods, Design, Data and Research Questions

By adapting a practice-based design approach, we aim to develop the system and the practical scenarios together with the target group (athletes, clubs, associations, and municipalities) to identify factors in the early stages of development that are relevant for the continuous use of the solution. The paper work seeks to address the following research questions: 1) Which specific practice-based factors are concerned in designing an AR-based system to foster physical activity, enable social participation and encourage their long-term use, and 2) to what extent can individual and social activities in the context of sports be supported by AR-based activities? Regarding data collection, we followed the Design Case Study Approach by Wulf (Ahmadi et al., 2018; Wulf et al., 2011) by applying different methods and participatory instruments from the fields of human-computer interaction (e.g., different levels of prototyping) and qualitative research (e.g. interviews, design workshops, participant observations). Our stakeholder network consists of sports clubs, and associations (see table 1) from different cities and rural areas.

To gain meaningful insights into the structure, daily routines, and organization of sports associations, we began with an empirical study regarding existing practices, organizational and social perspectives, individual and social needs, and the challenges confronting our target group in their everyday surroundings.
This involved semi-structured interviews with different sports associations. Right from the outset, the approach enabled an open collaboration amongst a variety of actors, reflecting their different perspectives, knowledge, interests, and expectations. In a second, iterative step, we conducted a design workshop together with managers, training group leaders and sport club members to discuss possible scenarios, use cases, technical restrictions, and barriers. Based on the initial interviews and internal workshops, the idea of a cooperative and competitive AR-Setup with various features evolved, which was then introduced to the sports associations and their members in the joint design workshop. All researchers participated in three sets of internal design workshops with different foci in which we developed the technical, organizational and social framework. The study



included overall 11 participants from sport associations with different backgrounds (see table 1 for an overview) and 9 members of the research and development team. The qualitative data consisted of audio recordings and field notes collected during the interviews and workshops. Our data analysis was performed using a Thematic Analysis (TA) approach (Braun & Clarke, 2006). This involves a series of established steps, including open coding of the data material, systematic revision of the coded segments, and identification of code families and their relationships in the search for themes. After the transcription of the interviews, the transcripts were reviewed and coded in an iterative process leading to the compilation of the data categories present in the collected data and to the elaboration of relationships between these categories. We identified the following principal themes during the coding sessions: individual adaptability; social aspects; and technical requirements. These overarching themes were derived from our original codes, which included terms such as motivation, interaction, participation, engagement, movement, etc. Coding differences were discussed and eliminated by adding, editing, or deleting codes according to the outcome of the discussion.

Table 1: participant overview

ID	Participant	Role	Institution
1	Mr. S	Project Manager	Local Umbrella Organisation <Name>
2	Mr. R	Regional Coordinator	Local Umbrella Organisation <Name>
3	Mr. B	Manager	Sports Association <Name> with > 50 members
4	Ms. S	Manager & Training Group Leader	Sports Association <Name> with > 500 members
6	Mr. G	Manager & Training Group Leader	Sports Association with > 450 members

7	Ms. K	Sports club member	Sports Association with > 450 members
8	Mr. D	Manager	Sports Association with > 200 members
9	Mr. R	Sports club member	Sports Assocation with > 200 members
10	Mr. F	Manager	Sports Assocation with > 80 members
11	Mr. B	Sports club member	Sports Assocation with > 80 members
12	Mr. U	Researcher in HCI	University of <Name>
13	Ms. J	Researcher in HCI	University of <Name>
14	Mr. C	Researcher in HCI	University of <Name>
15	Mr. F	Researcher in HCI	University of <Name>
16	Mr. A	Researcher in HCI	University of <Name>
17	Mr. P	Co-Founder	Sports Equipment Company <Name>
18	Mr. T	Co-Founder	Creative Management Solutions Company <Name>
19	Ms. M	Researcher and Project Manager	Creative Management Solutions Company <Name>
20	Mr. M	Researcher in Sport Science	Technical University of <Name>

Results

In the following, we present our findings in relation to our research questions and the connected categories, which describe the individual adaptability and social interactive as the different requirements to led to the design and the technical infrastructure.

Individual and Institutional Customizability

The conducted interviews showed that there is a rising importance of digitalization within sports associations. Mr. D, the manager of the senior hiking sports association, explained: *"The tendency of digitalization has to happen within the next years. It is essential for sports clubs to keep their members and offer something attractive"*.

Similarly, Mr. B, the manager of a sports association founded in 2017, stated that additionally to the regular training practices, they *"want to achieve a digital regularity"*. The most common reason for digitalization amongst the interviewees was the facilitation of data collection and thus training optimization and analysis. Most of the *"athletes that are to some extent ambitious already use sports watches"* described Ms. S, the manager and training group leader of a sports association with 500 members. Mr. G, a manager and training group leader of a sports association with 450 members, described how the athletes are mostly more digitally involved than he is when it comes to collecting data:

"Almost all of them have sports watches now. When they are done with their training, their watches show their timing. They tell me what the watch says and I note them into my chart by hand". Furthermore, Mr. G wished for a possibility to immediately transfer the athletes' data to his technical device and continued to express: *"It would be sensational if I could immediately analyze their data and my feedback in return would be instantaneous and always accessible"*. The use of technology was not only perceived as

convenient for the sports group trainers but also for the athletes themselves. As Mr. G ideated:

"*If the performance-driven athletes could see their development within the last weeks. What kind of training was beneficial or what do I still need to improve? Where are my weaknesses? Where are my strengths? And to be able to analyze that and compare it to another athlete that might have similar abilities*".

Besides the facilitation of training analysis, Mr. B emphasized the possibility of using that data to create individualized training offers through *"an app, based on the scope of previous training"*. During the workshop, one participant suggested using your own data for a *"virtual race* against *the own personal best"*. Ms. K, who is a sports club member herself, pointed out the recent importance of collecting data for the sake of sharing it online: *"If you did not record and upload an activity, it does not count"*.

During the interviews and the workshop, the participants were asked to name what they consider to be the most essential functions and technical requirements of sports wearables. Mr. G emphasized the importance of *"a stopwatch to measure lap times"*. Ms. S mentioned the importance of a *"route map"* and further explained, *"it is essential to explore new routes or retrace them"*. During the workshop, one participant stated: *"The wearable should convey some kind of diagnosis or motivation without the necessity to look on my watch"*. The placement of the wearable is essential, as Ms. S stated: *"As a runner, everything that is dangling and jingling bothers you. There is nothing worse than something dangling on you while you run"*. She concluded: *"It is annoying how you always need three technical devices to do something. There should be one device with everything I need implemented"*.

Social Connectedness and Motivational Aspects

The manager of a triathlon sports club, Mr. B, stated during the interview that *"feedback received through technology might be motivating but it is not essential"*. Referring to digital sports watches used by members, he concluded:

"If you improved, you'll immediately get feedback on your watch. That can definitely motivate but to be honest, when looking at the whole season, the most motivating part is the competitions".

The competitions turned out to be the most prominent factor in all of the interviews we conducted. Mr. B mentioned in the initial interview, "*I know that the athletes miss one thing most during the pandemic: The competitions"*. Due to the COVID-19 pandemic, training and competitions no longer took place, leading to interviewees pointing out how the athletes miss training and competing with all its long-term individual and social preparations and implications). During our Co-Design Workshop, one training group leader stated: *"In times where the direct comparison is not possible, the digital one is even more important"*. Similarly, it was mentioned by Mr. G that the *"community that wants to compare themselves is very big"*.

Competitions were described as not only being motivating because of wanting to win but also the social component, *"to be together and talk about the* great *competition afterwards"* as argued by Mr. B. Other factors mentioned were the involved playfulness and related motivational aspects. For example, Ms. S mentioned that, "*I always say: Adults turn into children when involved in activities that include competition",* and that in terms of group dynamics and competitions, "*everyone automatically wants to be a part of it"*.

As seen in the foregoing statements, competitions were identified as an essential motivator for most athletes. Yet, not only for the reason of competing. It turns out to be of similar importance to cooperate as a team as well as to experience the competition together. As Ms. S, the manager of a sports club with approx. 500 members stated: *"Most members are in the* sports *club because they want social connection"*. The social connection includes both the connection to other members as well as their connection to the trainers. As one manager pointed out: *"We realized that we have to keep in contact or else our members will leave*". Keeping in regular contact with their members has proven to be especially difficult during the COVID-19 pandemic. Thus, sports clubs changed their way of communicating with the members. The interviewed sports associations used different infrastructures to stay in contact with their members and offer them activities during COVID-19 restrictions. The range of improvised actions varied significantly.

One manager from a senior hiking association reported that *"we needed to create a telephone list"* to stay in contact. Another manager explained that they are *"communicating with the athletes via chat messengers"* and tried to provide alternatives to the training and competitions that no longer took place. Ms. S referred to an initiative of the regional umbrella sports association, which coordinates projects and activities across all sports associations in a region. They offered some projects for the sports clubs to participate in such as *"a fitness application that allowed you to create teams and within a time span of 8-12 weeks you could collect points as a team"*. Some sports clubs even came up with their own events. One triathlon club challenged their members to be as active as possible for a time frame of two weeks and counted the total of kilometers they completed running, swimming and biking: *"This initiative received a lot of positive feedback"* stated Mr. B, and further explained that they rewarded their members, "*we said: Great, in total all of you completed 800 kilometers. And then we rewarded them by placing gifts on their doorsteps"*.

The interviewees emphasized the importance of integrating a social component into sports technology. One training group leader pointed out that "*communication between athletes that are en route alone is very important*". Similarly, Mr. G, the manager of a sports club with 450 members stated:

"As a cyclist, for example on racing bikes or in groups, it is fairly difficult to communicate with one another. Especially if there is a pothole or some other obstacle. There are certain hand signals but to use them you have to let go of the handlebar. It would be great if that could be facilitated via sports technology".

Mr. B mentioned the existence of some technologies that have online functions allowing competition or cooperation with other athletes: *"While indoor cycling, you're not cycling alone. You're actually racing with other people all around the world"*. During our workshop, we explored several other scenarios that technology could achieve with the participants. One workshop attendant ideated: *"It would be great to compete in a race* *as a team, so that everyone is wearing augmented glasses and can see where everyone else is".* Another interviewee suggested the following scenario:

"If you could meet together virtually, 2 pm Saturday, us three will meet for running, maybe two will take the bicycle, five are hiking with their parents, but all together. Having digital groups that can meet". Another suggestion was to create a social sports platform that allows people to "create small challenges, for example jumping across three rocks, and if you complete other people's challenges, you'll get an achievement". One more idea that came up in the workshop was to design "an active digital lunch break with friends that work in another place".

Technical infrastructure

The technical infrastructure of the designed and developed system consists of three main elements, which are interconnected: AR glasses with different multimodal input options (gestures), a smartphone application to create groups, organize challenges, track records, and a PostgreSQL database, which is collecting and forwarding activity data (GPS, average speed) from multiple users to connect user synchronously from different places on comparable running routes that are chosen within the app. The system can be used as a navigation and orientation system (near-real-time positioning) and synchronize movements of multiple players between the real and virtual worlds to initiate a digital-supported marathon for users who are in different places in the world. Compared to existing AR interfaces in gaming contexts, the input modalities allow for more immersive interaction during outdoor activities. Similarly, the wearable interface enables the user to move more freely and naturally without having to hold additional technology.

Figure 2: AR glasses with a monochromatic field of view

System Components and System Design

The system consists of AR glasses and a smartphone application to command the system as well as to store and analyze data (see Figure 2). The data can be used to analyze and present individual results, share achievements within a group and derive long-term activity trends from strengthening health awareness.

User-friendliness was a design objective in the presented work. We designed the system so that the interaction of the system highly correlates with the naturalness and simplicity with which a user can operate it (intuitive & multimodal control via touch or swipe gestures). Within the system, both active and passive interaction modalities (sensor, actuator, device) were developed to enable users to interact directly (actively) and indirectly (passively) with the system and the multi-user interface. The route planning system, which visually displays the selection made by the user via the AR glasses and provides additional, supplementary information via a voice output, ensures that the additional information provided by the voice output also matches the route selection made, even if the user performs different actions in quick succession. The interaction with the AR system was designed to command via voice and motion commands. We designed the system to ensure that the user is provided with the best possible combination of available modalities for processing a specific task before and during the training activities without stopping the outdoor activity. For this purpose, the development of multimodal interaction enables accessibility and increases the efficiency and ease of use as well as the flexibility of human-technology interfaces.

The smartphone application itself (see Figure 3) is structured so that user always sees the current navigation menu at the top. At the bottom, the permanently visible main navigations bar is always accessible, regardless of where the user is, and is designed with icons and texts aligned in a row. These elements are the main elements (dashboard, navigation, activities, settings, communication, team) of the application and should be easily accessible for the user to operate through different functions quickly.

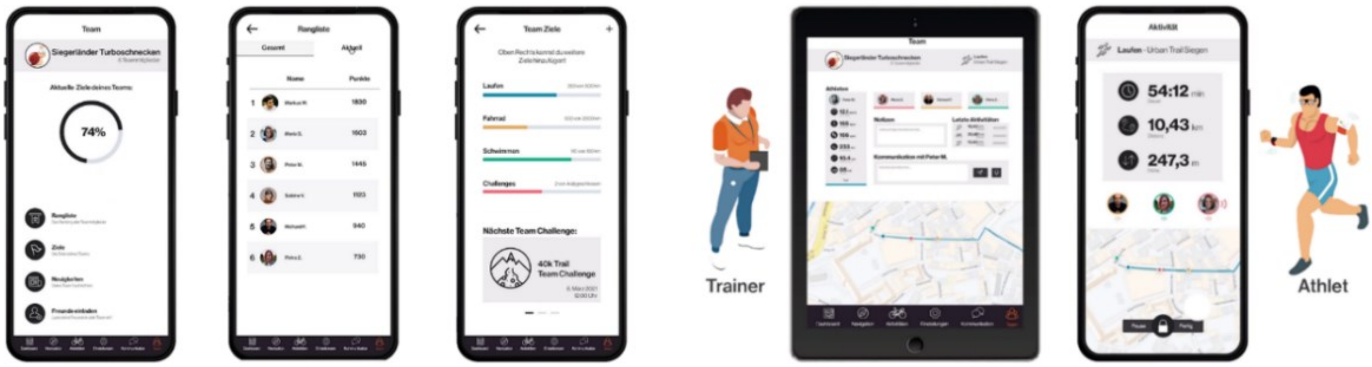


Figure 3: Smartphone App Overview

Conclusion

To conclude, our work presents a multi-user and multi-device AR technology intending to make PA more enjoyable. Hence, based on an immersive and multi-user capable AR technology, an innovative, individualizable opportunity of movement and cognitive training for health promotion was created. These multi-user sports- and exercise-related applications to be developed will be researched with regard to their suitability for everyday use and user acceptance of AR-systems as well as their individual physiological and social-emotional effects and evaluated in an upcoming proof-of-concept. The suggested scenarios may serve as a blueprint for further development scenarios such as an AR-based marathon, biathlon, or triathlon or interactive scenarios of experience-oriented discovery at the point of interest, such as AR-supported city tours in urban environments or digital tools in schools or inclusive settings.

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The Narrative Future of (digital) Care – Envisioning Care Fiction(s) in Education-based and professional Care Settings

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Abstract. This paper explores future opportunities for care through practice-based interventions in real care settings and the use of design fiction as a method. Based on real innovation spaces within care-schools, we applied a design fiction approach to conceptualize and envision future care scenarios that include prototypical solutions for a digital transformation for both, people who in care contexts and people in need of care. We reflect on the content and implications of care fictions developed in collaboration with care-schools for shaping future systems of care and health. With this publication, we contribute to the emerging field of human-computer interaction by highlighting the value of design fiction as a methodological approach for exploring the narrative future of care.

1 Introduction and Background

Providing adequate care and healthcare services is a complex challenge due to various factors such as geographical remoteness, aging societies, shortfall of qualified caregivers, limited resources, and unique cultural contexts (Unbehaun et al., 2021; Unbehaun et al., 2019). For example, demographic transformation and social changes such as longer life expectancy and consistently low birth rates have resulted in more older adults requiring care. Additionally, the shortage of professional caregivers is a growing issue in many countries and significantly impacts the quality of provided care and the well-being of caregivers and people in need of care (ten Haken et al., 2018; Komendziński et al., 2017; Rothgang et al., 2012). Thus, there is a growing interest in exploring innovative solutions to address these challenges and improve care outcomes. Consequently, advances in medical technology and increasing quality standards are transforming the nature of professional caregiving and interdisciplinary treatment for those in need (ten Haken et al., 2018; Komendziński et al., 2017) so that care innovation involves developing new approaches to technologies, and interventions. Along with these trends and to enhance social interaction and facilitate healthcare processes, digitalization in the healthcare sector is rapidly progressing (Bhavnani et al., 2016), leading to more complexity of care, whether it be in information documentation, assistive systems, video game-based interventions, or social-assistive robotics (Schwaninger et al., 2019; Carros et al., 2020; Unbehaun et al., 2020a, 2020b, 2018; Müller et al., 2015; Aloulou et al., 2013; Fasola & Matarić, 2012). However, the future of care is complex and uncertain, and there is a need for creative and imaginative methods to explore potential futures and generate new insights. With this in mind, using socially assistive robots in care settings has been a topic of interest and research in recent years. Many researchers have explored the potential for improving the well-being of patients and addressing care challenges by using technologies and, more specifically, via socially assistive robots.

Design fiction has emerged as a valuable approach in HCI for exploring and imagining potential futures of technology, systems, and interactions since it offers a way to create narrative images of the future (Coulton & Lindley, 2015; Simon, 1969; Taugerbeck et al., 2019) and to present challenges of balancing between realities that are either far or too close (Grand & Wiedmer, 2010). In the ability to stimulate creativity, imagination, and critical thinking lies the relevance and importance of design fiction since it offers a means to explore diverse and sometimes radical future scenarios that may not be immediately achievable or feasible but can inspire new ideas, perspectives, and insights. Several variants exist to demonstrate design fiction, e.g., in narrative form through short stories, films, prototypes, and prototypical imagination (Ertl et al., 2019; Blythe, 2014; Hales, 2013; Wakkary et al., 2013; Tanenbaum et al., 2012). Especially in the care domain, design fiction can be precious since nursing and healthcare are complex and rapidly evolving fields that require innovative approaches to address current and future challenges, and this approach offers a way to envision and explore potential futures of care and healthcare, considering the domain's unique needs, contexts, and complexities.

In this paper, an innovative approach to envision the future of care was used by co-designing possible care scenarios based on the method of design fiction aiming to bridge the gap between imagination and reality, fostering discussions and reflections on potential futures of care. The methodological concept of "Care Fiction" was introduced for this purpose, specifically focusing on the future of care and drawing on reality-based settings and structures of care institutions to develop scenarios that incorporate narrative elements and design elements, as well as prototypical solutions. As a result, care-students and teachers developed and presented four scenarios characterizing future care-applications and innovative system as “Care Fictions” in various care contexts, highlighting their ability to create unique insights and encourage debates about future care scenarios. In addition, the relevance of this research is highlighted in the broader field of HCI, as it offers a unique perspective on how to use design fiction to explore the narrative future of care and healthcare systems.

Our findings contribute to the growing literature on design fiction and care and innovations processes (see also Krüger et al., 2022; Boden et al. 2020) and offer insights for researchers, practitioners, and policymakers interested in designing future care solutions.

2 Methodology, Concept and Background

Our research activities follow a qualitative methodology, and we used co-design workshops as participatory design methods (Nofal, 2023; Wagner, 2018) to understand users' needs, experiences, and perspectives in-depth, capturing their opinions, attitudes, behaviors, and needs in their real-world context. We conducted our research as part of a project led by the Centre of Digitalization in South Westphalia, aimed to support small and medium-sized enterprises (SMEs) in their digital transformation efforts, focusing on sustainability and a social-participatory approach. This project involved current care-students and future employees, empowering them to learn new technologies and act as digital pioneers within their companies. This concept was applied and involved four care-schools, five lecturers from four local nursing schools, and 22 care-students (Table I).

Table I. Overview of project participants.

care institute	GO 1	PS 2	PS 3	DS 4
facility management	FM1	FM2	FM3	FM4
lecturers	L1	L2	L3	L4
participants	P1	P7	P11	P17
	P2	P8	P12	P18
	P3	P9	P13	P19
	P4	P10	P14	P20
	P5		P15	P21
	P6		P16	P22
project focus	Robots in Skills Lab	Translation Agents	Smart Companion	App-based Concept

Our practice-based design fiction approach involved creating fictional narratives, prototypes, and scenarios to understand the social, cultural, economic, and technological contexts associated with the future of care and healthcare. This will provide a solid foundation for the design of care fiction in HCI research. In our case, we worked closely together with overall four care-schools in which we gave presentations about the potential of digital Technologies in care. The project's researchers played a key role as facilitators of digital worlds in the design of innovative care settings/critical role as facilitators in integrating virtual care into nursing practice.

Our task was to present digital nursing technologies, thus facilitating access for the participants and discussing concerns and questions in advance. A discreetly reserved attitude, but also the active participation of the researchers on site in the idea workshops, allowed the participants enough freedom to develop their own creative ideas and to design the scenarios in a scientifically sound and practical way.

In different workshops we discussed existing practices, organizational and social perspectives, and individual and social needs and challenges confronting care-students in their everyday life. We initiated a project and announced a “call for participation” for a project called “future of care – your ideas” together with the local district. In a second, iterative step, we designed and developed small prototypes together with the care-students to demonstrate the potential of available technologies within their outlined care fictions. We proceeded in this way in order to examine the potential of the system for all of the relevant stakeholders. In particular, and in keeping with a participatory design approach, we were keen to involve the care-students and their teachers as co-developers, drawing upon their different bodies of knowledge, interests, and aspirations as both the research and system evolved. There followed a short period of re-design and media production, where we created videos and storyboards, based on the insights arising from the main care fictions that was further discussed with the care-students and their teachers. Then, in a third and final step, we asked the care-students and their teachers to prepare a presentation that will be held in a official event with all participants, their relatives and local politicians.

3 Care Fiction Scenarios

3.1 First Scenario: Integration of Robots in Skills Lab for Care Institutions

Given increasing digitalization, it is essential to adapt and modify the training structures to current support needs in the care sector to fulfill the requirements of the digital age. Together with six care-students from two different courses of care training, the groups initiated the T-project under the qualified guidance of a teacher from the care institute *"GO1"*. The project's background was to create an innovation and exploration space for prospective nursing professionals to practically design and experience various technologies and assistance systems through active participation in skills training. This team created a future-proof concept for a Skills Lab in nursing education, focusing on two important application areas. The qualification concept for practice supervisors and trainees includes two modules that teach trainees basic skills for using technical support systems in patient care. While one module focuses on intercultural communication between patients and caregivers, the other concentrates on support for nursing care and counseling. In an on-site Skills Lab equipped with various technologies, such as tablets or smart-screens and by providing an educational platform, the team worked out possible fields of application in patient care, where robots like TEMI can support and relieve nursing staff in their daily routines. On this basis, the group developed and fictitiously implemented three scenarios for recording vital data tracks, digital pain analysis, and supporting employees in overcoming language barriers in intercultural communication. The group centered their ideas for potential application areas of the robot TEMI on nursing and counseling tasks before and after surgical procedures.

As a result of the workshops, the group developed a learning module for the digitally supported recording of pain in patients after operative treatment using the robot. Direct interactions primarily took place between the robot and the caregiver: to determine the pain level, the nurse asked the patient to categorize and rate their pain intensity on a scale from 1 to 10. Based on this value, the robot recommends to the nursing staff: *"Sensation of pain increased; please inform a doctor."*

In the second learning module developed during the workshops, the project group concentrated on the role of the robot TEMI as a "digital interpreter". These considerations aimed at reducing language barriers between nurses and patients and avoiding potential complications during upcoming surgeries that could result from failure to follow medical procedures. In two application scenarios, a verbal exchange of information was held in German-Croatian and German-Turkish in both directions, whereby we can use the robot's voice humanly or digitally. In this fictional scenario, TEMI assisted in the pre-operative counseling and care of foreign language patients by mediating in the explanation of food abstinence before surgery. In these hypothetical patient conversations that required robot translation, interactions were realized between the patient and TEMI and the nurse and the robot.

Overall, translation systems such as robot TEMI can help facilitate communication between patients and healthcare providers who do not speak the same language, improving the quality of care and patient outcomes. P1, for example, made clear how important it is to modernize the care sector by integrating robots: *"I am participating in the T-project to show that care can do much more than society can, that the robot could be a possibility in the future and I think because we are the new generation, we can make a good step in the right direction." (P1, GO1)*.

In order to consolidate the results, the project group produced a short film showcasing the designed modules for language and healthcare by using robotics in a Skills Lab Concept. In addition, the team currently works on a "train-the-trainer" draft application guide that will provide detailed information on the various scenarios for robots in care organizations and their competencies. In conclusion, integrating modules focusing on digitalization into modern educational infrastructures, such as Skills Labs, could improve the quality of care in the future and is essential to prepare and educate carers – especially those of the new generation – to use digital assistive systems and technologies.

3.2 Second Scenario: Robots as Intercultural Translation Agents

The project group of the *"PS2"* educational institute found a similar approach to address societal challenges related to cultural diversity and health care by incorporating their practice-based expertise in the field of care. As an outcome, the team created a future-oriented scenario using the robot NAO to encourage diversity in a multicultural and multilingual work environment in the care sector to reduce patient concerns and uncertainties. The team also noted that the timely provision of interpreters and translation programs is either difficult or often too complicated to use. In any case, the caregiver is usually parallel involved in nursing activities and services, and appropriate systems to support and relieve them are not immediately available. From the perspective of the project group, robotic systems such as NAO could expand cultural competencies in interaction and reduce differences, which could lead to greater involvement of relatives and patients in medical and nursing measures.

In the brainstorming phase of our workshop, the group jointly considered the basic requirements for a mobile robot as following:

- speaking all common languages (including relevant dialects and sign language)
- individual language settings for children and people with dementia to reach different target groups with different needs
- building trust with patients in nursing, as data protection is crucial for trustworthy care
- integration of existing nursing document management system with the robot system
- interface to medical documentation systems

The NAO robot was a suitable option in this fictional scenario because of its multiple uses, human-like behavior, and appearance.


Figure 1: The Nao robot act as a translator between patient and nurses

The team independently developed film sequences illustrating a fictitious patient case history, in which a new patient suffered from severe pain shortly before his surgery. The scene also illustrated that it could be challenging to establish successful contact with the patient in interactions between people from different cultures. Despite repeated inquiries by the nurse about his pain and speech, the patient did not respond verbally. As a result, the department head entered the patient's room with NAO as a mediator, who approached the patient: "*Hello, my name is NAO. I am happy to help you.*" The team considered using NAO to recognize and translate speech automatically through facial recognition technology and patient wristband scanning. Unlike the TEMI robot, NAO did not require additional manual input from staff during direct interaction and initial contact: interactions between NAO and the patient were initiated as soon as the speech was recognized, whereas TEMI required partial manual input from nurses. With the robot translator's help, the caregiver could administer the correct medication, e.g., to reduce pain. This group intended to enable quick and easy communication between all participants regarding interculturality. The increasing integration of digital technologies and services into routine nursing care could increase interest, as it shows that nursing care can be modern and innovative. The video's last scene showed the relevance and possibilities of robotics in nursing and illustrated the team's opinion that it can contribute to a contemporary and technology-oriented understanding and image of nursing: *"Our NAO has, for example, a translation function, can carry out small* *auxiliary work, [...], or do general work activities. It simply brings a good atmosphere to the stations; because of the presence of NAO, the external image of the hospital is quite different, positive, and is perceived more positively." (P7, PS2)*

3.3 Third Scenario: Smart Assistants for Navigation and Orientation in Social Infrastructures

Group three consisted of six trainees from the professional care school *"PS3"* and used a storyboard – a known UX method from HCI research (Briggs et al., 2012; Carroll, 2003) – in the form of a photo series for the narrative representation of their idea of TEMI as a guidance and companion robot in a hospital setting. The participants chose to use a visualized photo story in which the robot guides a 74-year-old man through the floors and corridors of a hospital to a diagnostic appointment and then to a doctor's room. The group's idea is to address social problems such as fears, worries, insecurities, disorientation, and the need for help through robotics.

In the imagined scenario, the employee informs the patient about his upcoming diagnostic examinations, but he cannot find the appropriate room without assistance. The background to the designed scenario is that several time-intensive specialist tasks often cannot be completed adequately and satisfactorily due to staff shortages and the associated time pressure, so the assistive robot should make it possible to create time capacities for basic nursing activities. This project group considers this situation problematic, as it could pose a risk to patients and nursing staff due to the stress level and the persistently high workload, which could negatively impact job satisfaction.

Figure 2: The story telling scenario in which Temi robot helps an older adult to find his way to the doctor

The project group's overview of the requirements that are of central importance in the scenarios includes aspects such as multilingualism, sensors for control at room change, automatic directional information, an information point for patient questions, automatic trips to the charging station or a medical technology department for error notifications and camera function.

The technical concept behind this idea is that the hospital staff instructs TEMI to pick up a patient, and the robot will navigate independently to the patient's room. The photo series features a patient who reaches orientation limits in unfamiliar settings. Taking medication also impairs his cognitive abilities, which leads to reduced physical and mental resilience. TEMI plays a central role in the photo story: after informing the patient about the appointment and upcoming examination, the patient initially seemed uncertain. Although the patient is skeptical about the robot, TEMI guides him to the doctor's room. Therefore, the nurse interacts with the tablet integrated into the robot. When the robot and the patient reach their destination, it navigates to the next station and returns to its base station at the nurse's office. At the same time, TEMI accompanies the patient every step of the way, giving him a sense of security and may alert employees if help is needed. While waiting for and with the patient, TEMI can suggest using the time for further interaction possibilities, such as entertainment applications or information concerning medical activities during waiting times. In this narrative, TEMI offers a card game to the patient. Both the game function for entertainment during waiting times and security-related requirements and aspects such as reliability or availability leads to a positive user experience at the end of this story that could reduce any reservations and inhibitions about new technologies.

3.4 Fourth Scenario: App-based Concept for More Time and Humanity

Intending to make care practice more humane, the *'DS4'*-group decided to use app-based care documentation to support the care process for older people and those in need of care. With the prototypical 'I-App' as a solution, caregivers and relatives would have essential information at a glance and could respond individually to the needs of the patients. In many cases, basic patient information is lacking, and transitions in care are not available or inadequate, leading to dissatisfaction among relatives. In order to counteract these conditions, caregivers could use the app to record biographical data about the patient, such as likes, dislikes, or interests. This feature would enable caregivers and relatives to specifically address the unique wants and requirements of the individual receiving care and adjust their daily routine accordingly. All involved caregivers and relatives could gain insight into, e.g., administered medications and upcoming therapies at any time, including therapeutic and medical treatments. In addition, individual patient progress and changes could be documented for targeted therapy adjustment. The group highlighted the recording function of individual support needs as an essential aspect of the I-App since it would allow caregivers or relatives to indicate what support is needed, such as personal hygiene, eating, or mobility. Special aids (e.g., accomplices or wheelchairs) could also be managed through it. This idea potentially has implications for all areas of healthcare. On the one hand, handling personal patient data could be improved; on the other hand, exchanging information between different care settings could be facilitated. A significant focus of the group is to strengthen the interdisciplinary collaboration among various care institutions to guarantee a complete and unified gathering of information because it would allow care facilities to ensure that all documentation is done consistently with high quality while saving time. In this context, the nursing staff could optimize the quality of care and work processes. As part of an expanding digitized care industry, the team aims to help improve the quality of care and staff workflows with this innovative and user-friendly solution.

4 Discussion, Conclusion and Outlook

While previous studies on design fiction have mainly used speculative designs and narratives without actual implementation or realization to generate new ideas and pathways into the future (Rüller et al., 2022; Ertl et al., 2019; RTD Conference et al., 2019), this paper opens the view to the connection of real worlds in the form of Skills Labs and practice-based scenarios as experiential spaces and fictional worlds. In doing so, we explored future pathways using different technologies and presented them in future narratives that tell positive "successful stories" (Hüer, 2020) to create opportunities for identification and provide positive outlooks on the future of care. With our work, we intend to advance the care discourse toward digitization and innovation by making an important contribution to the field of HCI with our study of care narratives based on the practice of design fiction. Three scenarios focus on using robots in specific roles (Skills Lab training, translation agents and smart assistants for navigation), while the fourth scenario (see 3.4) focuses on an app-based care concept. The first scenario (3.1) conclude that innovative learning approaches could play an important role as an essential link between science and nursing practice in Skills Labs. From the nursing educators point of view such projects offer numerous opportunities and learning possibilities: *"Particularly valuable is the learning effect that results from looking beyond the boundaries of one's discipline and gaining insight into the interface between nursing and technology." (P23)* This conclusion demonstrates the importance of considering the conditions and needs of care in different regions when developing visions for the future and encouraging collaboration between universities and care institutions. The second scenario (3.2) focuses on the cultural dimension (e.g., language diversity, interculturality) of health in the care sector. It was particularly important that patients from different cultural backgrounds receive better medical care and guidance tailored to their needs (e.g., food ingestion, medication) through the use of robots. Another important aspect was the insight that robotics in care could positively impact on patient access in an increasingly cross-cultural care environment.

The third scenario (3.3) elaborated on how technologies such as assistance robots could be a valuable aid in wayfinding, orientation, and accessing departments in social infrastructures (e.g., hospitals, care-facility). The three groups- who chose robots in the development process of care fiction- were able to gain valuable insights into how robotic systems such as TEMI or NAO can provide valuable support services while conveying a positive feeling and creating a pleasant atmosphere through their friendly demeanor. Group four (3.4) designed a prototype app as a digital solution. The finding shows how the app can improve communication between care providers and implement more individualized care plans and content. This tool can lead to patient-centered care and better coordination between professionals from nursing, medicine and psychotherapy. These four fictional scenarios demonstrate the potential of Care Fiction as a methodological framework that enabled participants in our study to think creatively and imaginatively across boundaries and develop new ideas. This can potentially shape the future of nursing and the reputation of care by combining narrative elements, design elements, and prototypical solutions. Care fiction can create a shared understanding of complex care challenges and explore innovative solutions that may not be immediately apparent in the current context by engaging stakeholders in the participatory development of narrative futures in the care sector. In this study, it became clear that co-designing care fiction can facilitate discussion and collaboration among stakeholders, as we used the combination of tangible artifacts and narrative elements to stimulate conversation, debate and problem solving in participatory workshops.

Furthermore, our empirical process offers a creative and imaginative approach to exploring potential care solutions, fostering discussions among participants, generating new insights, and addressing ethical and social considerations. Our paper demonstrates how technologies such as robots or apps can be used meaningfully to promote cross-nursing collaboration and individual and person-centered care.

Another finding shows that integrating and implementing such technologies must consider the individual needs and dignity of the groups of caregivers and patients involved from an ethical and privacy perspective to ensure successful implementation. Moral issues in transitioning to more contemporary care must be constantly challenged if respect, autonomy, and humane treatment of patients, families, and caregivers are to be ensured in the care sector.

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Social Robots in Care and Data Privacy – A European Perspective

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Abstract. Social Robots increasingly become a challenge for data privacy regulations within care facilities, as they are not prepared for robots that can scan their surroundings and possibly share this data in real-time. The needs of stakeholders to these emerging challenges must be analyzed to apply existing data privacy rules. We collected data from stakeholders through interviews (n=66), surveys (n=271), and workshops (n=39). The data was analyzed towards opinions of data privacy concerning robots in care facilities. Our findings have then been contrasted to existing data privacy regulations (GDPR) in Europe and show how the needs of the stakeholders towards such systems can be harmonized with the existing rules and what additional regulation is needed. This study enables a better understanding of the expectations and challenges of social robots regarding data privacy.

Introduction

With recent developments in social robotics, it is likely that such systems increasingly become prevalent in the care sector. Robots are seen as potentially supporting for caregivers or people in need of care (e.g., guiding physical and cognitive training, communicating information, companionship, and religion (see Coghlan et al. (2018); Helm et al. (2022); Trovato et al. (2021, 2018); Moharana et al. (2019); Carros et al. (2020, 2022a)). In all these applications, we argue, that ethical, legal, and social aspects must be considered in addition to questions of technical feasibility. A key challenge in this area is providing users with a solution that supports them and improves their well-being while at the same time ensuring data protection and privacy (Störzinger et al. (2020); Carros et al. (2022b)). This is important not only because the General Data Protection Regulation (GDPR) is a legal requirement in Europe, but also because it is required to be acceptable in care environments. This paper explores the attitudes of stakeholders (caregivers, insurances, older adults, doctors, and other professions surrounding the care sector) about the usage of social robots in care about data protection and privacy. We discuss the potential challenges posed by GDPR and, for this purpose, we analyzed qualitative and quantitative data (e.g., survey results, interviews, and field observations) obtained during the course of our work. The aim is to compare the present GDPR legislation to the elements identified by stakeholders about data protection and privacy that are necessary for effective and accepted robot use.

Context

Our study is located at the intersection of three research areas: 1) The increasing use of robots in the context of care; 2) research on users' attitudes towards privacy issues; and 3) the current legal framework and practical challenges of data protection.

Numerous concepts, projects, prototypes, and established solutions already exist in the field of robotics in the care setting. However, they are, for the most part yet to be fully established in the routine practices of caregivers. The spectrum of applications is diverse and ranges from commercial robots for logistical support to robots talking and playing with care recipients. Robots can not only assist in functional tasks such as bathing (e.g., Satoh et al. (2009)) or dementia care (e.g., Felzmann et al. (2015)) but also become social interaction partners (e.g., Aminuddin et al. (2016); Carros et al. (2023)). However, to integrate these potential solutions fully a legal base is needed. Within Europe, the regulation of GDPR is working as a legal frame. We identified some functions of robots in care settings that will make this legal implementation difficult and propose alternatives in the discussion.

Widespread concern has been expressed about privacy issues and the use of personal data (e.g., Lanchester (2017); Zuboff (2019); Landwehr et al. (2019)). In addition to well-known issues surrounding Facebook and other social media, there is some evidence that factors such as loyalty programs, trust in marketers, and other benefits influence people's decisions to share their data (Chanhoo Song and Chan Ik Park (2006); Fathi et al. (2013)). It has been shown that people are more willing to disclose information such as names and demographic information than, for example, financial information (Phelps et al. (2000)). Such concerns are also manifest in the context of healthcare (Abouelmehdi et al. (2017); Hathaliya and Tanwar (2020)), largely because of the enormous potential value of user data. This can also be observed in the care sector, research has shown that many have reservations about giving out personal data (e.g., Pickard and Swan (2014); Shen et al. (2019); Müller et al. (2010)).

Since May 2018, the General Data Protection Regulation (GDPR) has protected the fundamental rights and freedoms of natural persons and in particular their right to the protection of personal data in the European Union. Processing the personal data of robots in care contexts falls within the scope of the GDPR. Since robots in care contexts often require monitoring systems, particular attention must be paid to data protection and data security (Ethikrat (2020); BMFSFJ (2020)). From a legal perspective in Europe, the robot manufacturer as well as care institutions and operators are considered responsible parties and thus addressees of data protection obligations (Steinrötter (2020)). One example of such an obligation is voluntary and informed consent, which is central to the legal conformity and processing of personal data. Several challenges arise here in practice. For example, an "information overload" must be counteracted (Steinrötter (2020)). In addition to the question of whether informed consent is still possible at all or whether "information overload" can be reduced, lawyers have also questioned the balance between the personal rights of individuals and the potential benefits of big data—as well as the question of the extent to which individuals can make sovereign decisions about the use of their data (Marckmann (2020)).

Our study contributes to the ongoing research by uniting these topics and focusing on data protection and privacy for the use of robots in care contexts. We contrast the results from our empirical work with stakeholders of the care sector to the existing GDPR regulations and develop additions to the existing legislation to give suggestions on how the regulation should accommodate the use of care robots within this sensitive field.

Methods

The results presented in this paper are based on three types of data (interviews, statements in workshops, and a quantitative questionnaire). A mixed method approach was chosen (Schensul and LeCompte (2013)) to combine the data. The qualitative data in particular add insight and show the concrete opinions of the participants on topics regarding data protection in care robots. The quantitative data support these statements and show that the statements are supported by a larger group. None of the data sets are considered representative. The participants were thematically related and did not correspond to the cross-sections of society.

Data sources

The data shown in this paper were based on four different data sources: 1. Interviews 2. Questionnaire 3. Questions during workshop 4. Follow-up Survey. The interviews (Data source 1) were conducted with 66 stakeholders from the care sector. They were carried out in 2018, based on a project which was concerned with science communication. For this purpose, the robot Pepper (humanoid robot) and its care programs were presented to a broad public. This included the demonstration of the robot at fairs and events with the themes of care and IT. At these events, interested visitors were asked for an interview. Since the events were thematically focused on care, most interviewees were employed in this sector or otherwise had some connection to it. Interviews typically lasted for 20-30 minutes. The questionnaire (Data source 2) with 250 persons was administered at the same events but who preferred to fill out a questionnaire.

Then we asked questions about privacy and related matters during workshops (Data source 3), all concerned with care robotics. The participants (39) came from two different backgrounds, comprising both older adults and upper-school students.

The participants were not employed in the sector, but they did have prior knowledge of the topic through personal experience. Lastly, we did a follow-up survey (Data source 4) with the same participants and received 21 responses.

During interviews and workshops, all participants were confronted with social robots and their potential application. They were able to experience the robots in action or touch them and could ask researchers questions about them and their field of application.

Procedure of Data Analysis

All interviews were transcribed and analyzed using reflexive thematic analysis (Braun et al. (2018)). The transcripts were processed with MaxQDA and the categories were established deductively. The quantitative evaluation was carried out with the help of Excel. All statements that the participants made were categorized according to four major thematic fields: (1) Ideas and conceptions about the functions or the purposes of the robot; (2) Weighing the benefits of the robot against the privacy of the person concerned; (3) Informed consent; (4) Attribution of responsibility.

Results

Robot as Monitoring Tool

The first function of the robot mentioned by some interviewees was the monitoring of the residents in the care home. For example, P48 (Management, Care Company) saw the robot as a monitoring technology for the care workers: *"I can also imagine that they are on the move in living areas and that I, as a nurse, can look over the face or the camera when I am providing care in a room: are the residents still sitting in their chairs or has someone slipped down or something?"*. She was not alone with this opinion, P54 (Management, Care Company) classified the use of robots in nursing similarly: *"To cover safety topics, i.e., as a safety guard who makes rounds and checks whether everything is in order[...]"*. But, while this seems like a convenient use case, P18 (Family Member of Person in need of care) saw it differently and thought that the robot is: *"[...] Like a surveillance camera in the room, just different."*.

P46 (Quality Management, Care Company) could even imagine robots seeking help for the residents and reacting to voices or vibrations: *"[...] at least now there is this robot that fetches help. I mean, there are already these alarm buttons that call for help and things like that, but you just know that there is someone who has a sensor system that responds to a voice or really notices when someone falls or things like that."*

The ability to decide for oneself how much and to what extent a robot collects and stores data was important to the participants; P48 (Management, Care Company) mentioned that *"You also have to have the possibility to be unobserved."* In line with this statement, P49 (Accountant, Care Company) discussed the importance of default settings to ensure data protection, elaborating that *"[...] I* *would like to determine for myself in which time window and I would also like to determine for myself from when to when [...] It could also be that I am at risk of falling and say that I don't want to use the motion detector, thus accepting that I might fall and that I might not be found until a little later. So, I would like to have these possibilities."*

Trade-off between Benefit and Privacy

Several interviewees described data protection as an ambiguous issue that, on the one hand, is critical for protecting older adults' rights and data. However, it is difficult to put into practice. For instance, P15 (Employee, NGO in Care Sector) stated that *"How to cope with data storage is always an ambiguous problem. I believe you must weigh the benefits it brings."* Similar points were made by P24 (Employee, IT Company in Care Sector): *"I think we should be careful about security and data protection on the one hand. On the other hand, we should not let this stop us from actually doing something good for people."* P26 (Student of IT) agreed with these comments, adding that *"[...] it's a balancing act between wanting to offer people more services or saying, okay, there are a lot of possibilities where we could help you, but for that, we also need this information."*

The respondents thus weighed the benefits of the robot against the intrusion of privacy that they would represent for the person using it. In this consideration, it is important to note that the privacy of care home residents is already affected — whether by different caregivers, social service workers, or doctors, who tend to come into the rooms of the residents on very short notice without waiting for an answer when they knock on the door. In some cases, it may be less unpleasant for a person to ask a robot for assistance than to ask someone working in a care home. Accordingly, P16 (Neuroscientist) saw a great benefit in a robot's freedom of evaluation: *"I could even say that acceptance is even greater because of shame. So, let's say you feel yourself to be unaesthetic and ashamed. But if a robot is there, you might have less shame."*

The willingness to make data available (acceptance of data processing) is greater if the people concerned expect a great benefit. For instance, P54 (Management, Care Company) explains that the benefits of the robot can outweigh the disadvantages, especially in emergencies: *"[...] especially when it came to the health card in particular, there was a great willingness to store things, be it an X-ray or a medication plan, blood group, etc., so that information can be exchanged as quickly as possible. Especially when there are emergencies."*

At the workshop, almost all respondents thought that the purpose of health monitoring would justify the use of a robot, or that the purpose to be fulfilled was rated as more important than the invasion of privacy.

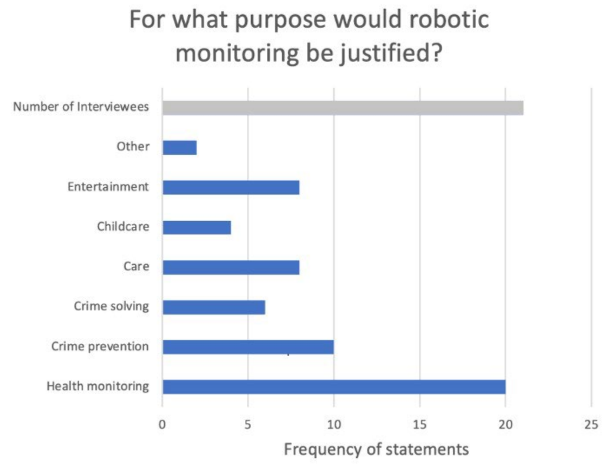

Figure 1: Justifications for monitoring. n=21.

Non-functional Acceptance Criteria

The interviewees saw additional requirements that needed to be fulfilled for social robots to be acceptable. They referred to data security, to the transfer of data, to the storage of data as well as to "privacy by design" aspects. These requirements do not fulfill a function in the sense of a purpose; rather, they represent prerequisites that, in the opinion of the respondents, ensure the robot can be used at all. P16 (Neuroscientist), for instance, felt that data security or the location of personal data storage plays an important role in connection with the use of robots: *"The moment a robot is connected to the network, the question is, all the things you entrust to the robot, how confidential is that? And does a clinic have any security at all [...] not that it is stored on Google, Facebook, and the like."*

Regarding data collection P47 (Management, Care Company) discussed the concept of privacy by design, explaining that *"You have to be able to say exactly up to here the robot is allowed to record, up to here the robot is allowed to search. In which cloud is it saved, the video, is it saved at all, that must be precisely documented and also adjustable. So that I can say myself, up to here and no further."* P49 (Accountant, Care Company) agreed with this statement: *"[...] As long as I can say, I don't want the robot now and it goes out and maybe it has a big button somewhere that you can also see [to switch off]".*

These statements show that robotic systems in care environments need to be transparent about the data they collect and the way they are stored, analyzed, and transmitted.

Discussion

The results showed that stakeholders view the robot as a useful tool for monitoring people in need of care or for making rounds at care homes to perform check-ups or answer questions. Further, the robot was seen as useful to assist residents and to call for help in case of an emergency. However, the interviewed also foresaw restrictions on the usage of robots, believing that there must be transparency regarding where any recorded data are being sent and that there must be an option to stop the recording of data at any time. This raises important questions about what data is to be recorded, how it is stored, and, above all, who has access to it. Nursing, after all -and whether it is institutional- involves several practitioners with varying degrees of medical knowledge and different kinds of organizational affiliation. Data may also, in some instances, be shared with 3rd parties such as kit suppliers or external medical facilities.

With the GDPR, data protection has been harmonized and adapted across Europe. This was intended to generate "solutions to questions raised by 'Big Data' and new techniques or types of data processing such as profiling, web tracking or cloud computing for the protection of privacy" (BMWI (2021)). The focus of this regulation is the "fundamental right to informational self-determination through greater transparency and more co-determination of citizens with regard to their data" (BMWI (2021)). Through this, an important step has been taken to better protect the fundamental rights of those affected. Since nearly every use of social robots in a care context requires the processing of personal data, the GDPR also applies in these cases. In the following sections, we discuss the results and contrast them to the current state of the law of GDPR. By doing so we show where the current regulations make the use of robotic systems difficult and derive some possible solutions to it.

Self-Determination - Trade-off between benefit and privacy

The usage of a robot in the care context was seen as a trade-off where less privacy is traded for a higher quality of care. Until now, care always involves some reduction of privacy since, even without technology, care workers are necessary and, by definition, their presence involves some intrusion on privacy. However, the problem with the use of robots is that, theoretically, the private information they are privy to could be easily shared with people with malicious intent. It is evidently the case that access rights will need to be managed in some way. Nevertheless, participants also discussed privacy advantages, including that some people might feel less shame being helped (e.g., going to the bathroom).

For care home residents it is often not transparent what data are collected and stored by social robots and for what function it is used. This applies not only to the use of robot technologies but currently to vast parts of the internet as well (Fiesler and Hallinan (2018)). Data protection itself is a sensitive, complex, and, above all, ambivalent issue in the use of social robots in the care sector. On the one hand, it is essential to protect and respect the rights of people in need of care. On the other hand, effective assistance for caregivers (and residents) through robot technologies (and tailored to individual needs and concrete situations) typically requires the processing of data. This data must usually be made accessible to a larger group of people, and their usefulness and potential misuse must be constantly monitored. As the results showed, the stakeholders in this field are aware of this trade-off and rely on legislation to ensure that it is not to their disadvantage.

Self-determination was significant for the stakeholders interviewed; self-determined action requires a certain degree of understanding. This is due to the fact that data processing is often non-transparent, and the user can be unaware or only superficially aware of it. In this respect, a pronounced digital competence is necessary for self-determination. Such competence is not strongly developed within the group of people in need of care. Although studies have shown that adaptation to new technology by this group has occurred faster than was previously assumed, the group nevertheless has a lower affinity for technology than the average in society Golant (2017). There are many reasons for this. One is that some may lack understanding about modern media technology Kim et al. (2016); Pang et al. (2021). That said, other factors also play a role, such as how and with whom they use the technology (e.g., Schwaninger et al. (2022)). In this respect, transparency of data processing is particularly important for this group. Technology providers, we argue, must ensure that their solution is transparent so that this group can- as far as possible- make an informed, self-determined decision.

However, the controller of the robot could also base data processing on permission other than consent. In such a case, the data subject would no longer be able to decide for himself whether the personal data should be processed. It is conceivable within the framework of legal bases for lawful processing, for example, for the legitimate interests, the fulfillment of a contract, or the protection of vital interests of the data subject to be used instead. It is questionable whether the processing is necessary in the first two cases and whether consent is not obtainable in the case of the protection of vital interests (according to Recital 46 GDPR).

In case a robot can process personal data offline more efficiently than, for example, one or more humans could, it can be discussed whether the use of the robot is desirable under the GDPR. It may be that the robot requires much less data to achieve the same result as a human. Or it may, conversely, require just as much data as a human, but can collect it much faster. Since one of the principles of the GDPR is data minimization (Art. 5 I lit. c GDPR), it could be argued that this principle indirectly dictates or requires the use of new technology (Meents (2020)).

Classification of Data

If the assumption that robots need less data than caregivers is true, this could lead to a more frequent use of legitimate interests (Art. 6 I lit. f GDPR) as an element of permission for the use of a digital care assistant by the data controller. This, in turn, would harm the self-determination wishes of the persons concerned.

If it is a matter of processing sensitive data, the choice of permissions is more limited for the controller (Art. 9 II GDPR) than if he/she/it wants to process general personal data, as Art. 6 of the GDPR no longer applies. An essential difference in Art. 6 of the GDPR is that it provides no possibility to base processing on legitimate interests or contract performance.

Since sensitive data are usually involved in the area of social robots in care (e.g., the body mass index can quickly be calculated from general data such as weight and height), the explicit consent of the data subject (Art. 9 II lit. a GDPR) should be considered an element of permission. There are other possible legal bases for lawful processing under Art. 9 of the GDPR, for example, the protection of vital interests (Art. 9 II lit. c GDPR). If the controller can also base the data processing on legal permission of Art. 9 II GDPR, the consent of the data subject is no longer necessary (or, in relation to Art. 9 II lit. c GDPR, the protection of vital interests may not even be possible), which would in turn run counter to the data subject's wishes for self-determination.

Here, an individualization of the classification of data, which is in the existing law not envisaged, could be conceivable. For one person, bank data are essentially in need of protection, while for another, data on lifestyle habits would be more important. Nevertheless, they are both considered general data and are not classified as sensitive data under the GDPR. It is conceivable that data subjects would be able to weigh the data being collected prior to processing regardless of whether the GDPR classifies the data as sensitive. For example, the controller could list all categories of data, and the data subject would mark the categories of data that he/she/it considers particularly worthy of protection. All unmarked data would be treated as general data, and all marked data would be treated as sensitive data (Loh (2020)). This individualization could influence the resulting possible permissions: all processing that relates to marked data requiring special protection that then requires authorization under Article 9 of the GDPR. If, however, the processing relates to general or unmarked data, a permissive element from Art. 6 of the GDPR is sufficient.

In this way, the person in need of care could increase their chance of making self-determined decisions by classifying general data as sensitive. This would influence the choice of permissions for the controller and increase the chance of (explicit) consent. This, in turn, would be at the expense of the information content since such a "data category upgrade" should only be possible if the data subject has a corresponding understanding of the facts and all the consequences involved in the decision (the same applies to "data category downgrade").

Conclusion

In the above, we have rehearsed the attitudes, beliefs, and preferences expressed by several stakeholders concerning data protection. Although the context we have discussed is a specific one, where GDPR regulation governs decision-making, the complexities we have discussed have much wider ramifications.

Transparent handling of the functions of social robots is essential in the event that these technologies are used. In our case, the federal government, as well as the Council of the European Union and the European Parliament in addition to the subsequent data controllers who must comply with the provisions of GDPR, bear great responsibility for defining the concrete framework conditions for using these technologies. In any case, a significant number of issues need to be resolved if robotic care is ever to be widespread, as other researchers also have recognized (e.g., Papadopoulos et al. (2020); Schwaninger (2020); Marchetti et al. (2022); Maibaum et al. (2022)). A wide range of professional, institutional, family, and personal interests need to be managed so that clear lines of right and responsibility can be drawn. These interests start with manufacturers and distributors, extend through institutional responsibilities, through to medical interventions and the attendant roles, down to routine caregiving and the rights of individuals and their families. Policy decisions in terms of how these complex rights and responsibilities are to be managed are, yet not fully understood and yet will have important consequences for the emerging robotic technology. What matters need to be made clear to the individual user and, above all, to the people in need of care, how what data are collected and stored as well as when, how, and for what purpose, are all yet to be managed.

Furthermore, the older people who come into contact with the robot must be informed in simple language of what data are processed in this context and what they are used for. They should be given the choice of whether to consent and if they would classify the processed personal data as general or sensitive. At the same time, they should be given the option of deciding for themselves when and under what conditions a more data-saving variant of data processing should be used. Furthermore, both the controller and the manufacturers of the robots should be held responsible for complying with the privacy by design requirements of the GDPR.

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Preparing for Implementing Commercial Algorithms in Radiology; A Formative Evaluation Study.

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Abstract. The aim of the paper is to contribute with an understanding of the empirical preparation necessary for adopting and scaling AI solutions in clinical radiology. We do this by asking the following research questions; How is the organization preparing for implementing CE marked algorithms? How to establish acceptance among the radiologist when implementing commercially available AI solutions for radiology? Our empirical case is the procurement and preparation of implementing AI solutions for radiology in a Norwegian health trust. We have used a formative evaluation approach and followed the procurement and pre-implementation process from it started in autumn 2020.

Introduction

Artificial intelligence (AI) is developing rapidly and for radiology, it has the potential to handle an ever-increasing volume of imaging examinations and thus be a countermeasure against the increased lack of human radiological resources. AI is expected to cause large changes in clinical work practices and support radiologists by suggesting diagnoses and increasing the likelihood of earlier detection of problems (Silsand et al., 2023; Van Leeuwen et al., 2021). In high-tech radiology practices, AI can be used to plan examinations, in example to correct position of body parts to be examined; to prioritise tasks according to severity; or to perform time-consuming and repetitive tasks like processing images (Syed and Zoga, 2018).

Despite many studies showing how AI technologies for radiology can have certain benefits, very few commercially available AI solutions have made their way into actual use (Van Leeuwen et al., 2021; Strohm et al., 2020. Existing studies have largely blamed this on technology, while organizational aspects have been overlooked (Strohm et al., 2020). Among the most prominent hindering factors is the uncertain added value for clinical practice, which causes low acceptance of AI applications among adopters and complicates the mobilization of funds to acquire AI applications.

The market for AI software in radiology is growing and there are over 180 CE-marked products commercially available. CE-marking implies that AI is classified as a medical device and therefore must be CE-marked before it is allowed on the European market (Van Leeuwen et al., 2021). This means that it meets the essential requirements of the relevant directives and that it may legally be placed on the market freely throughout European member states (Harvey, 2019). The rapid increase in the number of commercially available algorithms and the variety of ways in which each algorithm can affect clinical workflows adds complexity to the AI procurement and implementation processes (Van Leeuwen et al., 2021, Strohm et al., 2020). This has led to a rise in marketplaces for AI software in radiology, which aim to offer multiple AI software on one platform (Ibid). Nevertheless, currently, CE-markings are granted without requiring proof of performance and added benefit for clinical practice. Previous studies have identified lacking acceptance as one of the most important causes for non-adoption and thus a barrier to the successful implementation of AI applications in radiology. A facilitator for adoption is the importance of clinician understanding of and trust in AI systems (Ibid). To increase the acceptance of commercial AI applications among adopters, more evidence of the added values of the applications in the clinical setting is needed. There is a need for more real-world research, which requires a shift from measuring technical accuracy to evaluating the impact on processes and people to overcome the resistance to implementing and adopting commercially available AI solutions in clinical operations (Ibid).

Based on this introduction, we ask the following research questions: How is the organization preparing for implementing CE-marked algorithms? How to establish acceptance among the radiologist when implementing commercially available AI solutions for radiology?

Our empirical case is the procurement and preparation of implementing AI solutions for radiology in a Norwegian health trust. The project procurement lasted from 2020 -2022 and the HealthTrust is now in the pre-implementation phase. The first algorithm is set to go-live in June 2023. We have used a formative evaluation approach and followed the procurement and pre-implementation process from it started in autumn 2020. We have used the Non-adoption, Abandonment, and challenges to Scale-up, Spread, and Sustainability (NASSS) framework to outline the complexities related to different aspects of the empirical process. In addition, we draw on the information infrastructure (II) literature (Hanseth and Monteiro, 1998; Hanseth and Lyytinen, 2010), where systems in an II are never seen as standalone entities. Algorithms must also be integrated in the existing II, comprising other information systems and embedded in conventions and practices (Hanseth and Monteiro, 1998). The aim of the paper is to contribute with an understanding of the empirical preparation necessary for adopting and scaling AI solutions in clinical radiology.

Background procuring AI solutions.

In Norway, almost non commercialized AI solutions have been implemented in clinical practice. This led to a national initiative coordinated by the Norwegian Directorate of Health (NDH), addressing the need for acquiring and implementing such solutions (Directorate of e-health, 2022). In relation to the national initiative, the HealthTrust's project gradually emerged as a national pilot for procuring and implementing commercial AI solutions for radiology. The motivation for the Health Trust is related to a steady increase in labour-intensive imaging examinations, estimated at 5–10% per year. The HealthTrust was given a budget of 1.7 MNK by the regional health authority and was expected to use internal human resources. Given its role as a national pilot, NDH commissioned the Norwegian Centre for e-health research (NCE), as an external research institution, to conduct a formative evaluation research study of the procurement and implementation process to identify and explore challenges and benefits of procuring and implementation project. The formative evaluation study is funded by NCE.

The HealthTrust started their process in early 2020. First, by 'scanning' the AI marked, mapping the needs of the radiologists, and then starting the procurement process. The procurement was aligned with EU regulations for public tender acquisitions conforming to the principles of competitive dialogues. During the procurement process, the HealthTrust project changed their plan of procuring 4-5 single algorithms to procuring a platform resembling an App-store. In August 2022 the procurement process was finalized, and a contract was signed with one of four vendors.

The HealthTrust defined three broad requirements for the AI solutions. First, they wanted to procure commercially developed CE-marked solutions already used in European clinical practices to limit the need for local validation of the algorithms. Second, they were going to acquire static CE-marked AI solutions that cannot be trained on local data – a of the shelf product easy to implement. Third, the AI solution should not operate autonomously but assist the radiologists. In addition, three modalities were highlighted as important for improving the radiologists' workflow I) CT thorax for lung nodules, pulmonary embolism, and lung metastases, II) MR caput for multiple sclerosis (MS) follow-up, and III) Conventional X-ray for skeletal X-ray and chest X-ray.

Theory

We use the EU's expert group's definition of AI: "Artificially intelligent systems perform actions, physically or digitally, based on interpretation and processing structured or unstructured data, for the purpose of achieving a given goal. As part of an AI system, specialized algorithms operate on specific datasets, i.e., an algorithm takes the dataset as input and produces some output, specifically, a classification". The algorithms may also have machine learning (ML) abilities that enable them to learn from previous actions, which means that they can change behavior (Directorate of e-health, 2022).

AI and ML are associated with an uncertainty that requires engagement from users to ensure that the algorithms adapt in a useful direction and conform seamlessly to the sociotechnical configuration in radiology departments (Silsand et al., 2023). It is established evidence that differences in the context in which technology is embedded are associated with changes in performance. The impact of technology will thus change with time, as the way it "fits", an organizational network changes (Strohm et al., 2020). Conceptually, we draw on the information infrastructure (II) literature to account for the size and scope of the socio-technical system, see for instance (Hanseth and Monteiro, 1998; Hanseth and Lyytinen, 2010). This concept has been frequently used for analyzing the implementation and use of large-scale socio-technical information systems [(Ibid). In healthcare, an II consists of a range of systems, health professionals, institutions, and established practices, i.e., the installed base that evolves gradually over time, and possibly in many directions (Hanseth and Monteiro, 1998; Strohm, 2020).

IIs develop through extending and improving the installed base, meaning that the existing infrastructure influences the design of new components and systems (Hanset and Lyytinen, 2010). However, CE-marked AI solutions cannot be changed, in terms of adding new data to improve the algorithm. Therefore, implementing such AI solutions requires changes in the installed base, which not influence the design of the AI component. When changing an installed base, it is essential to design the new version for usefulness and build upon the existing infrastructure (Ibid). According to Design Theories and Principles, new systems should deliver immediate benefits to users and gain momentum by being adopted by as many users as possible while incorporating new functionality only when required and supported by a sufficiently large user-base (Ibid).

Previous research has demonstrated that implementing healthcare technology is complex, and successful implementations for one organization can be a total failure in another setting (Greenhalgh, et al., 2017). However, the technology is only responsible for 20% of AI implementation failure, the rest of the complications are directly linked to the lack of socio-technical considerations (Lebcir et al., 2021). To map the socio technical complexities of the installed base and the evolving II, we lean on the NASSS framework (Greenhalgh et al, 2017). The framework is designed to guide and evaluate success and failure in technology implementations in healthcare organisations in addition to evaluating the complexity in a project. It includes seven categories that we use to define the socio-technical concept; the condition, the technology, different aspects of values, user adaption, organizational relations, the wider context the solutions interact in and adaption and embedding over time (Ibid). The categories provide an overview of the socio technical areas influencing the implementation process. By mapping these categories in different stages of the procurement and implementation, it is possible to understand how the socio-technical interplay influences the installed base and the II as a whole.

Method

The HealthTrust is one of the largest health trusts in Norway, located in south-east of Norway with about 10 000 employees and the responsibility of providing specialist healthcare services for about half a million people. It includes four different hospitals where the imaging department is organized as one department with branches across all of them. In 2019, the department performed approximately 50,000 CT examinations, 17 500 MRI examinations, and 155 000 X-ray exams.

This research project is inspired by the formative evaluation approach, which can help navigate the associated complexities by capturing the perceptions of the stakeholders involved and feeding findings back to program management (Cresswell et al., 2020). The research team has monitored the HealthTrust's empirical process from it started and to date (the research project continues throughout 2023). This has given us a thorough understanding of the facilitating and hindering factors of the process. The research team from NCE represents a neutral and independent party without business interests in the HealthTrust's project. The **data collection** has taken place in collaboration with the HealthTrust over a two and a half-year period. It consists of 27 semi-structured interviews of stakeholders and clinicians collected at two points, 26 meetings with the project group, 15 observations in meetings with vendors (50 hours), minutes, and document studies. The interview guide is based on the NASSS-cat tool (Greenhalgh et al., 2017) and tailored to our empirical case. Each interview lasted for 30-60 minutes and were recorded and transcribed verbatim.

By using the NASSS framework, it helped us to establish an overview of the interactions between the socio-technical domains over time and to untangle the complexities. We also used NASSS to categorize data from the interviews. The further **analysis** followed the hermeneutic approach informed by II theory, in where all the collected data was included to get an overall understand of the complex process (Hanseth and Monteiro, 1998; Hanseth and Lyytinen, 2010; Klein and Myers,1999).

Results

After starting out relatively modestly – with the requirements for a few algorithms, the project gradually scaled in ambition, purpose, and outlook. The organization needed to make several strategic choices in preparation for adopting the CE-marked algorithms.

A platform solution - Increasing flexibility and complexity.

Today the IT infrastructure at the radiology department consists of the electronic health record (EHR) system, the Picture Archiving and Communication System (PACS), the Radiology Information System (RIS), in addition to the medical imaging modalities e.g., Magnetic Resonance Imaging (MRI). The IT infrastructure is complex as of today and adding new technologies demanding smooth integrations can be challenging. Procuring a marketplace solution is expected to generate flexibility for the HealthTrust since it provides access to a number of algorithms through a single point of integration (see figure I.)

If the HealthTrust does not get the desired benefits of using an algorithm, then it can easily be replaced with another algorithm without having to undergo new procurement processes. The marketplace solution with its algorithms is supposed to work in the background without any user interaction. It is a cloud-based solution that will receive images from examinations, check these for findings, and report the findings back to the work list in RIS - where the algorithm can prioritize the various findings and mark the findings in the images in PACS.

However, it is not clear if the findings in the images will be presented within PACS or presented in an extended view – a widget. Then the question is, will each algorithm need to have its own widget? (See figure I).

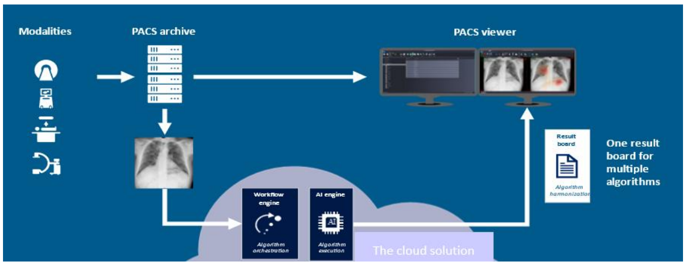

Figure 1. The integrated solution

The radiologists explained their concern:

> "We have to test the algorithm to find out how many extra clicks it will take to use it, how much time do we use or save by using it" (Radiologist II).

Even if the marketplace approach addresses flexibility related to the number of algorithms to access, it also addresses questions of complexity when it comes to integrating the findings generated from different algorithms into the clinical work processes. A radiologist stated:

> "No application can cover the whole patient, so if you really want an effect you may have to use three or four applications in addition to RIS/PACS. If they all have different interfaces, do you have to switch between them or does the marketplace solution solve that problem" (Radiologist VI)

CE-marked algorithms need local validation.

Another expected goal of procuring an AI platform offering CE-marked algorithms was that these solutions are ready for clinical use and should be easy to adopt in local clinical work processes. However, the CE-marking is generic and does not say anything about the overall quality of the product and the performance cannot be fully predicted in advance. Some of the algorithms have a well-documented clinical effect and provided benefits for the organization but most of the algorithms lack documentation about whether it works as intended in different contexts. The HealthTrust's project group analysed the documentation of the algorithms they wanted to procure. The documentation was more or less insufficient, in terms of which data was used to develop and test the algorithms, no description of the use cases or context of where the algorithms were deployed and how they were integrated into the local workflows (Van Leuween et al., 2020).

So even if they had bought CE-marked algorithms, the HealthTrust plans for an extensive local validation process (prospective and retrospective) to document how the algorithms function on the images from their patient population before using them in clinical operations. From the interviews, the radiologists emphasised that it was difficult to trust algorithms that had not been validated on data from their own patient population. The need for local validation is necessary to build trust in AI among clinicians.

> "If an algorithm is trained on one specific population, it is challenging to use it on other populations with a good result. This we need to know before implementing and trusting it". (Radiologist VI).

Moving the algorithm from one contextual infrastructure to another is challenging due to the risk of extensive differences in the patient populations, but also differences in the medical imaging equipment that provided the data when developing the algorithm compared to the equipment where the algorithm will be used. This also includes differences in how the images are taken (the protocol), which is the work of radiographers. Hence trusting the algorithms address the need for both validating the algorithm on local data and also in local work processes.

Choosing the first AI algorithm to implement

When preparing for implementation, the HealthTrust's project management decided to start with an application called "Bone View". This app was not one of the most wanted solutions pointed out by the radiologists in the beginning of the project. However, there were several arguments for starting with this application, First, the application is one of the few apps that is taken into use in large-scale in other countries (200 hospitals in 12 countries). Second, the algorithm is documented to be clinical accurate in sorting the images in positive, doubt and negative findings. The application can be used as a preliminary tool meaning that the final approval and confirmation still need to be done by the radiologists. However, the radiologists were sceptical to start with this application because bone fractures were not one of the areas they had pointed out as important for reducing their workload. In the interviews, a radiologist said:

> "The area where the first AI algorithm will assist us is not where we really have problems. Assessing x-ray fractures is a very small part of our workday and it does not take much time."

However, the clinicians are not negative to integrate new technology into their work practice but are unsure if this algorithm is the right means to solve their challenges. The scepticism is underlined by a statement from the interviews:

> "This is very new and the scepsis is high. Many radiologists don't really see how a few algorithms can be used to improve the clinical work processes." (Radiologist VII.)

Overall, the radiologists defined themselves as cautious optimists and one said; "I don't believe the effect of the algorithms will be that huge. Still, every small step ahead helps, and small pieces turn into a puzzle by the end."

Concluding Discussion

Implementing CE-marked algorithms – preparing the use case

In II theory the challenges of implementing new technology to an existing II is a dilemma that often is addressed (Hanseth and Monteiro, 1998; Hanseth and Lyytinen, 2010). For such implementation to succeed, it usually is necessary to change and adjust the technology to fit the existing installed base (workflow) in healthcare. Another alternative is that the installed base and the technology need to be adapted together. When it comes to implementing CE-marked algorithms, the preconditions are slightly different. CE-marking implicitly means that the algorithm cannot be changed. If changes to the algorithm are made, the CE-marking is no longer valid. Therefore, tailoring CE-marked AI applications to the II must be done at the organizational level, the installed base needs to change. This is contrary to the principle of a successful socio-technical implementation.

In addition, different organizations might decide to use an AI application in different ways. Some organizations may choose to run the "Bone View app" in the emergency rooms as an autonomous solution. Then the AI makes decisions without radiologists involved. If the AI-result is negative, then the patients can be sent home without further examination of a physician. In other organizations, e.g., remote radiology departments, the AI solution may be implemented as an assistant to radiologists or to physicians. While others organization may choose that the "Bone

View app" makes the first assessment of an image and then a radiologist do the second and final assessment before the finding is presented in PACS/RIS.

Accordingly, there are numerous ways to implement the same algorithm in an existing installed base, and each organization need to define its use case. Therefore, preparing the organization for implementing CE-marked algorithms is about describing the use case and how an app should function in a workflow. Formative evaluation approaches can support organizations in such change processes (Greenhalgh et al., 2017).

Indeed, there is a risk that the use cases are so different that it is difficult to identify overall values and effects for the HealthTrust. However, formative evaluations make it possible to outline the socio-technical values, and facilitating/hindering factors (Greenhalgh et al, 2017). Previous studies shows that formative evaluations make it possible to identify facilitating factors that makes the II evolve and identify values for different actors affected by the implementation. Formative evaluations can also reveal unexpected values, not defined in advance of the implementation but still of importance to the organization (Severinsen et al., 2022). In this case, the target group is the radiologists, but the implementation of the "Bone View app" is described to support a smaller part of their diagnostic work.

> "It is not the fracturs that breaks us. So, the workload comes from other heavy examinations, like cancer investigations" (Radiologist VIII).

However, when looking at the evolving II in total, there are several actors to include when defining values of a technology implementation. "I think that starting with the bone fracture app is sensible to do, but then you have changed the objective from what you wanted early in the project" (Radiologist I). In this case, the HealthTrust project's management starts using a 'simple' algorithm that is not too complicated to integrate with the installed base, is expected to generate value for the HealthTrust, however, not really solve the main issues for radiologists (Hanseth and Lyytinen, 2010). Overall, the implementation will generate important knowledge and competence for the next and more complex applications to integrate.

One way forward; start using AI algorithms.

To ensure that a technology like an algorithm fits with the installed base, there is only one way to actually do it; start using it. The discussions about promises of AI solutions has been ongoing for years. Healthcare organizations are evolving infrastructures and it is important to define and redefine the values alongside the growing II (Greenhalgh et al., 2017; Hanseth and Lyytinen, 2010). Procuring and implementing CE-marked algorithms is a learning and maturity process. In this case it several hindering factors to address and solve along the way to rich the starting point of implementation. This process has improved the HelathTrust's digital maturity. In addition, the hindering factors must be solved in the context where they belong, it is hard work demanding for collaboration among the actors and stakeholders – and is not to be solved in academia.

However, the HealthTrust took the chance of starting the procurement and implementing CE-marked algorithms for radiology to be able to make such maturity improvements. By implementing one algorithm at first, the HealthTrust learns and stays in the "drivers-seat" for making CE-marked algorithms part of their II. This provides important knowledge to enable scaling the use of AI solutions in the future. Sorting out the facilitating and hindering factors from the first implementation process, will support the next deployment of an AI app into the II (Greenhalgh et al., 2017; Hanseth and Lyytinen, 2010).

This empirical study describes the preparations necessary to start using CE-marked algorithms. The study shows the importance of validation to gain radiologists' trust in AI solutions. Moreover, this also addresses the need for sharing the results from local validation processes, as well as sharing the socio-technical considerations and changes made when implementing and adopting AI solutions. Validation and sharing of results from local validation processes are key factors to establish acceptance and trust among the radiologist when implementing commercially available AI solutions for radiology. In addition, then scaling and sustainability of the clinical use of AI becomes possible.

"When looking 10 years ahead I am pretty sure that a lot of radiology examinations will be more or less fully automated without radiologist involvement unless there are diagnostic doubts" (Radiologist VIII).

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Smartorials – A Smart-Glass-Based Infrastructure for Knowledge Transfer in the Health Sector

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Abstract. Knowledge transfer plays an important role but is still a challenge in the healthcare sector. In the past, the use of video tutorials has been explored to support knowledge transfer. However, the question of how to efficiently record video tutorials remains. With *smartorials*, we describe a smart-glass-based video-recording-system which represents a low-threshold way to integrate knowledge transfer into existing infrastructures. In this paper, we describe the system and present results of an exploratory study that focused on the preparation process of video tutorials. An interactive design process was utilized to develop the so-called *preparation form*, which incorporates best practices from the literature and aims to better prepare caregivers for video recording. An exploratory study involving caregivers was conducted to evaluate the efficiency and effectiveness of the *preparation form*. The study measures the time required to create video tutorials and analyzes their content quality. Results show that using the *preparation form* reduces the time required to create video tutorials, ensures sufficient content quality, and is a simple method that can be easily integrated into the daily work of caregivers. These findings suggest that *smartorials* including the *preparation form* can be an effective tool for improving knowledge transfer in daily work environments.

Introduction

Knowledge transfer has become increasingly important in various areas due to an ongoing change and restructuring in many workplaces (Dalkir 2017). When looking at the healthcare sector, knowledge transfer plays an important role to provide the best possible care to patients. Due to technological limitations in care work infrastructures, accessing knowledge about good work practices is not always easy (Rolls et al. 2020). Consequently, it is important to offer knowledge transfer tools that can be integrated into the daily work routine. In the past, video tutorials have been proposed as a solution to support knowledge transfer in healthcare (Forbes et al. 2016). However, new challenges become apparent with creating video tutorials: It can be stressful for the caregivers to authentically reflect their knowledge and skills in a video. Work activities are usually performed routinely, so presenting the work verbally and visually might be a challenge for the caregivers. Here we present the *smartorials*[1] system that provides support for this knowledge transfer and its challenges: It provides a smart-glass-based infrastructure for creating, exchanging, and viewing video tutorials efficiently during the daily work routine as well as a short *preparation form* that allows caregivers to prepare for the video shoot in a short time. In the following, we present an exploratory study on supporting caregivers to plan and create video tutorials in a short time using *smartorials* including its *preparation form*.

Related Work

The importance of knowledge transfer in healthcare is increasing, but there are several obstacles that hinder effective knowledge sharing (Almansoori et al. 2021). One of these obstacles is the time factor. Due to the lack of time among healthcare employees, knowledge transfer and its practical methods are often considered too time-consuming (Karamitri et al. 2017). In addition to time factor, non-existent or insufficient technology is often a reason for inadequate knowledge transfer (Dalkir 2017), also in the healthcare sector (Sheng et al. 2013). One reason for a failed technological solution is often the lack of user involvement. The technological solutions are often developed around everyday work instead of integrating them into the everyday work (Karamitri et al. 2017; Morr und Subercaze 2010).
Numerous studies have demonstrated that video tutorials can be an efficient tool for knowledge transfer in various domains (van der Meij und van der Meij 2014; Worlitz et al. 2018), including healthcare (Forbes et al. 2016; Sharma et al. 2021). However, there are fundamental challenges in the use of video tutorials in healthcare: First, the creation of video tutorials is very time-consuming, and second, it results in a natural selection of work processes: Activities that can be well reflected by video tutorials are not yet represented due to the production effort and costs (Forbes et al. 2016). This results in a trade-off between the effort required to create a video tutorial and its potential benefits. In the following section, we will provide an overview of the findings from previous work on producing video tutorials efficiently and highlight the criteria that can be used to evaluate the accuracy and comprehensiveness of their content.

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[1] Abbreviation for “smart-glasses tutorials”

One of the main challenges of creating a video tutorial is the preparation required before filming. While professionals are familiar with the tasks that should be explained in the video tutorial, they often lack experience in structured verbalizing the work activities in video tutorials. To address this challenge, Weeks and Davis conducted a literature review to identify best practices for planning and creating successful video tutorials (Weeks und Davis 2017). One important requirement is the creation of a script, which should contain both instructions and the content of the video tutorial (Weeks und Davis 2017). Norman mentioned that a detailed script can be quite time-saving of the overall process; however, creating a script is still very time-consuming (Norman 2017). Weeks and Davis found that defining the goal, narrowing the target audience, and creating a script were particularly helpful in creating a successful video tutorial (Weeks und Davis 2017). The authors emphasize that the script should only include essential content. Regarding length of videos, Weeks and Davis recommend to divide video tutorials over two minutes into segments (Weeks und Davis 2017).

Smartorials as Infrastructure for Knowledge Transfer

Here we present the *smartorials* system, which we consider as a prototype of a smart glasses-based infrastructure for knowledge transfer.

Concept

With *smartorials* users can wear smart glasses during their work and record videos to document knowledge or watch videos to retrieve knowledge. *Smartorials* hereby refers not to a single pair of glasses but rather to the complete knowledge infrastructure which contains also cloud-service to exchange videos and a web application that can be used to modify the content of videos. Each video is recorded in multiple user-defined segments. The segmentation is used for editing videos later on or for playing only a subset of segments of a video.

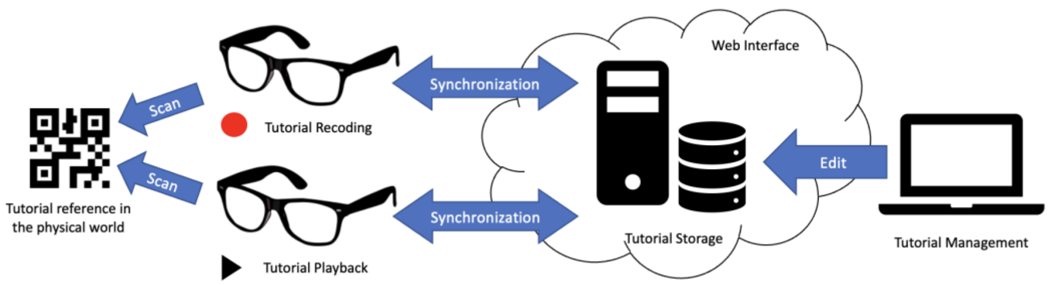


Figure 1 – Concept of the smartorials infrastructure

The concept of the infrastructure is shown in Figure 1. Video tutorials are stored on a server and automatically synchronized with all connected smart glasses. In the real world, a reference to video tutorials is created by printing quick response (QR) codes that contain an identifier (ID). This ID represents hereby a particular task at a specific location. When scanning a QR code, users can either record a new video or watch a video, if a video for the specific ID was already created. In a web-based tutorial management application, videos can be modified in a way that videos can be cut, segments can be created or changed and the sequence of segments within a video can be changed. Furthermore, the assignment of videos to QR codes be changed and new QR codes can be generated.

Implementation

Our current prototype implementation contains the smart-glass-based application as well as the tutorial management software, as first step into the web-based infrastructure. However, videos are not yet automatically synchronized with the server. For implementing the smart-glass application we used the smart glasses "Vuzix Blade Upgraded Version" („Vuzix Blade® Upgraded Version" o. J.) that runs Android as operating system, so the mobile application for the glasses was natively developed in Android. The server software as well the web application follows a microservice architecture, using Docker („Docker" o. J.) with Kubernetes („Kubernetes" o. J.) for the orchestration of the microservices.

User Interaction with the *Smartorials* Glasses

Users can interact with the *smartorials* glasses using the head gestures that have been presented earlier by Prilla et al. (2019). The gestures are shown in Figure 2.

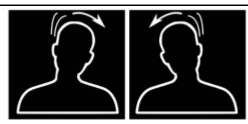
Gesture			
Description	Nodding	Tilting to the side	Shaking head
Usage	Selecting, Approving	Navigation: Switching active button to left/right	Opening menu, pausing video (create segment)

Figure 2 – Head gestures for the interaction with the smartorials glasses. Image is an edited version of the image presented in (Prilla et al. 2019).

While the gestures are used to navigate through the application, scanning a QR code is the initial user interaction: when starting the application, a QR code reader is shown and a QR code with a specific tutorial ID has to be scanned.
If the ID has no video assigned, the user can select to record a video by nodding. During recording, users can shake their head to pause the video, which also automatically creates a new segment. The system determines the start of the head gesture so that the time span of the gesture itself is cut from the video recording. The user then can decide whether to continue recoding the video (which creates a new segment), to re-record the last segment, or to finish and save the video.

If a specific ID contains already a link to a video, users are asked if they want to record a new video or if they want to play the existing video. In the playback mode users can play, pause and stop the video or navigate through segments. The user interface follows the common interaction patterns of media players here.

The Preparation Form — How to Support People to Plan the Tutorial Recording?

The preparation form was motivated and informed by the results of a prior evaluation. This section summarizes this previous evaluation, describes how the form was developed based on the results and presents the preparation form.

Experiences from the Evaluation without Preparation Form

In the first iteration of the project, the prototype of *smartorials* was evaluated in the field of nursing within three realistic use cases: placing medications according to a medication schedule, patient transport with the help of a lift from a bed to a wheelchair, and tracheal cannula exchange.
In this evaluation, several video tutorials for each use case were recorded by caregivers. From the video tutorials of a use case, a "best case" was then cut together manually with the help of an editing program. This procedure took several hours for recording a single video tutorial. The recorded video tutorials in the field of nursing were on average 9:48 minutes long. The videos were divided into segments. Afterward, the tutorials were tested with untrained employees followed by interviewing the participants about their experience.
Overall, the feedback from the participants about *smartorials* was mostly positive. Learning unfamiliar work activities was very helpful through the video tutorials. Additionally, the hands-free aspect of the smart glasses was noted as a particularly beneficial feature. However, there were several issues regarding the recording of the videos. First, the experts had no experience creating and recording video tutorials. Therefore, the participants who created video tutorials mostly lacked a clear structure of which aspects should be shown in each use case and which should be excluded. As a result, the recording of the video tutorials was quite time-consuming, with an average of almost a whole working day required for each video. In one of the evaluations for a use case, the preparation alone took more than three hours until the first recording. Feedback from some caregivers indicated that preparing for a video recording was challenging: *"We had also needed a lot of time in preparation, too."* On the one hand, the lack of structure in the preparation asked for a lot of creative space, but on the other hand, this also led to a high time consumption: *"I would have thought it would go faster after all."* During the video recording, the caregivers sometimes forgot the structure or the content they had thought about in the preparation. Some recordings had to be stopped and started

several times. As a result, stressful situations were sometimes observed by the researchers during the recordings.
Moreover, the video tutorials typically required post-production editing, a skill that was not readily available within the healthcare company in question and thus had to be performed by a researcher.

Development of the Preparation Form

Based on the previous findings, we identified the need to enhance the efficiency of the video recording process for the next iteration. The long time for creating video tutorials, and in particular the long preparation phase, conflicts with the goal of integrating video recording into everyday work. Consequently, the focus was on more efficient preparation. A workshop was conducted to elicit the requirements for a type of script to increase the efficiency of the video recording process. From the workshop, it was concluded that a cognitive preparation for the corresponding work activity is necessary to possibly reduce the time needed for preparation. An iterative process was started to create a "tool" for supporting cognitive preparation. In the first phase, a team of three researchers discussed initial ideas, during which the "form" medium was selected for cognitive preparation. Choosing written documentation or forms had a significant advantage in that caregivers are already familiar with them from their daily work. This idea was presented to the stakeholders from the healthcare sector, who agreed to use the form.
In the following a first version of the preparation form was created and tested with a caregiver. The caregiver was asked to use the preparation form to prepare for the video shoot and was interviewed afterwards. The input was used to revise the form resulting in the form which is presented in the following.

The Preparation Form

Figure 3 shows the final developed and evaluated preparation form. The best practices of goal definition, target audience, script, and dividing longer video tutorials into segmentations as described in related work for proper preparation were adopted in the form. The form was divided into three sections: *Objective* (goal definition), *Target Group*, and *Segmentation*. On the left of Figure 2, the two sections *Objective* and *Target Group* are shown. The first section contains the *Objective* description, which is use case depended and summarizes in a short sentence the goal of the video. The second section contained the best practice target audience, represented based on the persona concept. The caregiver should select one from these personas that they think is appropriate in the context. In the evaluation of the form, the real situation was represented by a previously given scenario description. In the future, the persona should be selected based on the real situation. This section was designed to make the caregiver aware of who would be using the video tutorial later, and therefore increase awareness of what content is relevant to explain the activity through the video tutorial.

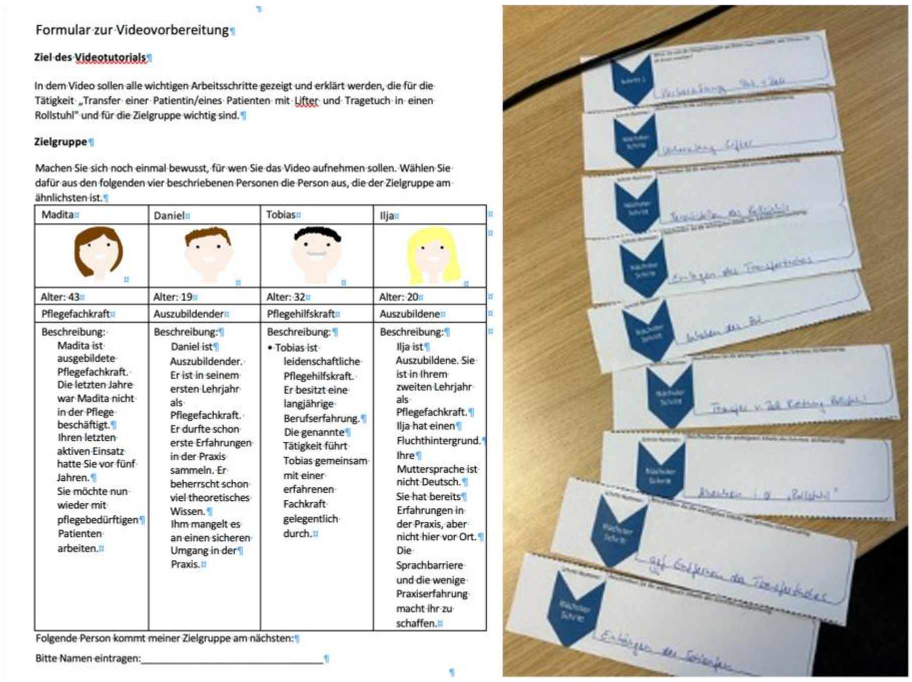


Figure 3. The Preparation Form. On the top left is the goal description with the heading "objective of the video tutorial". Below is the persona concept to create awareness of target audience to reach. The selection of the target group depends on the context. In our evaluation, the target group should be "students". On the right is the third section, with the segmentation of the video tutorial. Here already filled in and chronologically sorted by a participant during the evaluation.

The *Segmentation* section of the form is meant for dividing the planned video into shorter segments (see Figure 3, right). Caregivers are asked to break down the activity into smaller steps and write down the content of each step while ensuring that breaks can be taken between these steps without risking themselves or the patient. Each card represents one segment, and caregivers can choose whether to write down key points or sentences about the content of the segment on the card. The cards can be kept nearby during video recording and can be sorted e.g., according to their chronological order. In addition, while recording the segments, they can be used as a reference guide or a reminder. This approach creates a script with the essential content aspects which is split into segments.

Evaluation with the Preparation Form

Evaluation Method

To evaluate the use of *smartorials* including the preparation form, we run a study under conditions close to the field. We used the use case of transferring a patient, which was setup as follows: in the center of the room was a patient bed, as used in nursing. To the right of it was an electronic patient lift, and a chair represented the wheelchair. The patient to be transferred was played by students. Figure 4 shows the test bed during a video tutorial recording.

Figure 4. A caregiver uses data glasses to record a video tutorial in the test environment.

The participants, all caregivers, were introduced to the background and purpose of the study and consent was obtained for data collection. Next, the participants were given time to familiarize themselves with the electronic lift, followed by instructions on how to operate the smart glasses through a tutorial and practice with a short video recording. The scenario was then described to the participants, including the reason for the video recording, the use case, described above, and the target group (in this case, first-year students). The form was given to the participants to prepare for the recording. The participants could choose to take their previously completed segmentation cards with them or leave them on the table. After the video recording was completed, the participants were asked to come to a separate room for a brief post-session interview. The researchers thanked the participants for their participation.

A total of eight participants were scheduled to record one video tutorial each. The participants all have practical and long-term experience in the chosen activity. Eight recording sessions were planned, but due to illness and a technical malfunction, only seven participants were able to participate and a total of six videos were created.

To assess the effectiveness of the video tutorials produced using the preparation form, time taken during preparation and recording was measured, and feedback on the form was gathered immediately after recording.

Moreover, the quality of the videos was evaluated by an expert, a nurse scientist, who evaluated the videos based on content quality. To do this, she watched all videos from both iterations (without and with preparation form) and rated content in terms of completeness and errors. All videos addressed the basic aspects that are critical to the safe performance of the work activity. If any aspects of the content were missing, they were minor details that did not pose a threat to the safety of either the caregiver or the patient.

In the end, a conclusive statement was reached regarding the critical factors for producing high-quality video tutorials for healthcare work activities, as well as an assessment of the quality and efficiency of the videos created using the preparation form, in comparison to the previous videos created without the form.

Results and Discussion

The preparation form was generally accepted by the participating caregivers and found to be practical. The form proved to be important for cognitive preparation: *"Very helpful as a tool for mental preparation."* Participants stated that the form helped them to prepare for the video tutorial in a structured way: *"I was thinking in myself -hm- now also filling out slips of paper beforehand, but this was helpful."* In particular, the segmentation with the small cards helps the nurses to remember the essential aspects for the explanation of the work activity. In addition, it was emphasized that the little cards could be looked at once again during the recording and offered a structured overview: *"The little cards are mobile and I can also rearrange them flexibly."*

Table 1 summarizes the results on average in terms of time for preparation, recording, duration, and content quality of the video tutorials. The table contains the data from the first iteration (without preparation form) as a baseline. The average time spent preparing and recording video tutorials using the form resulted in significant time savings compared to those created without the form (a total of 24 minutes and 20 seconds compared to several hours). Furthermore, it was found that the error rate regarding missing aspects was reduced. In videos that have been recorded without previous preparation, an average of 13 errors were identified by the nursing scientist. In the videos with the preparation form, only 5.5 errors were identified on average. This means that the error rate could be reduced by 7.5 missing aspects on average. Additionally, it should be mentioned that none of the recorded video tutorials with the preparation form required any post-editing.

In summary, the results demonstrate that the preparation form achieved the following successes: First, it reduced the time required to record a video tutorial. Second, it simultaneously increased the quality of the video tutorials by reducing the number of missing content aspects with the aid of the form. Third, the form is a method that can be easily integrated into the daily work of caregivers. Our initial research demonstrates that the form can increase the efficiency and content quality of videos. The form is a proven documentation tool within many infrastructures of the healthcare system and is flexible enough to be used in digitization projects. Moreover, the form can be easily implemented digitally, and information can be directly displayed on the glasses.

Table I. Results with time units in mm:ss, content completeness, and number of missing aspects in average

	Time for preparation	Time for recording	Video duration	Content complete?	Missing aspects
Video creation without preparation form (n=3)	*Several Hours*		*10:25*	*No*	*13*
Video creation with preparation form (n=7)	*09:50*	*14:30*	*10:30*	*No*	*5.5*

Of course, the presented results are subject to certain limitations: the study was intentionally designed in an exploratory way to obtain initial insights into whether an improvement can be achieved with the preparation form. For this reason, only a small number of participants were evaluated with this method.

Summary and Conclusion

Video tutorials have the potential to significantly enhance knowledge transfer in the healthcare sector by making complex and individual activities more comprehensible. However, creating video tutorials efficiently presents some challenges. In initial investigations within the context of this research project, it became clear that video tutorial preparation is a significant time factor that needs to be minimized. There are only a few best practices in the literature that focus on structured preparation. The most common methods for creating successful video tutorials include defining objectives, identifying the target audience, and creating a detailed script. These three methods were considered in the development of a preparation form through an iterative process. The final developed form provides the caregivers with a quick overview of the content-related goal and the target group. In addition, the caregivers are asked to split the activities into individual steps and to write down initial notes on the content. The preparation time for recording a video tutorial was significantly reduced using the preparation form. Our data shows that the preparation time was reduced from several hours to less than one hour. Furthermore, the content completeness of the videos was improved. From an average of 13 missing content aspects, this rate was more than reduced by half with the new preparation method. We assume that with the help of the form, the caregivers are better primed cognitively for the content aspects that are to be shown. Smartorials offer a low-threshold way to integrate into existing infrastructures and daily work routines. Future research should explore other use cases using the preparation form and investigate its potential for other target groups, such as onboarding experienced caregivers after a long career break. In the future, the form could be integrated into existing digital infrastructures and displayed on data glasses used for real-time support during video recording.

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Facilitating Collaboration by Opening the Common Information Space in Mental Health Care

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Abstract. In this paper, we explore the role of common information space (CIS) in mental health care. CIS and collaboration have been prominent themes within the field of computer-supported cooperative work (CSCW). The study investigates two research questions: (i) How is CIS constructed and shared in mental health care? and (ii) How can CIS facilitate collaboration between health care workers and patients? We draw from a rich set of data from two separate research projects in the domain of mental health. The first project is on mental health home treatment, while the second project studies patient-accessible electronic health records. Based on our analysis, we structure our findings into three themes. First, we describe the construction of CIS. Next, we outline how opening CIS unfolds in mental health care. Finally, we provide insights into how collaboration is facilitated by sharing CIS. We conclude with a discussion of our findings.

Introduction

The importance of facilitating collaboration in a health care setting continues to be a prominent theme within the field of computer-supported cooperative work (Fitzpatrick and Ellingsen, 2013). The underlying work practices of health care are characterised by a multidisciplinary approach where information from various analogue and digital sources and its interpretation contribute to the decision and sense-making (Klein et al., 2006; Robertson et al., 2010). Furthermore, these multidisciplinary health care workers are often distributed over time and space, and constructing a shared understanding to provide care requires effort (Bossen, 2002; Schmidt and Bannon, 1992; Schmidt and Simonee, 1996). This is especially true in mental health care. Here, the close interaction within a multi-professional team but also between health care workers and patients comes to the foreground.

Hence, we have chosen common information space (CIS) as our conceptual ground to present and discuss our empirical material (Schmidt and Bannon, 1992; Strauss, 1988; Suchman, 1996). We observed how artifacts common in health care settings, such as whiteboards and health records, participate in constructing a CIS (Berg, 1999). Further, these artefacts also take an active role in 'opening up' or sharing the CIS – and by doing so, facilitate collaboration and participation. Consequently, the study aims to answer two research questions:

(1) How is CIS constructed and shared in mental health care?
(2) How can CIS facilitate collaboration between health care workers and patients?

The study draws from a rich set of data collected through two neighbouring research projects in Germany. Although they have many things in common, the findings emphasised other aspects and allowed for an exploration of CIS in mental health care from different perspectives (i.e., constructing, sharing, and collaboration).

Background

We have chosen to investigate cooperative work practices in mental health care with the conceptual lens of common information space (CIS). Within computer-supported cooperative work (CSCW), a research field concerned with collaborative work arrangements and its involved artefacts, CIS has been a central theme for decades. In their programmatic paper, Schmidt and Bannon describe the focus of CIS on

> 'how people in a distributed setting can work cooperatively in a common information space - i.e., by maintaining a central archive of organizational information with some level of "shared" agreement as to the meaning of the information (locally constructed), despite the marked differences concerning the origins and context of these information items' (Schmidt and Bannon, 1992, p. 22).

The construction of a CIS requires effort and interpretation by the actors involved, and it is subject to change as it is temporally constructed. In practice, a CIS evolves over time as daily routines such as multidisciplinary team meetings occur regularly, and a common understanding is carried forward (Schmidt and Bannon, 1992). Further, the concept of CIS can be relevant for distributed teams and work settings, where a CIS is inscribed in an artefact (e.g., electronic health record) and later interpreted and thus re-created over time and space (Bannon, 2000; Bannon and Bødker, 1997). Although playing an important role in the creation of a CIS, an object holding information can not solely be characterised as a CIS, as it always requires interpretation by actors. Rather, it is necessary to consider the object's origin, context and politics when assessing its information (Schmidt and Bannon, 1992).

Over time, CIS has been investigated from many perspectives and further conceptualised. The dialectic nature of CIS described by Bannon and Bødker (1997), i.e., the openness of a CIS when it is constructed within a community of practice vs the closedness when a CIS is shared and resembles characteristics of immutable mobiles (Latour, 1987) or boundary objects (Star and Griesemer, 1989), is highly relevant for our study as we follow a CIS in different stages. However, we agree with Rolland et al. (2006) that 'sharing and negotiating common understanding are much more temporary and fluid than the term boundary object suggests' (Rolland et al., 2006, p. 494).

Moreover, CIS was refined and elaborated from different perspectives and through varying practices. For instance, Bossen (2002) elaborated and refined the concept of CIS based on fieldwork in a hospital ward. Further, previous studies have investigated the role of CIS and its artefacts in coordinative practices (e.g., Schmidt and Wagner, 2004; Scupelli et al., 2010), different roles and forms of CIS (e.g., worker-driven CIS, Møller et al., 2020), CIS in various domains (e.g., understanding personal health records as a hybrid information space, Vassilakopoulou et al., 2019), how the internet of things can support the construction of CIS (Robertson and Wagner, 2015), and the significance of shared understanding across actors (Mohallick et al., 2022). To sum up, we could draw from a rich and manifold research theme to form our conceptual grounding.

Methodology

This paper is based on two research projects within mental health care and digitalisation. The first project conducted an interpretive case study on mental health home treatment (HT) and investigated how health care workers carry out temporal and spatial distributed care activities (Hochwarter et al., 2022b), hereafter referred to as the HT project. The second project follows a participatory approach to design, pilot and evaluate a patient-accessible electronic health record (PAEHR) system in mental health (Hochwarter et al., 2022a; Schwarz and Esch, 2022), hereafter referred to as PEPPPSY-project (Pilot Testing and Evaluation of Participatory Patient Record in Psychiatric Care). While the two cases have many things in common, for instance a similar research setting as the services are offered in-part by the same hospitals, they provide different insights to the interaction between health care professionals and patients (see also Table 1).

Table I. Characteristics of the two projects / research settings

	HT project	PEPPPSY project
Research setting	Two general hospitals (urban/rural area) in eastern Germany (Berlin/Brandenburg)	One general hospital (rural) in eastern Germany (Brandenburg)
Treatment setting	Home Treatment (i.e., inpatient care at home)	Outpatient care
Central information system	Hospital information system	Web-based patient portal
Focused type of information investigated in the research project	All clinical and organizational treatment information	Clinical notes
Data collection duration	March – August 2020	June 2021 - May 2023 (ongoing)
Number of patients (observed/participated)	15	16
Number of health care professionals (observed/participated)	16	9

Research setting

The HT project took place at two departments of psychiatry, psychotherapy, and psychosomatics in two German hospitals. They both offer a broad variety of services for their users, one of which is inpatient-equivalent home treatment (IEHT). Internationally, this form of treatment is known as home treatment for mental health or crisis intervention teams (Catty et al., 2002). The two hospitals were also selected due to their different characteristics. While the first hospital is located in a metropolitan district of a major city, the second hospital covers a catchment area in a mixed rural and suburban district in eastern Germany.

The PEPPPSY project is ongoing and started with a single location with participants from a psychiatric day clinic in a rural area. In the beginning, the study investigated the preferences of patients and mental health care professionals when accessing their notes (Schwarz et al., 2021). In a second pilot, it was expanded to include a comment function and the creation of multiple instances. The latter makes it possible to test the pilot at currently five outpatient and one inpatient mental health setting. An accompanying process and outcome evaluation will examine (i) which outpatient psychiatric patients want to use open notes (or not) and for what reasons; (ii) the potential of the commentary function for the doctor-patient interaction; and (iii) the question of how the documentation (behaviour) of healthcare professionals changes when clinical notes are shared with patients.

Data collection and analysis

The HT project followed mainly an ethnographic approach, and the large majority of data were collected by conducting go-alongs (Kusenbach, 2003). This choice of the method allowed us to follow the HT teams, observe their work while they were on the move, and allow for questions of informal conversations in between. While we have been visiting patients together with the HT teams, our focus was on the health care workers, and we did not collect any therapeutic details during the visits. Patients were informed of the presence of a researcher and could deny access. Data collection took place in March and August 2020 and included 63 hours of go-alongs and additionally two interviews with the senior physician at each clinic.

The PEPPPSY project started in June 2021 and is currently in its second pilot phase. It follows a participatory approach, and the design is based on four focus-group sessions with the aim to co-design and evaluate the pilot (Krueger and Casey, 2014; Simonsen and Robertson, 2013). The first pilot took place from December 2021 until April 2022, and a total of 277 notes were shared with 16 patients. The second pilot phase started in October 2022 and will end in June 2023; 88 patients have been enrolled so far. In this second phase, an accompanying mixed method process and outcome evaluation is being conducted, with the primary focus on in-depth interviews with patients and staff to examine how documentation behaviour and physician-patient interactions change as a result of open notes. Qualitative data from both pilot evaluations were used for the present study (patients: n = 34; health care professionals: n = 8).

Data analysis followed an abductive approach (Tavory and Timmermans, 2014). First, we explored the data of the HT project with initial open coding and memo writing, and first themes emerged, including CIS and collaboration. We decided to follow CIS for our conceptual lens. Then, we included the data from the PEPPPSY project as we realised that it could contribute to these themes. Eventually, three themes emerged in relation to CIS: (i) CIS in mental health care practices; (ii) Opening the CIS; and (iii) Facilitating collaboration, which we present in the following section.

Findings

CIS in mental health care practices

We observed the creation of CIS in the daily routines of the home treatment (HT) teams. While the health care workers can be considered a community of practice, the HT teams consist of multi-professional team members, and they visit the patients in different compositions. Hence, the morning meetings to update the team members are an important part of their daily routines in a heterogeneous environment:

> ‘Both teams have their morning meetings. I sit close to team B. The team members sitting in front of their computers have the EHR system open, showing the overview of the beds. Each HT team has their patients in their own "virtual" room. The team discusses its patients one after each other, together with the assistant physician O. The visits for the next few days are planned and documented on the whiteboard. Nurse M takes notes on a pack of yellow PostIts, nurse L takes her notes in her calendar.’ (go-along, March 11, 2020)

As the above quote demonstrates, the heterogeneity can further apply to artefacts partaking in the creation of the CIS of the morning meetings. Besides the EHR system and the virtual rooms where the HT patients are placed, there are paper artefacts such as medication lists, paper-based paper charts, various lab reports and work schedules. All these documents might be consulted in the creation of the CIS when discussing the upcoming HT visits. The health care workers also consult their notes (e.g., written on sticky notes, calendars etc.) and take notes for the upcoming visits. These morning meetings are intense and very focused, and the resulting CIS can be seen as an effort to provide good care in limited time to all their patients (usually they have between six to eight patients per HT team).

The whiteboards in the offices are notably the most prominent artefacts in the office (Figure 1), and the HT teams hold their morning meetings around them. They consist of a table where each row represents one HT patient, holding information relevant to the delivery of care. Magnets with the first names of each team member show who is visiting whom on which day. The senior physician's magnets are coloured yellow, while all the other team members are red. Team members often take a picture of the whiteboard with their phones before leaving for their daily visits. The whiteboard, which is updated during the morning meetings, provides them with other relevant information that they need during their visits. For instance, different appointments of a patient or a change in the current living situation.

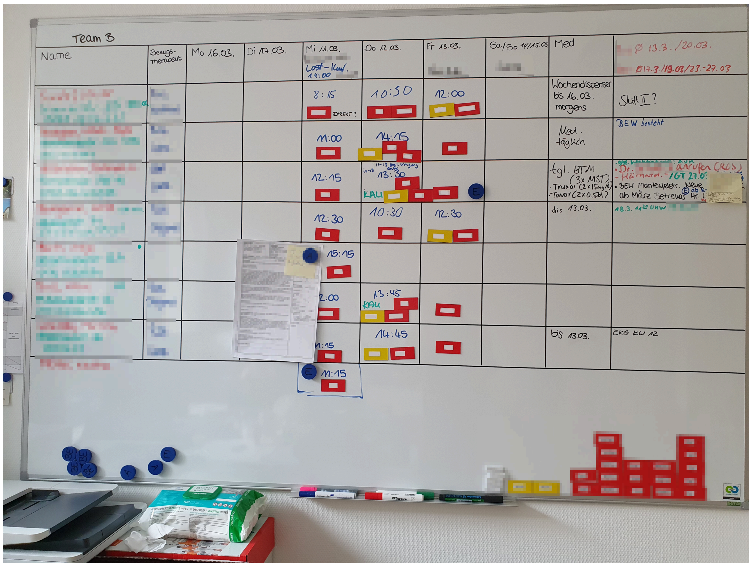

Figure 1. Whiteboard of HT team (anonymised)

The important role of the whiteboard and other related artefacts for the creation of a CIS becomes apparent when the HT team discusses a new submission:

> ‘There are two suggestions for a new HT admission. The information about these two patients is printed on A4 paper. They discuss the patients, their clinical picture, demographic data and where the patients live. One patient lives at the border of the district. The team members complain about the long journey that would encompass the admission of this patient. They look for the detailed address of this patient, G is using her computer and Google maps. M stands up and takes a look at the district map, which also has the location of the other patients marked with a coloured pin. G: "Well, then the patient will be visited around 8 to 9 am on the weekends." [Remark: On weekends, only one team member visits all the patients, usually 6-8 patients. They start from home and drive directly to the patients. When they are done, they document their visits in the office.]’ (go-along, March 11, 2020)

During the multi-professional team meetings, usually in the afternoons, where the teams discuss each patient as a team together with the responsible senior physician, we can observe how these different artefacts take part in the creation of a CIS:

> ‘The team members read the progress of their patients, mostly from handwritten notes. B is simultaneously writing the doctor's notes in the EHR system. In addition to the documentation in the EHR system, an Excel sheet with checkboxes is used for quality assurance. Further, patient charts and handwritten notes are used to discuss a patient.
>
> For the discussion of one patient, they are searching for the overview of the PIA (psychiatric outpatient department) appointments in the EHR system. Many experiences are shared by the team members, but they are not all put into the report.’ (go-along, March 11, 2020)

Furthermore, there is often information that is considered important for the creation of a CIS and hence shared with the team, while it is not included in the patient's report.

The HT teams work in a distributed setting, and they visit the patients in varying constellations. It is all the more important to have a common understanding of the patient's history and upcoming visit. While every patient has a reference therapist, who visits the patients regularly, the senior physician usually joins once a week. Here, the EHR serves as a mechanism to hold the common understanding, but its interpretation still takes place on the way to the patients:

> 'We do the senior doctor rounds on Wednesday and Thursday so that I can see the new patients, every new patient will be briefly consulted with me when I am in charge. Before I go there, I print the admission out or read it in the morning so that I am a little bit prepared. That is one thing. The other is that we use the trips for a short update and then also other things, background etc. The anamnesis is reflected again by the nurse, and so are the specialist doctor visits.' (Interview, Senior physician, April 2, 2020)

Opening the CIS

The role of CIS in mental health care, as we have observed it, is not only to provide a shared understanding of working routines (e.g., route planning) and therapeutic concerns. It is also opened and shared with the patients and sometimes with their relatives:

> 'G is documenting the treatment information and the procedures during the visit. Questions for the next appointment are noted as well as wishes expressed by the patient. They discuss the head physician round and where it will take place.' (go-along, August 24, 2020)

The patients are included in the planning of their therapy, they decide on the treatment plan together with the HT teams. Their questions are recorded for the next visits. All this information, now part of the treatment documentation, will be picked up by the next HT team when they prepare for their visit, i.e., constructing a CIS for their daily work. Hence, we see the CIS, at least in our case, as a 'mutable mobile' (cf. Rolland et al., 2006) as the CIS is shaped by opening and sharing it with patients.

Patients are usually in home treatment for a period of four to six weeks, typically when they experience a crisis. The artefacts relevant to the CIS grow over time and become not only an important source of information for the HT teams but also fulfil a therapeutic function when shared with the patients:

‘We arrived at 8:40 am. The patient welcomes us into the living kitchen of a one-family house. S opens the laptop and sits diagonally opposite the patient. S asks the patient if they shall read together her therapy transcript. The patient does not want to, she says: “By reading it, it will get worse again”. S replies: “Yes, maybe it is better if you don’t read it.”’ (go-along, August 25, 2020)

Another way of sharing information with patients is by providing them with a therapy plan on paper, which has a similar structure to the table on the whiteboards in the HT offices. The therapy plan is typically updated at the end of the visit. The team members provide the details for the next day's visit, such as the visiting time, who will visit them and what will be done. They provide these details only for the next day to avoid confusion and additional stress for the patients in case of any changes. While the HT team has good reasons not to share everything, this shows there are limits on what will be inscribed and shared with the patients.

In the PEPPPSY project, too, not everything is shared with the patients. Only by recording in an addressee-oriented manner what has been discussed in the course of the physician contact, it is possible to record in the PAEHR and keep the CIS open for the patient also after a physical contact:

‘I have always tried to write in such a way that it corresponds to both the patient and me and that it is understandable for the patient. In any case, that is very important, I think. Only this makes it possible that the patient can later find himself in what I have written down. So I say with technical terms or whatever, many people can't do anything with them or have to google them or something. Yes. So the goal would always be to enter the notes in such a way that patients understand it as precisely, concretely and simply as possible.’ (Interview, health care professional, PEPPPSY II)

Facilitating collaboration

The previous section already showed how opening the CIS allows the patient to participate in forming the treatment. Further, it contributes to becoming an active part of the therapy and decision-making by being informed. We have moreover observed how patients take part in relevant decisions regarding the therapy and medication:

‘B comes with the patient back to the living kitchen. They discuss the medication of the patient. The patient says that “1.5 g is better than 2g” regarding the doses of a medication. The patient would like to start working, something simple. They arrange tomorrow’s appointment. Tomorrow the son is coming by, they come a bit later to see the son.’ (go-along, August 27, 2020)

Collaboration and participation belong to the objectives of the PEPPPSY project. PAEHRs are understood by patients as a medium to keep the CIS open, e.g., between several outpatient treatment appointments, and prevent what was discussed from being forgotten. Another aspect that becomes clear in the following quote is the ‘scalability’ of the CIS, which allows the latter to be extended to the patients’ social network, or to include the care partners involved in the patient as co-knowers and contributors to the shared growing body of knowledge:

> ‘Then you also know about the thoughts that the doctor has. And I can give feedback. I find it very difficult, if something [such as symptoms] has happened at home, to bring it to the next appointment. After three days it's forgotten again, and I don't bring it to the psychiatrist. My wife, for example, would also like to talk to someone to find out more about how she should deal with it [my illness]. That was my first thought at the same time, that she could read what the doctor writes. I can't remember it all and reproduce it. And so they can share with me what we've been thinking about together, [the doctor and I] and how to move forward with me.’ (Interview, patient, PEPPPSY II)

However, mental health care professionals expressed concerns and uncertainties about integrating PAEHRs into their routines, such as about how to put their own previously unshared thoughts into the PAEHR so as not to withhold relevant information about their condition from patients on the one hand and not to blindside or irritate them with it on the other:

> ‘I was always afraid of having written down something that I had thought but had not yet said to the patient as written by me. And then, I started to read out what I had written at the end of an appointment and to ask the patient if it was true and ask for additions. And I think that helped me to relax; to give myself the assurance that I had not expressed anything inappropriately. And it is not uncommon for my patients to correct some of it. But that's fine with me: I just adjust it and then it's right on the record for both [the patient and me].’ (Interview, health care professional, PEPPPSY II)

Concluding discussion

In this paper, we investigated the role of CIS in mental health care. We could draw from a rich set of data, and the findings describe different aspects and roles of CIS. Based on go-alongs and interviews, we have examined the two research questions and further discuss them below.

First, we asked how CIS is constructed and shared in mental health care. We have described how CIS in a highly heterogeneous and distributed setting is constructed and highlighted the role of reading and writing artefacts (Berg, 1999) such as whiteboards and EHRs. The construction of CIS not only takes place as a local effort during the morning meetings, but we also described how the HT teams as a distributed organisation make sense when they assess objects that have traces of the CIS inscribed. In its minimalistic form, it can be only one person (e.g., the senior physician reading the documentation before the visits) accessing information entered by a multi-professional team. But even this can be considered as a construction of CIS 'because both the producer and the receiver consciously make an effort to understand each other's context' (Bannon, 2000, p. 5).

Next, we explored the sharing of a CIS in mental health care, or as we labelled it in our findings, the opening of CIS. The dialectical nature of CIS becomes apparent and the description of frontstage and backstage tensions play an important role, as described by Bannon and Bødker (1997). Artefacts take different roles, they can be seen as part of a hybrid CIS (Vassilakopoulou et al., 2019). For instance, the therapy notes serve to inform the distributed and multi-disciplinary team, but are also actively part of therapy when they are shared with the patients. This leads to the issue of origin, context, and politics of information, which has been discussed in previous literature (Bannon and Bødker, 1997).

Finally, we have seen CIS as a facilitator for collaboration in our findings. Here, we also hint how the boundaries of CIS are blurred and by doing so facilitate participation of patients and closer interaction between health care professionals and their patients (cf. mutable mobile, Rolland et al., 2006). Our findings underline this, they described how sharing CIS with patients goes beyond information sharing and invites the patients to collaborate by shaping the CIS. This does come with some side effects, for instance, when a physician feels initially anxious to share his or her thoughts in a PAEHR.

Although we have focused on mental health care, we believe the concept of CIS and its potential to facilitate collaboration can be transferred to similar domains where close interaction with patients (or users) stands in the foreground.

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Navigating the Challenges of Remote Research in Times of Crisis and Beyond

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Abstract. Crises such as the COVID-19 pandemic put heavy restrictions on researchers who mainly follow a qualitative, ethnographic stance that typically relies on immersion in the setting, bringing remote research into the spotlight. In this paper, we describe how we, as qualitative researchers, responded to the crisis by comparing our experiences in conducting remote interviews in two German contexts: 1) with employees from a video game company during the summer of 2020 and 2) with several political and non-political actors in a rural region during autumn 2020 to summer 2021. Drawing on these experiences, we provide lessons learned for times when physical distancing is necessary but also beyond. While we faced some challenges and limitations, such as technical difficulties and a lack of contextual insights on-site, we also found a more profound quality in the absence of the regular interview setting. Thus, we advocate retaining some procedures and alternative ways as future practice.

Introduction

The COVID-19 pandemic brought numerous changes in people's private and work lives, from lockdowns, contact bans, and travel restrictions to physical distancing measures (Beaunoyer et al., 2020; Wang & Tang, 2020) and also had a lasting impact on aspects of academic life that rely on in-person contact, e.g., conference visits, lectures, and our focus here, research activities. While there is a critical need to consider and document individuals' experiences of the crisis from a qualitative perspective (Teti et al., 2020), such studies face challenges compared to purely quantitative large-scale investigations. Having to find alternatives to collect data, many qualitative researchers relying on an ethnographic and face-to-face approach to fieldwork turned to information and communications technology (ICT) to conduct 'remote research' (e.g. Dupuis & Renaud, 2020; Roy & Uekusa, 2020). From the era before and during the pandemic, two relevant lines of discourse have unfolded, dealing with i.) pragmatisms and ethics of qualitative remote research and ii.) social aspects and technical affordances of virtual meetings. While we can borrow from these insights, studies from pre-pandemic times did not consider the crisis's new circumstances and potential lasting impacts (Vindrola-Padros et al., 2020) since various domains experienced significant changes during the crisis, leading to fragmented work and policy shifts that affected informal processes (Waizenegger et al., 2020) as well as physical distancing and remote work impact spatial and psycho-social factors.

With this in mind and as diverse populations increasingly use remote communication technologies (Beaunoyer et al., 2020; Brohi et al., 2020; Rahman et al., 2020; Vaishya et al., 2020), it is essential to critically review qualitative methods to adapt existing methodologies and develop new approaches without physical co-presence in order to understand the long-term impacts of changing research strategies and co-production relationships (Roy & Uekusa, 2020; Vindrola-Padros et al., 2020). In this paper, we build on previous reports (Hensen et al., 2021; MacLean et al., 2021; Simons, 2019; Vindrola-Padros et al., 2020; Webber-Ritchey et al., 2021) and emphasize the need for innovative remote research methods, sharing our experiences conducting remote interviews in two German contexts during the pandemic (MacLean et al., 2021).

Related Work

Remote ethnography, or digital ethnography (Pink et al., 2015), has roots in World War II when ethnographers conducted distant fieldwork due to mobility restrictions (Postill, 2016) and employed various remote qualitative methods, including telephone (Mealer & Jones RN, 2014), videoconferencing (Sedgwick & Spiers, 2009), and instant messaging interviews (Kaufmann & Peil, 2020), as well as co-design (MacLeod et al., 2016). The pandemic intensified the focus on remote research, particularly for qualitative studies (Dupuis & Renaud, 2020; Roy & Uekusa, 2020), prompting the development of collective knowledge like Deborah Lupton's (2020) "Doing Fieldwork in a Pandemic." From pre-pandemic and recent studies, two main discourses emerge: first, remote fieldwork is not a mere "second best" option (Postill, 2016, S. 68) but offers increased flexibility, practicality, efficiency, and adaptiveness compared to face-to-face research (Buckle, 2021; Dupuis & Renaud, 2020; Hensen et al., 2021). The term 'research pragmatism' (Smaling, 1994) captures this idea, recognizing various factors influencing data collection, including ethical considerations such as data privacy, security, and informed consent (Hensen et al., 2021; Janghorban et al., 2014; Kaufmann & Peil, 2020; Staudacher & Kaiser-Grolimund, 2016). Second, we have to consider the social aspects and affordances of virtual meetings: building trust and rapport is more challenging for remote research than offline work (Hensen et al., 2021; MacLean et al., 2021; Webber-Ritchey et al., 2021), particularly with unfamiliar researchers (Lo Iacono et al., 2016; Seitz, 2016), since spatial distance and lack of face-to-face interactions can create insecurities (DeSanctis et al., 1999), and remote research cannot fully replicate personal interactions or convey subtle body language cues (McColl & Michelotti, 2019; Novick, 2008). However, these challenges can be mitigated by repeating remarks, asking follow-up questions about nonverbal communication, and observing facial expressions when webcams are used (Lechuga, 2012; Seitz, 2016). Video interviews can offer authenticity comparable to face-to-face conversations by providing access to verbal, nonverbal, and social cues (Sullivan, 2012) while maintaining flexibility and privacy (Hanna, 2012). Even if physical contact information is still lacking (Podjed, 2021; Roy & Uekusa, 2020), voice-only interviews can reduce emotional distress for sensitive topics (Mealer & Jones RN, 2014; Sipes et al., 2019), and different interview methods may not necessarily yield diverging results (Sturges & Hanrahan, 2004).

The shift towards remote approaches during crises like the pandemic necessitates a further reflection on methodology (Hensen et al., 2021), as few authors have discussed the challenges and practical issues faced in conducting this type of research on time (Vindrola-Padros et al., 2020) and in terms of crisis readiness. In pandemic times, this has become crucial as organizations have had to rapidly adapt to remote work and ensure the well-being of their employees by providing adequate infrastructure, changing work practices to respond to new work and life conditions, and handling multiple and diverse interruptions at the individual and organizational levels (Caldeira et al., 2022). We contribute to these ongoing discussions, emphasizing the need to adapt remote ethnographic methods to address the evolving landscape of qualitative research. Like many other researchers, the pandemic has compromised our qualitative approach since it builds on ethnographic and co-design approaches to fieldwork. Therefore, we utilized a multiple-case-study approach (Yin, 2014) to present and compare insights from two remote interview studies. In the following, we systematically share our experiences (Ellis et al., 2011), offering valuable insights (Roy & Uekusa, 2020).

Research Context

Our first study in setting A occurred during the summer of 2020, between the first and second waves of the pandemic in Germany. We conducted an interview study collaborating with 20 employees from a medium-sized German video game company from a larger city. Already accustomed to the organization, we reinitiated our collaboration amid the pandemic. Our contact person forwarded our request to a workforce and property management employee who played an integral role in developing strategies to respond to the March 2020 COVID-19 outbreak. During an informal talk in May of 2020 via MS Teams with this employee, we thus received the first insights and, subsequently, started with the interview phase.

Regarding our sample, we strived for variety in terms of gender, background, duration in the company, occupation, responsibility, relationship status, and living conditions. We contacted employees we had worked with before, and the majority responded positively to our request to participate voluntarily in our study (seven overall). Our initial interviewees then suggested other interview partners. At the time of our study, most participants were still in their home offices. The age of our participants ranges from 25 to 52 years. Our sample consisted of eight female and 12 male employees and three couples. Initially, we shifted the interview study to a virtual space, using remote interviews as the best practice. Since our research partner already used Microsoft's business communication platform Teams and relied more heavily on it during the crisis, we used it to conduct our interviews. Familiar with the organizational context, two researchers conducted the (expert) interviews: while one researcher was mainly responsible for guiding the interviews, the other took protocols and occasionally asked questions. The interview length ranged from approximately 45 minutes to two hours, with most of the interviews lasting roughly 60 to 90 minutes. Our interview guidelines broadly covered the home office situation before COVID-19, experiences during the ongoing pandemic, and personal lessons learned for the future. Our questions involved the household situation, productivity, technical solutions, maintenance of work tasks, remote collaboration and virtual meetings, resilience, and time management. We recorded the interviews with the feature in MS Teams, and our participants made these data accessible to us.

We realized the second interview study in setting B with twelve participants as part of a project that dealt with digital citizen participation to gather information about a citizen wind farm's ongoing process and its possible citizen participation measures. Our participants live in two rural, remote areas with less than 30.000 inhabitants. Compared to setting A, their age range of 24-84 was much broader. Four were female, and six were male. The study occurred from October 2020 to July 2021, and participation was voluntary. Our interview guidelines broadly covered questions regarding political positions, civic participation experiences, and media usage behavior. During this period, the fourth author conducted twelve interviews. We recruited one politician (four overall) from each of the parties represented in the council in the region by personally approaching them via telephone and e-mail without previous personal contact. For this, we collected contact details from a council information system. In this way, we also contacted NGO participants (two overall), whose contact details we took from the organizations' respective websites. We initially recruited citizens (two overall) through a participatory design workshop offline in pre-pandemic times in early 2020 and through personal networks. Due to the pandemic, we conducted one-on-one interviews via Zoom. For analysis purposes, we only used the extracted audio tracks. The interview length ranged from approximately 40 minutes to two hours, with most of the interviews lasting roughly 60 to 90 minutes.

Experiences

Matters of Space

In our study, participants were forthcoming, and we observed no reluctance to disclose their experiences and opinions; this was true for both new and already familiar participants in setting A and B. In setting A, the discussion topics were wide-ranging, including personal sentiments about the pandemic, household situations, homeschooling, mental health problems, resilience strategies, coping with stress, and work-life balance. Several participants took advantage of lockdown time to reflect on their living situations, while others were comfortable debating serious topics or criticizing conservative work processes. We observed the same in setting B: participants were forthcoming, showed no reluctance to answer the actual questions related to the project, and opened up regarding their sentiments about the pandemic; e.g., a 62-year-old politician expressed dissatisfaction with how the public sector dealt with digitalization matters during the crisis, pointing out that especially data protection measures are restrictive.

Justified by the abovementioned indications, we established rapport quickly in a virtual meeting room. The 'shared' crisis created a joint degree of rapport and influenced the conversations' topics, and we found that the locality played an important role. We observed three different kinds of 'spaces:' i.) the private space; ii.) the shared office space with the possibility of colleagues being present in the same room; and iii.) (quasi-)isolated rooms within the office (e.g., dedicated, reserved meeting rooms or offices where no co-workers were present). We had never been confronted with this kind of complexity before since we usually had face-to-face interviews, which took place in our participants' executive rooms, homes, or at the university. Various personal factors and preferences thus influence questions of space: we felt it made a difference in how much the researchers opened up about their concerns and elicited a similar level of understanding from our participants when they worked from their home offices rather than in their relatively anonymous (shared) office buildings. At the same time, some participants felt more comfortable giving interviews at the office because they are calmer than in their home situation. This aspect was also observable regarding the use of webcams of the participants situated at home when we could also look into people's homes (and vice versa) which was beneficial in building a feeling of authenticity.

In setting A, some participants willingly allowed such insights (e.g., showing us their pets or game-related goods) as a way of self-presentation. Others hesitated to give a more extensive glimpse into private spaces because of the spatial and especially family situation and decided to blur their background. In setting B, only one participant used a virtual background; all other participants used neutral backgrounds. A distinction that became particularly apparent is related to the visibility of the recording process since the devices are less visible in remote interviews, encouraging participants to open and share more freely. This finding is consistent with previous research showing that technology-mediated communication can positively impact communication and social interaction (Walther & Parks, 2002). In particular, reduced visibility can help create a more relaxed and informal atmosphere: when participants feel safe, they are more likely to speak freely without fear of negative consequences or judgment (Edmondson, 2018). However, this can also have potential drawbacks since participants are less aware of the recording process, leading to discomfort or distrust. Additionally, reduced visibility can make it more difficult for researchers to ensure the quality of the data, as they cannot observe nonverbal cues as closely.

Technical Affinity and Challenges

Our findings indicate that, from a technical standpoint, age and occupational background did not significantly impact the success of our remote meetings in both settings. The participants' affinity and expertise with technology in the video game company setting enabled us to conduct our meetings seamlessly, with remote meetings being a common practice. Similarly, in setting B, we encountered a few problems setting up the interview situations, and there was no significant difference between age and occupational groups. Our study shows that older participants with varying experience levels, such as an 84-year-old who received a smartphone and laptop from his grandchildren before the pandemic, could quickly adapt to technology-mediated communication. This finding supports that age alone cannot be used to generalize knowledge of technology-mediated communication (e.g. Vines et al., 2015). However, participants with more experience and expertise in using technology were better suited to adapt to remote communication tools.

Despite the participants' technical expertise, our study uncovered several technology-related challenges: in some cases, sporadic connectivity losses and other technical difficulties disrupted the interview flow. In one interview in setting A, the participant's computer crashed, so it had to be rebooted, resulting in a delay. While recording interviews via MS Teams was a convenient way to receive audio files for transcriptions, technical challenges required a laborious workaround and extra work from our participants to provide us with the audio. These technical issues occurred because our university's data center was blocking access to the audio files on MS Teams after the interview, which meant that participants had to upload the files to the company server and provide us with a download link.

We found that using webcams during interviews had several benefits regarding technical equipment since this created a more personal and convenient experience, which helped establish trust and provided additional talking points. However, some participants did not have webcams available. We conducted all non-webcam interviews with already familiar participants except for one. While the lead of user research analysis believed less in the relevance of webcams for everyday business communication, he acknowledged that video conferencing could facilitate better communication for sensitive topics such as annual performance reviews (Sipes et al., 2019).

Flexibility, Efficacy, and Control

Our research experiences during the COVID-19 pandemic differed significantly from our previous studies in organizational settings, particularly in setting A. Offline research in the pre-pandemic period required on-site visits on dedicated days, which led to a lack of flexibility and canceled appointments. The crisis brought the benefit of flexibility in home office situations, allowing participants to integrate research requests into their schedules more efficiently. In setting B, we found that a remote approach increased the willingness of politicians and administrative officials to participate, shortening the time required to schedule interviews from several weeks to just a few days, allowing us to conduct more efficient research and overcome limitations in terms of geographic location and infrastructure. In addition, a calmer, more efficient, and flexible atmosphere at home also applied to us as researchers: traveling to the company has previously been a burden, and our remote study thus paid back regarding our time resources. In setting A, as a result, the interview process provided an efficiency previously unknown to us, with ¾ of the interviews conducted within just a month, whereas, before the pandemic, we could only visit the company twice a month over a quarter-year and collect seven interviews within that time. We observed this also in setting B since the areas are rural and difficult to reach in terms of infrastructure. Using remote interviews, we overcame these limitations, and in setting A, e.g., they also relieved the company's responsibility to accommodate us and prevented our attendance from disturbing business processes.

In setting A, we used MS Teams for the interviews, which had several advantages: participants scheduled and initiated the meetings, provided the recording, and gave us download links. This approach gave them control over the interview and increased trust. The use of corporate means also offered benefits in terms of security, as the software was already trusted and utilized in everyday business activities. In setting B, we used Zoom, and participants received invitations after arranging the appointment. After a technical check, our participants saved and confirmed the recording, which increased control and trust. Overall, the situation offered more flexibility than on-site or telephone interviews.

Lessons Learned and Conclusion

Analyzing the pandemic's dynamics and deriving lessons learned from a crisis is crucial for unlocking the potential for long-lasting collective learning processes (Egner et al., 2015). We think that qualitative research is essential to understand a crisis' social implications (Teti et al., 2020) via 'rapid research' (Hensen et al., 2021; Vindrola-Padros et al., 2020), which means it could be considered "unethical not to carry out the studies during the pandemic" (Vindrola-Padros et al., 2020, S. 2197). We are confident that putting our request to our participants in both settings after the first lockdown phase was acceptable (Buckle, 2021), although such decisions depend on the research settings. Concerning our setting A, the video game industry can be considered one of the 'winners' in the pandemic from a strictly economic perspective (Nicola et al., 2020), compared to more sensitive fields such as medicine and health care (Buckle, 2021; Hensen et al., 2021), or markets confronted with existential concerns (Buckle, 2021; Roy & Uekusa, 2020). In addition, and this is equally crucial, we had the impression that "the interviews were a therapeutic process, where (the participants) could freely narrate their experiences to an external party and feel that their voice was heard" (Vindrola-Padros et al., 2020, S. 2197). Our sentiments were that sharing their experiences during a persistent crisis brought emotional support to our participants; representing ourselves as equally affected by the pandemic aided bonding.

Our gained experiences leave us self-critical that, although reflectiveness and openness are essential prerequisites for a researcher mentality, we hardly questioned the fundamentals and practices of our research processes before the pandemic. Our experiences during the crisis showed us that research could be conducted more practically post-pandemic, supported by increased options because of more manageable and additional access to the research field, offering greater flexibility and efficiency (e.g. Buckle, 2021). Furthermore, we anticipate that we can include more participants from various backgrounds in remote research practices in future studies, which can benefit all parties involved, especially regarding time and cost savings. The fact that a broad audience appropriated video chat services during the pandemic (Beaunoyer et al., 2020; Brohi et al., 2020; Rahman et al., 2020; Vaishya et al., 2020) supports this shift. With our experiences, we also feel that we built future competencies regarding 'crisis readiness' (Caldeira et al., 2022) since we can now rely on a set of online and offline methods applied to meet the fluid context conditions within an ongoing crisis (Gruber et al., 2020).

Despite that, future research should investigate the ecological impacts of remote research. While we saved resources by not traveling to the company's office, we should not underestimate the environmental 'rebound effects' of, e.g., CO2 emissions created by increased use of digital streaming (Baumer & Silberman, 2011; Freire-González & Vivanco, 2020). Furthermore, our previously gained familiarity with the field proved beneficial in gaining access to participants and understanding the context; subtle sentiments researchers pick up when visiting an enterprise (Podjed, 2021; Roy & Uekusa, 2020) to conduct interviews on-site were lost with our remote approach so that relying solely on a digital approach in a post-COVID future seems myopic. Instead, organizational researchers will probably be confronted with more reciprocity of contexts and convergence; this will undeniably be the case with a sustained shift to hybrid work settings (Felstead & Reuschke, 2021), bringing new complexities, especially regarding the three 'spaces' we sketched, but also opportunities for ethnographic research to generate unique insights and facing challenges in terms of a multi-sided ethnography (Akemu & Abdelnour, 2020). Thus, remote ethnography can complement face-to-face research and vice versa (Podjed, 2021).

Most participants were at home and using their cameras, so we looked inside the people's homes (and the other way around). From an ethnographic perspective, this raises ethical considerations regarding data privacy, unintended disclosure of information, and further analysis of the data material. Moreover, having a stable internet connection (Sedgwick & Spiers, 2009) and the necessary equipment (Hensen et al., 2021) is the first prerequisite for participants to attend a remotely conducted study. From an ethical standpoint, this matter is essential as empowering the marginalized and vulnerable is crucial for qualitative (remote) research, especially during a crisis (Roy & Uekusa, 2020). Nonetheless, there are also chances that participants can be acquired more easily remotely (Akemu & Abdelnour, 2020; Barratt & Maddox, 2016; Brown et al., 2021; Dodds & Hess, 2020; MacLean et al., 2021; Teti et al., 2020; Webber-Ritchey et al., 2021).

Building trust and rapport is essential in qualitative research to obtain significant insights (Mealer & Jones RN, 2014; Webber-Ritchey et al., 2021), and despite the challenges of remote research, we established rapport quickly, and participants were willing to discuss sensitive topics. Our participants also suggested additional interview partners, and some volunteered for future interviews. Our shared experience of working from home and concerns about the pandemic likely contributed to the trustful relationship (Brooks et al., 2020; Dey et al., 2021; MacLean et al., 2021; Vindrola-Padros et al., 2020) since we created an intimate and enriching atmosphere for both parties (Munhall, 2007; Webber-Ritchey et al., 2021) by showing empathy and disclosing our sentiments. As technology was the enabler to realize such interactions in times of physical distancing and allowing spatial flexibility, we can derive some implications from a socio-technical side: with remote techniques such as telephone interviews lacking the possibility to express 'nonverbal cues' (Buckle, 2021; Roy & Uekusa, 2020; Webber-Ritchey et al., 2021), webcams, though not a substitute, at least proved to be a step forward (e.g. Janghorban et al., 2014). Thus, while videoconferencing tools usually cannot adequately replicate personal interactions and cannot convey the subtle notions of body language (e.g., McColl & Michelotti, 2019), they gave us a different access mode: we found that providing all parties involved with more flexibility regarding their location, depending on their affordances and preferences, evoked a more relaxed and less 'intimidating' appeal to the interviews. Ergo, we theorize that even if physical access decreased, access to participants' inner thoughts and opinions could improve if their spatial situation, such as their home, reflects a familiar and trusting environment – which can be challenging in pandemic times (Buckle, 2021). This aspect is even more true regarding a reduction of visibility of the researcher on-site since this can provide unique opportunities for more introverted individuals to participate. In this context, we subjectively felt that the virtual approach created a more egalitarian interview situation: the 'classic' interview situation potentially evokes a power imbalance (Velardo & Elliott, 2021) compared to a remote situation in which all attendees see each other in equally sized frames on a screen. Overall, we can thus back claims that remote research should not be regarded as inferior to offline research (Postill, 2016) but rather as a complementary option.

Furthermore, running virtual interview sessions requires careful consideration regarding the choice of applications since each platform must be checked for modality, availability, and security, as showed our experiences with different video systems. In this context, putting the interviewees in control of the process and using familiar software (Gefen, 2000) was arguably the most powerful feature, as it facilitated trust. Future research should address data privacy and security matters, not only from an ethical but also from a technical side (Grandinetti, 2021; Hensen et al., 2021; Mealer & Jones RN, 2014), regarding the different services and technologies. During our study, we experienced technical drawbacks (Dupuis & Renaud, 2020), and flexibility helped us navigate critical situations. Regarding technical aspects, future research could dive deeper into the potentials of, e.g., video-calling spaces (Song et al., 2021) or virtual reality, which could provide exciting features (Bennett, 2020) and the purpose of anonymity (Barratt & Maddox, 2016; Hensen et al., 2021). More work is also needed to compare the complexities and contingencies of diverse research contexts.

Furthermore, our research activities covered solely individual interviews, a format that arguably offered the lowest threshold compared to other remote approaches used during the pandemic, e.g., interactive systems for remote ethnography (Ju et al., 2021) or digital ethnography of the internet's sphere (Góralska, 2020). Our focus also excludes remote approaches to co-design (De Bleecker et al., 2018). Nevertheless, the general shift to a virtual space provided valuable lessons learned for researching in times of crisis and proved to be a catalyst for positive change for a post-pandemic era, respectively the 'new normal.'

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Augmented Reality enhanced device usage training tool for in-home health-self-monitoring by pregnant women

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Abstract. Virtual care comprising virtual visits and monitoring via audio or video has the potential to reduce access barriers to care and has been successfully implemented in prenatal care. It reduces the frequency of in-person visits and increases self-care skills. However, the knowledge and competence in handling monitoring equipment at home directly influences satisfaction and engagement with the system and the quality of the information provided to healthcare professionals. Therefore, providing ad-hoc training to end-users would help develop confidence in using devices at home correctly. This paper proposes an augmented reality (AR) application to guide and train pregnant women to use monitoring devices. The aim is to instruct pregnant women to use the monitoring devices and follow the video guidelines for handling them correctly. It validates pregnant women's encouragement and ability to self-care for their pregnancy.

Introduction

Nowadays, telehealth or virtual care interventions are gaining popularity in different healthcare sectors, including pregnancy (Nelson & Holschuh, 2021). Telehealth or virtual care comprises synchronous virtual visits via video or audio incorporating bi-directional communication/consultation between healthcare professionals and patients or asynchronous communication, remote patient monitoring, data transmission, and data sharing (Ghimire, Martinez, et al., 2022). Owing to the potential complications and being highly vulnerable to spreading diseases and pandemics, pregnant populations were stringently advised to follow healthcare measures during the COVID-19 pandemic, highlighting the relevance of virtual prenatal care (Almuslim & AlDossary, 2022). Virtual prenatal care includes remote monitoring of pregnant women, where pregnant women monitor their health status themselves by using different medical equipment such as blood pressure sensors, devices, etc. (Ghimire, Martine, et al., 2022). It has the potential to reduce access barriers to care, and increase self-care skills, allowing a reduction in the frequency of in-person visits. However, it necessitates the qualification of pregnant women to handle such devices.

Moreover, it is crucial to guide and qualify medical users in adapting to handle medical devices to achieve safer, more efficient, and effective outcomes (Ribeiro et al., 2019). With the advancement in biotechnology, wearables, and other medical and healthcare sensors and actuators, the need for medical users to be well-qualified to use such devices correctly and efficiently has increased. It often requires specialized engineers to handle more complex and specialized medical devices and their functions (Ribeiro et al., 2019). With virtual prenatal care, pregnant women, as central users, need the training and skills to handle those monitoring devices that are essentially for the routine assessment of the health status in virtual prenatal care. However, not every pregnant woman has all the skills to operate all required devices and their functionalities. Most of the pregnant women from regional areas or low-income groups generally lack technical skills and have no health literacy or are illiterate, thus, it is very challenging for those population to handle the devices, take measurements accurately and interpret those measured data. According to the studies on pregnant women's experiences and satisfaction with virtual prenatal care, discomfort in using devices and technical incompetence in handling device by pregnant women themselves was the significant barrier to participating and continuing virtual care at home (Ghimire, Martinez, et al., 2022). Thus, the usability of virtual prenatal care that includes self-monitoring of the health status of pregnant women themselves demands a state where the users can perform the monitoring more efficiently and effectively while enjoying the experience. The emerging Augmented Reality (AR) technology that overlaps virtual objects/ information on top of the real environment (Carmigniani & Furht, 2011) is a promising option explored in this study with the aim to instruct or guide the device users by superimposing device-relevant information on top of the device itself.

This paper proposes an application for mobile devices using AR to improve the usability of monitoring devices for pregnant women at home. With the support of AR, pregnant women can access information and guidance about the use and operations of their devices through several informational images and videos. It seeks to provide numerous information on the initialization of the device and measurement procedures, characteristics, risk factors, and interactive contents related to the device and measured values. The overall architecture of the system is illustrated in Figure 1. General monitoring devices used in routine prenatal visits, such as blood pressure monitoring device, oximeter, and temperature sensor are integrated into the presented prototype of this application.

Related Works

AR has been implemented in various fields, including medicine, in several ways: educating patients, students or medical staffs, training or procedural plannings, visualization aids in practices, remote collaboration, and telemedicine (Arpaia et al., 2021; Chamberlain et al., 2016; Cox et al., 2019; Munzer et al., 2019). Most AR applications as educational tools are employed for medical staff, students, or patients to educate them in specific disease or area of disease (Nifakos et al., 2014; Ribeiro et al., 2019). No studies have been found that employs AR for training patients to use medical devices themselves at their own home in remote patient monitoring. Similarly, numerous works have been done for prenatal care and virtual prenatal care, including remote monitoring of pregnant women (Ghimire, Martinez, et al., 2022); however, none employed AR for medical device use. Also, there exists an augmented reality tool for remote assistance to remotely guide people in factories or in need of assistance without being there, however, it is less practical for the rural regions where there is a lack of healthcare providers, and providing remote assistance has time constraints. Thus, we propose a system that supports pregnant women in handling the devices on their own, reducing the burden on healthcare providers.

Methodology

The proposed application of AR technology is a learning tool to provide information and guidance for the operation of specific healthcare self-monitoring devices is validated experimentally with a corresponding proof-of-concept prototype. The overall architecture of the system is illustrated in Figure 1. It contains three elements, which interact with each other, the users (pregnant woman in this specific study case), the user device (i.e., a mobile phone), and the real-world entity (i.e., the included monitoring devices). The prototype is developed following a rapid application development (RAD) approach, which consists of three main phases: requirements and problem definition, prototype design and development, and testing in terms of functionality and usability (Abd Ghadas et al., 2015; Kirpitsas & Pachidis, 2022; Martin, 1991). It is a software development process based on prototyping, where more priority is given to the development task than on the planning. It aims to develop a system in a short period of time. This methodology has been selected for faster development and implementation of the application, as it aims much faster development and implementation than the other methodology by collaborative participation of users in prototyping (Abd Ghadas et al., 2015; Kirpitsas & Pachidis, 2022; Martin, 1991).

Requirements and problem definition

This phase aims to identify problems, investigate existing works in the related fields and discover user requirements and gaps within them. Thus, a literature study was conducted to explore the information regarding approaches in practice for in-home monitoring systems for pregnant women and to investigate the used technologies, especially for supporting pregnant women in using monitoring devices correctly. The literature study on an in-home monitoring system for pregnant women to explore the technology used and its effectiveness and barriers indicated that training and usage support for handling monitoring devices is a prerequisite for the effective usage of an in-home monitoring system (Ghimire, Martinez, et al., 2022). A total of 23 studies were selected and analyzed in order to investigate the shortcomings and open issues of in-home monitoring systems for pregnant women. The study's findings demonstrated that pregnant women were more hesitant to use the whole monitoring solution due to a lack of skills and knowledge for correctly handling the monitoring devices (Ghimire, Martinez, et al., 2022). Thus, to address this issue, another literature study was conducted to explore the feasibility of technologies that have the potential to improve the effectiveness of training tools (Ahmad et al., 2021; Arpaia et al., 2021; Chamberlain et al., 2016; Cox et al., 2019; Ginting et al., 2021; Munzer et al., 2019; Nifakos et al., 2014; Nurlaily et al., 2021; Ribeiro et al., 2019). The preliminary search and analysis were performed in Google Scholar and Scopus to avoid duplication of the work, identify relevant articles addressing the problem in the first literature study (Ghimire, Martinez, et al., 2022), and ensure the availability of enough articles for the analysis. The literature study also gathered data from similar research fields to find useful technology that fits with problem statement. From this literature study, it was found that AR technology has been used as a training tool for educational and training purposes in a wide range of medical fields. However, no studies were done in the field of in-home monitoring systems, especially targeting the patient to make them handle the monitoring devices themselves.

Thus, the findings from the study revealed that the requirement or the target problem is the (potential) lack of skills and competencies of pregnant women in handling pregnancy monitoring devices themselves as part of an in-home pregnancy monitoring system. Since incompetence or lack of knowledge in handling equipment can result in reduced engagement to the system and likelihood of discontinuing the system, it directly impacts the overall success and efficiency of the monitoring system and its sustainability.

Prototype Design and Development

In this phase, the prototype development of an augmented training tool for handling monitoring devices for pregnant women was conducted, for which augmented reality technology was utilized. This augmented reality application was developed using Unity (Unity Engine 2021.3.4f1) (Unity 3D) and the AR foundation for Android smartphones. The application allows pregnant women to easily access device information and measurement guidelines on scanning the device with the application on their smartphone. The prototype supports two different medical monitoring devices for pregnant women, a blood pressure monitoring device and a pulse oximeter, which are generally used in routine prenatal visits. The prototype testing and evaluation were done using a Samsung phone (Samsung Galaxy A53, android OS), where two monitoring devices, an A&D UA-651BLE blood pressure monitoring device and Nonin Onyx 9560 Fingertip pulse oximeter, were used as a test device.

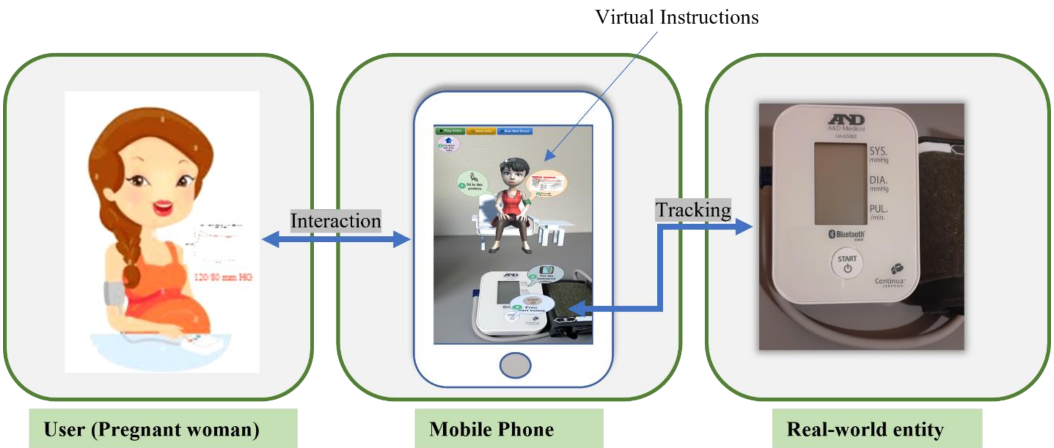

Figure 1. Augmented reality system architecture of the proposed application.

Testing: Functionality and usability

In this phase, testing and evaluation of the application were performed. Specifically, the functionality and usability of the application were assessed to find if the users find its functionality easy, usable, and appropriate. The testing was based on lab usability testing following a qualitative approach. For this, twenty potential users were involved, who had no previous experience using augmented reality application and were divided into different groups. The lab usability test was carried out in the usability laboratory at the University of Agder Grimstad/Norway, where the test users were asked to complete specific tasks (as listed in Table 2) using the application prototype. One group of participants was divided into "test user" and "observer" and allocated to corresponding rooms. Two rooms divided by a one-directional mirrored window were allocated for the test, where the test users, together with the test instructor, stayed in a test room, while the observer stayed in the controller room observing the test through the mirrored window. All the test users were asked to use the app with different medical devices and to test and evaluate the overall functionality. The focus of the test and evaluation was the usability of the prototype application and the efficiency to provide information to the test users that allowed them to achieve their goal in learning about the device operation and to collect feedback and suggestions on the overall system. Also, this approach allowed us to collect qualitative data about the users' attitudes and reactions and to provide instant feedback on their questions in real-time.

Table I. Areas asked to the participants for testing and evaluation of the App

SN	Title
1.	Usefulness of the instructions provided in the app
2.	Usefulness of the app
3.	Clarity and alignment of the virtual and real image in the app
4.	Overall functionality and user interface in the app
5.	Easy to use
6.	Improvement ideas

Results and discussion

Description of the developed prototype

The prototype included training and usage information for two monitoring devices, a blood pressure measurement device and a pulse oximeter. However, more medical devices and their training and handling information can be uploaded to the system. The overall functionality of the application is as described subsequently. When the pregnant woman opens the training and usage support app on her mobile phone to scan a monitoring device, e.g., a blood pressure measurement device, the virtual image of a woman appears on the mobile phone screen, presenting instructions about handling the monitoring device. In addition to the augmented instructions, three buttons appear on the mobile screen, allowing pregnant women to access further information, as shown in Figure 2. The instructions for handling the device give basic step-by-step pop-up instructions on where and how the device should be attached to the pregnant woman's body and how the measurement is done. If the information in the instructions is insufficient to learn to handle the measurement device, a pregnant woman can use the support buttons on the mobile screen. The *play video* button allows pregnant women to watch a video that gives detailed instructions on using the particular device. The video can also be played in full-screen mode. The second button provides information about the follow-up on the measured values. It gives information about the measured values and associated risks, especially data interpretation. Once the first and second buttons are clicked to watch a video or to get information on the interpretation of the measured values, the app stops tracking the device so that the pregnant woman can watch the instructional video without focusing the camera on the monitoring device and use the device for measurement. Also, she can see the information about potential risks associated with the measured values. The third button allows the scanning process for the next monitoring device by starting to track the device.

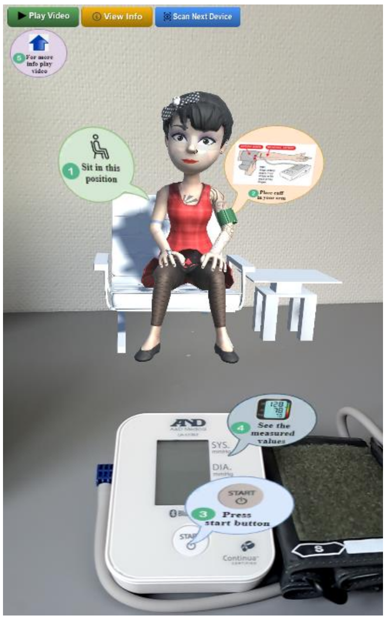

Figure 2.The app screen with instructions after scanning the monitoring device.

Results of testing and evaluation

The prototype was evaluated by nursing students as representative general pregnant women to evaluate how the system can guide pregnant women in using the application. The test and evaluation addressed the functionality and usability of the application and involved 20 nursing students (4 groups of 5 students). Among these 20 students three were male and 17 were female nurses. It was found that none of them were familiar with AR technology or AR applications. The participants were asked about the perceived usefulness of the provided instructions and usability of the app. The overall responses obtained from the test users are shown in Table 3. All participants (100%) expressed that the app was useful and relevant for pregnant women to use as a training tool. They showed their acceptance of the application. They expressed the application's ability to display the usage instructions for monitoring devices just by scanning them, without any need to type device names or to search through the application/internet or any requirement to have any training to use the application and enter the login information, as an insightful advantage. It is an easy and fast process. In addition to the provision of basic instructions, the possibility to access a more detailed instruction guide via video and other relevant information about the monitoring device was mentioned as the other positive aspect of the app. However, using the AR application as a training tool to support the measuring process by seeing usage instructions in the application was difficult due to the movement of the virtual image and the included instructions with the real device, which they (25% of them) considered a negative aspect in terms of usability.

They expressed that the app could be more useful if the virtual image and the instructions could be viewed constantly in a fixed position without the need to focus the app on the real monitoring device continuously. On the other hand, evaluation regarding the intuitiveness of functionality and user interface of the application was not satisfactory. Half of the test users were satisfied with the functionality and user interface, while the other half were not. All the users (100%) expressed concern about the text size of the instructions displayed on the mobile screen, where the virtual image could be magnified while the instructions could not. Some suggested that animated instructions could be more efficient than the tested approach of augmented instructions.

Table II. AR mobile application usability testing (n=20)

Title	Positive Response	Negative Response
Usefulness of the app	20 (100%)	0
Clarity of the instructions provided in the app	0	20 (100%)
Clarity and alignment of the virtual and real image in the app	15 (75%)	5(25%)
Easy to use	15 (75%)	5 (25%)
Overall functionality and user interface in the app	10 (50%)	10 (50%)

Some of the instant feedbacks provided by the test users after testing the application is listed below:

User 1:

"The application is very interesting, simply by scanning the device we can visualize the instructions."

User 2:

"The instructions are not visible and *since the instructions are also not stable and moving, how could a pregnant woman use the monitoring device by having the mobile phone in one hand? This might be less practical."*

User 3:

"This application could be more useful specially for other devices that are more complicated to handle."

User 4:

"Difficult to scan the device, the alignment of the virtual image is sometimes moving."

Considering the improvement suggestions by the users, the prototype has been iteratively developed further. The virtual image's position and instructions can now be fixed anywhere by the user by tapping in the desired location on the mobile screen. Also, the instructional text is now visible and can be magnified. Besides, implementing animated instructions is a promising approach to further improve the usage support for monitoring devices, and will be considered in future work.

Conclusion

AR application in handling monitoring devices for pregnant women in an in-home monitoring system was successfully designed and developed throughout several phases. The users' responses and suggestions show that AR can be easily used in a virtual care environment to support patients at home without healthcare professionals, providing more efficient healthcare practices for healthcare professionals. In future work, it is worthwhile to assess users' needs and requirements by directly involving users in system design and development. For this, human-centered methodologies such as focus group discussions, interviews, and questionnaire surveys will be considered.

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Sink Twice – Research through Design to promote sustainable usage of water at your home

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Abstract. The reusability and mindful consideration of water consumption within households, while often overlooked, can yield substantial benefits through even minor conservation efforts. Encouraging behavior change in a context of consistent water access presents challenges. This study employs the Research through Design approach to investigate the potential for significant cost and carbon emission savings by reusing "not dirty" water from kitchen and bathroom washbasins through sustainable means, thus reducing reliance on water filtration from sewage systems. Additionally, we aim to enhance our understanding of water wastage in domestic contexts by examining everyday activities like fruit and vegetable cleaning, face washing, and tooth brushing. The water collected by Sink Twice is unfiltered and lacks lab-tested data on mineral content, micro-nutrients, or pathogens for human consumption. Our focus is on observing behavior changes and informed choices when repurposing water in typical households. The study involves five participants divided into two groups to comprehend how the introduction of the Sink Twice device impacts their household behaviors.

Introduction

"Little drops of water make the mighty ocean"(Wolff, 2009). The issue of water consumption is not limited to developing countries; it affects developed nations as well. As times change and our lives in civilized societies become more comfortable, we tend to become unmindful, stubborn, and apathetic towards natural resources that may seem readily available in our well-designed homes but are not abundant. Managing water and ensuring its purity becomes increasingly challenging in arid regions with high population density. We have failed to encourage industrialists to refrain from discharging their waste into our rivers and ponds, but such discussions are often silenced by capitalism. In India, the repurposing of groundwater or fresh water is gaining momentum due to the drying up of lakes and rivers in cities (Kumar and Goyal, 2020).

This situation provides an opportunity to investigate whether reusing water within homes can promote mindful thinking when turning on the tap. Instead of solely relying on the government or other entities to provide fresh water, we can multipurpose the water we typically drain without reason. Sometimes, we are not held accountable for our behavior, and that is where an artifact like Sink Twice can play a crucial role. Sink Twice acts as a trigger, allowing users to actively observe the water being drained into the sewage system as they hold it in their hands, feeling its increasing weight. We had approximately three months to ideate, prototype, test, and evaluate our results. Employing the Research through Design approach, we dedicated most of our time to developing and prototyping the idea using cardboard and 3D printing in the University of Siegen's Fab Lab. Among the ten participants who filled out a survey questionnaire to understand water-saving availability and motivations in their homes, five were selected to use Sink Twice for seven days, followed by interviews at the end.

In the subsequent chapters, we will delve deeper into the methods and analysis of water reusability in different social situations. We will also engage in a comparative discussion between grey water filtration and the focus on saving treated water from entering the sewage system directly.

State Of The Art – Literature Review

The review spanned the period from 2018 to 2023 and concentrated on sustainable strategies for water conservation, household water reusability, and the application of design thinking in water-saving practices. Primarily sourced from reputable journals, the works aimed to confront the water-saving challenge within domestic environments.

A notable concern in water management involves greywater, originating from kitchen sinks, bathrooms, washbasins, and laundry. Typically, this water is either directed through sewage systems to filtration plants or released into water bodies. Both approaches incur considerable filtration and distribution costs, with untreated greywater posing health risks, even for irrigation. Nevertheless, greywater has found applicability in toilet flushing within households (Kuang-Wei et al., 2018). A study focused on implementing an in-house filtration system for treating greywater (Pravin et al., 2022). Evaluated over six months with an Indian family, the study assessed water composition for reuse, without investigating behavioral shifts post-installation. The treated water remained unsuitable for consumption. Another study aimed to segregate water sources for improved reusability through filtration (Delhiraja and Philip, 2020), revealing a lack of user behavior consideration in household research. Approximately 50% of domestic light greywater can be minimally filtered for safe reuse [9], although empirical support is lacking. A theoretical framework explored behavior change related to greywater and wastewater reuse, encompassing various factors. The study involved 280 Miami households, categorizing users by adoption potential, anticipating behavior shifts over 20 years (Kambiz et al., 2017). Water conservation feasibility varied across faucets and appliances. Despite its theoretical nature, the study posed pertinent questions about household water usage. Analyses of home water patterns showed peak wastewater flow in the morning, reducing during the day. Categorizing greywater reusability by source can reduce filtration costs and conserve up to 57% of freshwater (Cheng et al., 2020). Another study introduced an optimized filtration unit (Cheng et al., 2020), highlighting the importance of user behavior. Research indicated that 49-70% of domestic greywater in developed and developing nations can be reused (Makgalake et al., 2020), but practical solutions were absent. The theory of planned behavior was employed in Ghana (Otenga-Peprah et al., 2020), revealing cultural influences on water usage. A greywater reuse framework emerged (Shafiquzzaman et al., 2018) through research in Oman. A Turkish case study emphasized policy reform and awareness, aligning with the 6Rs framework for wastewater management (Maryam and Büyükgüngör, 2019). The COM-B model analyzed water conservation behavior (Issac et al., 2018), highlighting tailored solutions. An Indian study designed a product for greywater repurposing (Pandit and Gupta, 2022), overlooking wider waste management considerations. In Germany, a study explored recycled water usage (Schmid and Bogner, et al., 2018), underlining the need for gradual adoption. A Cape Town campaign sought water-saving (Azaki and Rivett, 2020), revealing challenges in reusability adoption.

The Sink Twice concept addresses these issues, fostering water conservation and repurposing without intricate designs, focusing on practical and sustainable change.

Methods and Setting

Growing up in an arid Indian town, my mother strategically placed water vessels around the house due to summer water scarcity. She reused water for various tasks, like rinsing utensils with rice water. In contrast, in water-abundant Germany, I observed fresh drinkable water being wastefully used. This prompted us to embark on a research through design (RtD) journey (Zimmermann et al., 2010) to comprehend water sustainability and reusability issues. We employed design thinking in a process of define, research, analysis, prototype, and evaluation (as shown in Figure 1), iterating until a suitable model emerged. Our RtD approach aimed to uncover behavioral shifts in water usage at home. This led to the concept of Sink Twice, a prototype given to participants for a week. Interviews informed our understanding, and design thinking guided prototype creation (Brown and Wyatt, 2010). Conversations with Germans facilitated a concept map, illuminating their water conservation and reuse perspectives.

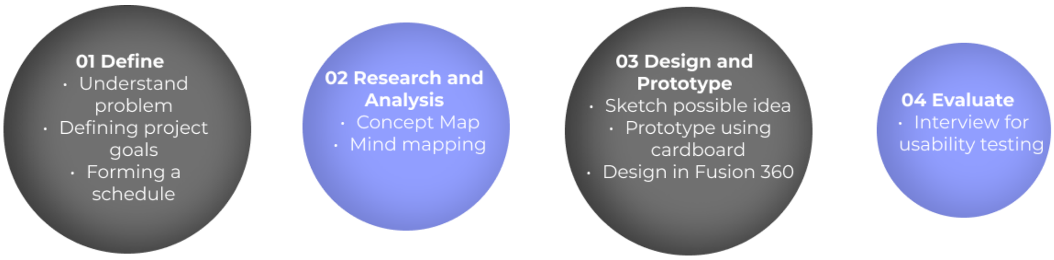

Figure 1. Design thinking steps involved during the process of Sink Twice development

During the creation of infographics to elucidate Sink Twice's purpose and use, we encountered challenges in symbol visualization. Thus, a mind map (depicted in the figure) was conceived and then translated into symbols for our infographics. The prototype design underwent successive stages, initially being sketched on paper. Satisfied with the design, we fashioned cardboard prototypes, which were subsequently translated into Autodesk Fusion 360 designs and 3D printed using PLA filament to match standard square kitchen sink dimensions. Sink Twice a minimalist design, effectively prompts users to reflect on water wastage at home without relying on IoT, alarms, or sensors. Its design intends to heighten user awareness about rapidly flowing water, achieved by employing a slanted shape and water-retaining markings. Remarkably, Sink Twice fits onto existing kitchen sinks and washbasins without the need for alterations, seamlessly integrating into daily routines. Our user study transpired in Siegen, employing a Convenience sampling strategy. Participants were selected via student hostel WhatsApp and Telegram groups, and a survey served as the gateway to the design case study. Proficiency in English was a prerequisite. Despite challenges posed by the summer break, we obtained responses from 10 participants and shortlisted 5 based on availability. These participants represented diverse backgrounds, as tabulated in Table 1. Each user incorporated Sink Twice into their living spaces, allowing us to observe its integration firsthand. Researchers visited participants to understand sink configurations, discuss sustainability, address artifact queries, and, after a week, conducted recorded, transcribed semi-structured interviews in MAXQDA, lasting 5 to 20 minutes. Analysis entailed multiple steps, including open coding, grouping codes, and identifying core categories germane to understanding domestic water use practices at sinks within socio-cultural contexts. The objective was multifaceted: unravel intricate facets and comprehend these practices and contexts more profoundly. Researchers analyzed data collectively and individually, ensuring inter-subjective reliability and quality control. By grasping participants' sustainable attitudes, cognitive processes, and behavioral tendencies, we intend to bridge the gap between sustainable thinking and practical action in future application development.

Table 1. Participant information and demographic information

User Name	**Age**	**Gender**	**Nationality**	**Status**	**Living Condition**	**Type of User**
User_1	23	Female	Indian	MSc HCI student	Student Hostel with shared kitchen	Without infographics
User_2	25	Male	Indian	MSc HCI student	Student Hostel with shared kitchen	Without infographics
User_3	29	Female	Vietnamese	MSc HCI student	Private housing WG with shared kitchen	Without infographics
User_4	30	Male	Bangladeshi	MSc HCI student	Student Hostel with shared kitchen	With infographics
User_5	30	Female	Pakistani	PhD Physics	Studio apartment	With infographics

Empirical evidences

Purposes of Sink twice by users

The majority of our users resided with two to five occupants, except for one user in a studio apartment who didn't share common areas. In shared spaces, flatmates often avoided using Sink Twice due to breakage fears. Users without access to infographics used Sink Twice in kitchens for washing vegetables, utensils, and soaking spoons after scooping Nutella. This reduced water usage and cleaning needs. They stored waste water to rinse utensils or water plants. The artifact was also used in washbasins for face washing, menstrual pad cleaning, and toothbrush rinsing. Users with infographics primarily used Sink Twice in kitchens and washbasins for various tasks. User_1 to User_4 used it 5 times a week, up to 2 times daily, and User_5 used it thrice for mindful water usage. In design, we initially considered rectangular or square sink dimensions, assuming a snug fit.

But, users had varied sink sizes and shapes, leading to occasional removal of the artifact for regular tasks. Users with narrow sinks or shared spaces had to temporarily relocate Sink Twice. This was consistent with bathroom washbasins too.

In conclusion, the behavior change observed among the users demonstrated the effectiveness of the Sink Twice device in promoting water conservation and mindful usage. However, the varying sizes and shapes of sinks presented challenges, highlighting the need for a more flexible design.

Figure 2. Sink Twice prototype placed on the user's kitchen basin and bathroom washbasin.

Conscious perception of water wastage and immediate practices

The utilization of Sink Twice as a vessel to visualize rapid water consumption can lead to immediate behavior changes as shown in Figure 2. For instance, leaving the tap running while brushing teeth or washing the face prompts users to realize the extent of water waste:

> "Yes, it made me a bit conscious... I turn tap off when I am ready to splash my face and use the water from the Sink Twice, because I scrub my face first so I turn it on when I am done scrubbing." (P2)

The application as alarm, reminder, and trigger

Sink Twice serves as a reminder and trigger for mindful water usage. In kitchens and bathrooms, where people often neglect sustainability, its presence prompts users to consider water wastage and reusability:

> "I will count all those reminders as part of the usage... kept me reminded about water wastage." (P5), "It just makes me trigger to use the water which is already kept in the Sink Twice to re-use it." (P3)

Stimulation of moral reflections

It was also noted that users tried their personal reflections and moral point of view regarding the water wastage

Affordance

Considering user living conditions, the size of Sink Twice became an issue. Users with limited kitchen space found it cumbersome, especially in shared kitchens, leading to artifact removal during regular tasks.

More motivations beyond sustainability of water usage practices

Sink Twice not only promotes sustainability but also simplifies tasks. Users soak utensils, reducing cleaning effort. This demonstrates the impact of using products or symbols on behavior over time.

Hygiene involved with water re-usability

Repurposing stored water raises hygiene concerns. Users used Sink Twice for various purposes, like rinsing menstrual pads, highlighting diverse perceptions of cleanliness:

> "This is a weird usage, so I use re-usable panty liners, re-usable menstural pads for eco-friendly menstruation I use the stored water form sink twice to rinse them." (P2)

Here we can think and question what makes dirty for some users is not same as for other. Infographics aided users in understanding water status for different uses

Ideas for improvements

Sink Twice's design evolved through rapid prototyping, considering user needs and living situations.

Improvement in product: Suggestion by users

As mentioned in section p*urposes of Sink Twice by users most users* lived in compact spaces and suggested a more compact Sink Twice to fit smaller kitchen sinks and oval washbasins. Hanging options for single occupants and faucet attachment for easier water removal and utensil washing were proposed. Precise ml markings were also recommended.

User suggestion in info graphics

Users found infographics helpful and suggested projecting data on walls for increased awareness of saved water's impact on the environment.

Discussion

The study underscores the potential of a simple device like Sink Twice to directly influence household practices and reshape behaviors concerning water consumption. While existing literature primarily centers on promoting the filtration of greywater or wastewater for sustainability, our approach highlights the significance of conserving every drop of wastewater through uncomplicated methods, enabling users to allocate water mindfully for diverse tasks. The Sink Twice, boasting a 1-liter water capacity, prompts users to utilize only the necessary amount for activities like rinsing a spoon, rather than allowing the faucet to run for an unnecessary 6 seconds. Nevertheless, the adaptations in water usage by research participants stem from more than just moral attitudes. The study uncovers that even in water-scarce cities like Cape Town, efforts are underway to leverage persuasive technology for sustainable water usage (Azaki and Rivett, 2020). Here, active moral consciousness and individual initiative are crucial to curbing water wastage. The precise degree of moral influence required for users to consider their water use thoughtfully remains uncertain. The study also unearths other motivating factors, such as bypassing certain practices due to perceived inconvenience or the utility of the device. This, in turn, reduces the need for frequent utensil rinsing and streamlines kitchen tasks, along with personal grooming routines like brushing, face washing, or shaving.

Comparatively, against initiatives involving reusable equipment for floor mopping and plant watering (Pandit and Gupta, 2022), or relying on government agencies for responsible water resource allocation (Schmid and Bogner, 2018), it's evident that a third catalyst often triggers users to adopt mindful water usage. Our primary focus revolves around nurturing lasting behavioral shifts, transcending the presence of the Sink Twice device. A noteworthy example is User_5, who developed the habit of saving water in a separate container for soaking dirty utensils after cooking. Our research also uncovers novel insights regarding perceptions of dirty versus clean water. Generally, literature centers on purifying impurities in wastewater and greywater for reusability. However, reimagining water usage is a relatively new concept (Maryam and Büyükgüngör, 2019). Users tend not to view the water stored in Sink Twice as unclean, owing to their confidence in its hygiene. They even employ it to clean razors and nourish plants, showcasing a circular economy approach to water waste. Notably, users also engaged in cleaning menstrual panty liners, shedding light on the gendered dimension of water usage. If Sink Twice were shared among couples or households, insights into the "dirty pictures" effect within communities could be gained. This prompts consideration of whether individuals perceive water as tainted if touched by others, sparking further exploration into water's transformative role in relation to people and the environment. Although the Sink Twice's stored water in the current prototype isn't fit for human consumption, it is safe for repurposing with no chemical content for plants, animals, and birds like the water after rinsing utensils, washing vegetables or fruits, starch from rice etc. This suggests a potential avenue for enhancing the device's water quality for broader use.

Finally, reflecting on improvement ideas, our initial prototype design catered to one sink type. Subsequently, recognizing diverse sink shapes and sizes in users' bathrooms and kitchens, we understand the need for a more adaptable design. Furthermore, optimizing the design for compact living spaces, allowing for wall-hanging, is essential. Improved water removal mechanisms, even when hands are dirty, should also be considered. Overall, users found the design intriguing and expressed interest in future iterations with added features. The current info-graphics on Sink Twice demand redesigning to provide a clearer usage illustration.

Conclusion

In conclusion, our study yields insightful perspectives on behavior change in the context of abundant resources, augmented by subtle prompts and active engagement. Sink Twice's user-friendly design allows secure water storage for various household applications, though not intended for human consumption. Our research, involving five participants with diverse backgrounds and living conditions, provides profound insights into communal water practices. Participants' week-long Sink Twice engagement reflects sustained interest. However, production constraints limit extending trials in this master's research. Future research may explore prolonged trials, diary-based experiences, or app-recorded water usage. Developing cost-effective filtration methods alongside Sink Twice, enhancing water circulation and potability, offers potential. Integrating sensors for flow detection and insights could enhance the design's impact and functionality.

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Enhancing Smartwatches through Value-Sensitive Design: Fostering Immediate Usefulness and Value Sensitization

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Abstract. This research employs Value-Sensitive Design (VSD) to investigate the user values associated with smartwatch use, with the objective of integrating these values into the design process. The study aims to provide insights that balance technical opportunities with ethical design responsibilities. An empirical investigation was performed collecting data through interviews with smartwatch users, developing a novel smartwatch prototype and organizing iterative feedback sessions. A key finding is that several of the values deemed important by researchers have limited significance for actual users emphasizing the need for designers to accommodate immediate user needs and also, introduce novel features to raise awareness. Future research directions include interventionist approaches to explore end-user customization options to accommodate individual needs and evolving user preferences.

Introduction

This paper uses Value-Sensitive Design (VSD) (Friedman et al., 2017, Friedman et al., 2013) to explore user values related to smartwatches and to suggest ways to inscribe these values to smartwatch design. While smartwatches offer many useful functions, they also introduce new difficulties and ethical complexities (Cecchinato and Cox, 2017, Foster and Torous, 2019). For instance, smartwatches can collect personal data about their users, which can be used for surveillance or marketing purposes. Additionally, smartwatches can be used to track people's movements, which can be a privacy concern. Also, the constant accessibility of information and functionality on smartwatches, coupled with users' tendency to check them frequently, makes them prone to causing distraction. The constant stream of notifications can pull users' attention away from the present moment and the activity they are engaged in. The aim of this research is to provide insights for the design of smartwatches that satisfy practical needs while also upholding ethical principles. By looking at smartwatches through the eyes of ordinary users, this work aims for solutions that balance between technical opportunities and ethical design responsibilities.

Friedman and colleagues defined VSD as a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process (Friedman et al., 2013). VSD can lead to designs that better align with users' needs, values, and preferences (Harbers and Neerincx, 2017, Strikwerda et al., 2022). To account for the relevant values and mitigate the impact of biases ingrained in technical artifacts (van den Hoven, 2017), VSD deploys an iterative tripartite method which includes a conceptual investigation, an empirical investigation, and a technical investigation. This tripartite method was followed in this study.

Method

As a first step, we identified in the literature (Friedman et al., 2013, Maathuis et al., 2020, Umbrello, 2019) values that are commonly listed as important. Specifically, the values identified in the literature are: security, privacy, transparency, sustainability, performance and reliability, control, trust, and human welfare. Subsequently, we empirically investigated the significance of these values for smartwatch users identifying the ones that are perceived as most important for them. For the technical investigation we integrated the values identified within prototypes and assessed them with users. We refined the prototype designs using user feedback ending up with a proof of concept that can be adopted by the industry. By focusing on the needs, perspectives, and priorities of smartwatch users themselves, this research provides design recommendations that are sensitive to values and consider user preferences. The process is illustrated in Figure 1.

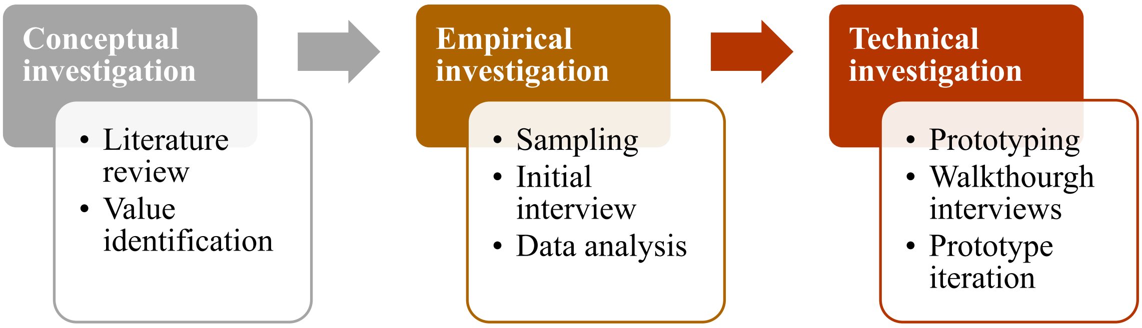

Figure 1. Overview of the methodological VSD process followed

The empirical investigation includes interviews with smartwatch users to investigate their values and views. In total, we performed 21 semi-structured interviews. Semi-structured interviews allow for consistency while also permitting flexibility to explore unanticipated topics that emerge. The first part of the interview related to their general use of the smartwatch. In the second part of the interview, the interviewees were asked directly about the values that were identified in the literature search. They were asked if they found these values to be important to them, if they could see some current issues relating to the values, and if there was room for discussion about their related experiences. In the end, they were asked to name the values that are very important to them. The age range of participants is 20 to 57 years old. However, the majority of the participants are in the 20-29 age range, reflecting the demographic that tends to use smartwatches more. The participants were recruited using snowball sampling. This means that initial interviewees were identified and then asked to refer other potential participants. An overview of interviewees is presented in table I.

Table I. Overview of participants

Gender	
Female	10
Male	11
Age	
20-29	14
30-39	2
40+	5

ID	*Gender*	*Age*
U01	F	20-29
U02	M	40+
U03	M	40+
U04	M	20-29
U05	M	20-29
U06	F	30-39
U07	M	40+
U08	F	20-29
U09	F	20-29
U10	M	20-29
U11	F	40+
U12	M	30-39
U13	M	40+
U14	F	20-29
U15	F	20-29
U16	M	20-29
U17	F	20-29
U18	F	20-29
U19	M	20-29
U20	F	20-29
U21	M	20-29

The recordings from the interviews were transcribed and coded according to values discussed. After all the interviews were coded we created a comprehensive set of objectives with associated functions and effects that would help us when developing a prototype following the approach suggested by Harbers and Neerincx (2017). The section that follows presents the findings.

Findings

User values - insights from interviews with smartwatch users

Most study participants stated that performance is the most important aspect in smartwatches. Interestingly, issues like sustainability, privacy, security, transparency are not prioritized. Overall, several of the users interviewed are not senistised towards most of the values deemed important in the literature.

When questioned about the importance of security, several participants stated that they had not thought about it or that they just expect smartwatches to be secure.

"I don't really think too much about it, at least not in relation to my smartwatch." (U02)

"I expect it is secure, but at the same time the information stored on my watch is limited." (U06)

However, some users did consider security to be important especially related to personal data or payment authorisation:

> "The only reason I think security is important is really because of weight. I don't want it to suddenly be posted on Facebook, for example." (U01)

> "I know that on some watches, you can link it so that you can pay with the watch in stores. If this is registered, security is important." (U10)

The majority of users did not consider privacy important:

> "Not important for me, I don't have anything to hide." (U03)

> "There is no problem for me that they want to use my data." (U04)

> "It's not something important to me. It's okay if the purpose is to improve the service." (U19)

Some users, however, wanted to be in control of their data:

> "I don't feel the need to share all my information with them. I make sure to always click "no" when prompted to limit the data they can collect." (U18)

> "I like to be asked so that I can make a decision. It's better than them just lingering in the background collecting data without me being fully aware of them. I prefer to have control over what information I share." (U12)

Transparency and Sustainability were also not problematized by many users:

> "I haven't really thought much about how they calculate things." (U10)

> "I haven't really thought about how it does it, it's not really important." (U16)

> "It hurts to say it, but no, sustainability is not important to me." (U13)

> "Sustainability is not something you think about when you're buying a watch; you assume that large companies have it under control." (U12)

Of those who valued sustainability the focus was on the treatment of workers.

> "It's important that workers are well taken care of, but whether it's produced in an environmentally friendly manner doesn't concern me that much." (U05)

Performance was considered important but also, most users valued control.

> "It's a bit important, because it's connected to my messaging system and many apps, so it's a hassle if it suddenly sends things that I don't want." (U16)

> "Yes, I like physical buttons. I only had touch before and sometimes I accidentally hit something. But my watch now has physical buttons, and I think that's important." (U12)

Trust was regarded important. But trust more often relates to the brand.

> "I only look at the brand, and when I think about it, I go for reputable brands, which I assume have certifications that I'm not even aware of." (U21)

> "I do a lot of research beforehand. And that's why I chose CompanyY because I know it is a good watch manufacturer." (U19)

Human welfare in the sence of improving the wellbeing of the users, was important for most interviewees.

> "The watch makes it easier to keep track of my own activity. It's something that motivates me to do positive things like going to the gym." (U04)

"It's motivating, at least when it comes to the workouts. You can see that you're in shape and keep track of your progress with the watch. I think it's fun to see the effect of the training instead of just doing it for the sake of it." (U08)

The findings of the interviews were used to develop a comprehensive set of objectives with associated functions and desired design effects. These are presented in the following subsection.

Value-driven design objectives, functions and desired effects

Clearly defining value-driven design objectives ensures that the design balances technical opportunities with ehical design responsibilities. A key finding of the empirical investigation is that several users have not problematized about sensitive aspects of smartwatches. Hence, we defined objectives to accommodate immediate user needs and also raise awareness. Table II provides an overview.

Table II. Value-driven objectives, functions and desired effects

Value	*ID*	*Objective*	*Function*	*Desired Effect*
Security	1	Users should be able to lock their watch.	The watch should have easy-to-use lock functionality.	The user has control over watch security.
	2	Users should know when the watch is locked.	The watch should show clearly if it is locked.	The user is aware of the watch status.
	3	Cybersecurity protections should prevent attacks.	Data integrity and protection should be followed.	The user will not be troubled by the threat of attacks.
	4	Users should be aware of security and how to protect information.	The app should include security guidance and tips.	The user can better protect themselves from attacks.
Privacy	5	Users should know when they are being tracked.	The watch should display an icon when tracking is on.	The user will become aware of tracking.
	6	Users should be able to turn off geolocation easily.	The watch should have visible turn on/off geolocation controls.	Users can decide when they want to allow tracking.
	7	The user should be able to control data sharing easily.	The settings should allow granular data sharing.	Users gain more control over what data they share.
	8	The user should be able to control what features they want to enable before registering.	The registration page should have options that can be enabled and disabled.	Users gains control over privacy without having to deactivate options after registration.
Transparency	9	Users should be able to find how calculations are made (e.g. sleep, pulse, steps).	The associated app should provide explanations of calculations.	The user can learn more about the technology they use.

Value	ID	Objective	Function	Desired Effect
	10	What data is used and how should be explained to users.	The associated app should show data used, why and how.	People become more aware of what their data is used for.
Sustainability	11	The location where the watch is produced and how workers are treated should be known.	The web page where the watch is bought should include an overview of all major production steps.	The user becomes more aware of the conditions under which the watch is produced.
	12	The carbon footprint of the watch should be accessible to users.	There should be an overview of the carbon footprint.	The user will become more aware of the environmental impact.
Performance & Reliability	13	The battery time should be optimizable.	The watch should show battery consumption and have an eco-mode.	The user can opt to charge the watch less often by tailoring use.
	14	Accuracy (pulse, sleep, steps) should be as high as possible.	The watch should use different calculations to give accurate data.	The user trusts the watch more and has a better experience.
Control	15	The watch should get feedback/ confirmation about key actions.	The watch should have physical, buttons in addition to a touch screen.	The user feels more in control of the watch.
	16	It should not be easy to accidentally do actions on the watch.	If buttons causing or disabling actions are pressed, confirmation must be requested.	The user feels more in control of the watch.
	17	It should be easy to disable all alerts.	The watch should have an on/off switch that easily disables alerts of all sources.	The user does not get disturbed when inappropriate and feels more in control.
	18	The user should rule how the watch activates.	There should be settings for watch activation.	The user feels more control over the watch.
Trust	19	The watch should follow best practices and market standards.	The watch should provide access to certifications.	The user feels they can trust the watch and the company.
	20	The watch should show evidence of quality assurance	The watch should be reviewed by certified specialists or auditors and the reviews should be available.	The user feels they can trust the watch and the company.
Human Welfare	21	The watch should motivate the user.	The watch should give feedback when goals are reached or records are broken.	The user gets reinforced and rewarded.
	22	The watch should allow users to define their aims.	The associated app should provide options to set goals.	The user can tailor and follow own activity aims.

Prototype

The objectives and functions defined, guided the design of a smartwatch prototype that takes into account what is valued by users currently and also aims to sensitise. The design was guided by the objectives formed after the identification of values. In the paragraphs that follow we present some of the screens designed. For instance, for privacy, the first design requirement is that the user needs to know when they are being tracked (Obj 5). The second design requirement is related to enabling and disabling the location services (Obj 6). An additional privacy-related feature was added to the watch, which is the easily accessible button that enables and disables data sharing (Obj 7).

Figure 2. Privacy features in the prototype

The prototype developed was presented to a group of interviewed users, and their feedback was gathered. Incorporating the insights gained from user feedback, the design underwent two iterations. During the user feedback sessions, participants were actively engaged in providing their thoughts, opinions, and suggestions regarding the prototype. This iterative approach allowed the research team to develop a comprehensive understanding of user preferences, needs, and values. The iterative nature of the design process not only facilitated the design but also served as a valuable learning experience for the research team. By embracing this iterative approach, the research team demonstrated their commitment to creating a refined and improved smartwatch solution that aligned with the needs and values of users.

Discussion and Conclusion

The findings of this study provide insight for research and practice. First, we find that although in the VSD literature (Friedman et al., 2013, Maathuis et al., 2020, Umbrello, 2019) there are several values commonly listed as important (security, privacy, transparency, sustainability, performance and reliability, control, trust, and human welfare) their significance for many everyday users is limited. This places a greater responsibility on designers to not only cater to user needs but also raise awareness among users about critical aspects of smartwatches.

VSD heavily relies on the perspectives of the participants. What a user finds important is influenced by a variety of factors, including but not limited to: time, context, and personal preference. What seems to have been much less recognized in VSD is that values themselves may be subject to change during the lifetime of a product as pointed out by Van De Poel (2021). It is possible to distinguish between value changes that primarily occur due to social developments and value changes that are induced by technology (van de Poel, 2021) and this research aims to contribute to inducing some positive value changes by raising awareness through technology. Prior research has shown that it is important to find ways to empower users and at the same time orient and sensitize them, striking a balance between dynamic/adaptive and static/predefined options in the user interfaces (Vassilakopoulou et al., 2019). This is an interesting area for further research. Interventionist research approaches such as action research, clinical research, and action design research (Pappas et al., 2023) that test and refine solutions in real-world contexts may generate useful insights on how to strike this balance.

The idea of including more adaptive options aligns well with insights from research on end-user development (Lieberman et al., 2006) related to parameterization or customization (i.e. activities that allow users to choose among alternative behaviors already available in digital applications). It also aligns well with the “dual design perspective” that includes a default of design choices and an environment in which the user may tailor the technology during its use (Germonprez et al., 2007). Such a design allows delivering solutions that will support user-defined tailoring at later stages to accomodate evolution over time and adaptation to setting-specific needs (Vassilakopoulou et al., 2016).

The value-driven design objectives identified and the respective functions point to the need to allow end-user customization that goes beyond aesthetics. Interestingly, prior research identified that commercially available wearables including smartwatches provide limited customization possibilities related to functional and interaction aspects although they allow significant customization related to appearance and location on the body (Jarusriboonchai, and Häkkilä, 2019).

This study contributes to a growing area of research on smartwatches and wearable technologies offering researchers and practitioners key insights into the complex design requisites for these increasingly ubiquitous devices. By developing a good understanding of user values and their evolution, designers can create innovative and meaningful solutions that cater to users' needs while promoting positive value changes and fostering user well-being. User interfaces can offer adaptive options accomodating individual preferences while also incorporating features to help users make informed choices during use. This delicate balance can enhance user autonomy ensuring that users are aware of the potential implications of their actions. This study can guide future work that takes a human-centered view toward building smartwatch devices and smartwatch management applications designed for both usefulness and human well-being.

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Establishing a Health Data Marketplace: Insights from Stakeholder Interviews

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Abstract. This study explores the potential establishment of a Health Data Marketplace in the Norwegian e-health sector by extending the capabilities of an existing health data platform. The findings are based on the analysis of interviews with key heathcare actors and point to key requisites for extending the data platform to a marketplace: developing a suitable Business Model, ensuring Data Standardization and Regualtory Compliance, providing Transparency and building Trust.

Introduction

This paper investigates the potential of implementing a Health Data Marketplace (HDM) in the Norwegian e-health sector. Data Marketplaces have emerged as new technological and organisational arrangements that encapsulate the economic value of data and facilitate data exchange (Abbas et al., 2021, Stahl et al., 2014). In healthcare, these marketplaces can contribute to the improvement of health services and also, facilitate medical research and stimulate health-related innovations contributing to societal sustainability (Emberland and Rørtveit, 2016, Pappas et al., 2023). Realizing the potential of digital technologies in healthcare infrastructures requires collaborative innovation among multiple actors (Aanestad et al., 2019, Grisot and Vassilakopoulou, 2015). Furthermore, the sensitive nature of health data requires cautious approaches. Ensuring data security and privacy while catering for patient safety is one of the big challenges for streamlining data flows and pursuing data integration in healthcare (Ajer et al., 2019).

Prior research emphasizes the importance of conducting in-depth case studies of data marketplaces (Fruhwirth et al., 2020) and encourages further research on the development of novel marketplaces that address domain-specific problems (Bergman et al., 2022, Figueredo et al., 2022). For this study we collected and analyzed empirical data by interviewing actors linked to an existing health data platform which was developed by a private company to facilitate data flow and integration within Norwegian healthcare. The findings of the study point to requisites for successfully extending the health data platform to a marketplace developing a suitable Business Model, ensuring Data Standardization, Regualtory Compliance, providing Transparency and building Trust.

Method

We performed a qualitative case study analyzing empirical data collected by interviewing actors linked to an existing health data platform. In total, we performed 12 semi-structured interviews (Decarlo, 2021). The interview questions explored experiences with the existing platform and perspectives on its further development towards becoming a data marketplace.

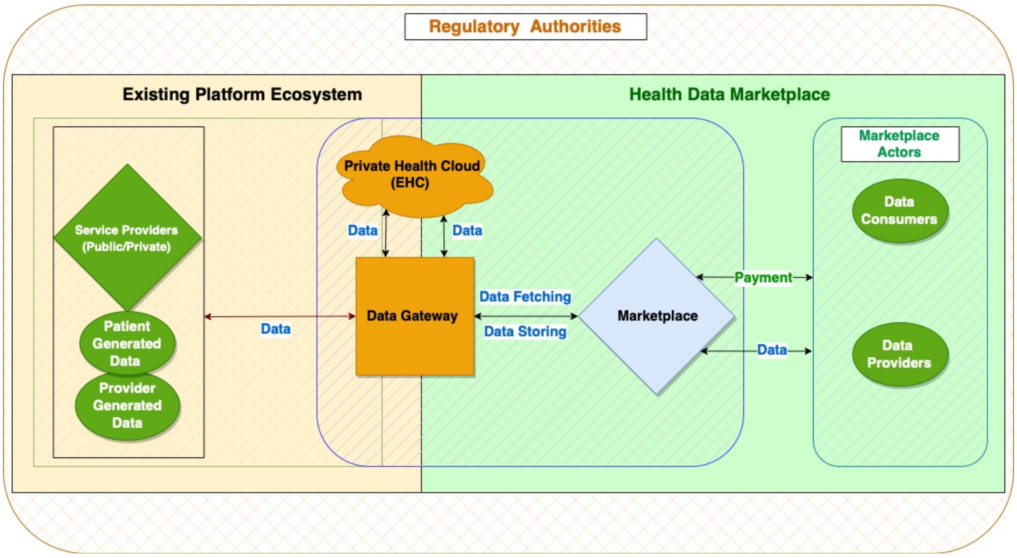

Figure 1. Overview of the existing platform ecosystem and its extension to data marketplace

The platform was developed by a private company to connect producers and consumers of health data such as Sykehuspartner (a public organisation providing information technology services to hospitals) and Helsepartner Nord-Norge (a private organisation providing services for people with long-term needs for personal assistance). The platform operates in a private cloud in Norway ensuring data security and compliance with regulations. It supports both electronic message exchange and APIs. The platform currently only aims to facilitate data flow and integration and is not oriented to data monetization. Developing a data marketplace around this platform can enable helathcare providers to better coordinate, researchers to identify and access valuble datasets and enterpreneurs to bypass the complexities of linking to multiple data providers. Figure 1 presents how the current platform-based ecosystem can be extended to a data marketplace. The existing ecosystem is represented on the left. The data marketplace extends the ecosystem leveraging existing platform capabilities and adding new ones to handle transactional aspects including consent management and payments.

All interviews were fully recorded and transcribed. We coded the transcriptions into themes using NVivo, discerned patterns and synthesized the findings. To ensure inter-coder reliability (Kurasaki, 2000), two different authors individually coded the themes from the interviews and iteratively consolidated the coding. Table I provides an overview of the interviewees.

Table I. Interviewed Study Participants

Interviewee ID	Description	Organization
HRE1	E-health Executive	Platform Owner
HRE2	Medical Researcher	Academic Institution
HRE3	Healthcare Researcher	Academic Institution 2
HRE4	Academic Researcher	Academic Institution
TDS1	IT Consultant	IT Consultancy firm 2
TDS2	Data Specialist	Platform Owner
TDS3	Data Consultant	Platform Owner
PMI1	Innovation Consultant	Platform Owner
PMI2	Project Manager	Platform Owner
PMI3	Innovation Consultant	Platform Owner
PHP1	C-Level Executive	Private Health Company
PHP2	C-Level Executive	Private Health Company

Findings

Several interviewees pointed to the importance of adopting a suitable *business model* for the marketplace:

> "The business model which I think will work well with Data Marketplaces is to sell consumption-based services. Here, consumers pay for the data that other parties sell. The price can also be based on usage of the marketplace." (TDS3)

> "The pricing model should be fair and transparent to encourage widespread adoption. It should incentivize data providers to share their data while ensuring that researchers can access the data they need at an affordable price." (PHP1)

Furthermore, a recurring theme in the interviews is the importance of *standardization* at the technical and semantic level to faciliate data reuse. One of the participants noted:

> "We should also talk about another aspect of health data, apart from how the data is structured and formatted. There is the whole terminology side, the semantics of health data" (PMI3)

Another important requisite is to ensure *regulatory compliance* especially related to *privacy and security*. One of the participants referred to another initative called "Helseanalyseplattformen," which started in 2018 and ended in 2021. This was conceived as a public sector resource for researchers who wanted to use health data. However, legal issues led to the discontinuation of the project. An interviewee noted:

> "GDPR, laws, and privacy are the challenges that come to mind. The whole world looks to the Nordics when it comes to ethical guidelines regarding data... We have strict rules that govern privacy in nordic countries" (HRE1)

This point aligns with another interviewee which mentioned the importance of aligning with the comprehensive Norwegian framework Normen:

> "probably the most comprehensive security framework for health data in Europe." (PMI3)

However, there is a need to diffenciate the levels of security and privacy depending on the type of data and provided health service:

> "if you are providing a diagnostic service that is actually giving you an answer (like a blood sample) then it is at a quite a high level of regulation. If it is a service helping you track minutes of running every week then it is very low on the regulatory scale." (PMI3)

> "there are different categories of health data. You have the most sensitive ones, and then you have non-sensitive data, which means general data. And when anonymized, there is another regulation you have to comply with. And especially in research, when there is consent, it is allowed to conduct research. So, you could say that as long as they obtain consent from patients or participants, it is legal." (PHP2)

Another interviewee emphasized the complexity of securing approvals at different levels:

> "…approval from the data owner at the service level... and you must have an overarching national ethical approval." (HRE3)

Participants also highlighted the importance of *trust*. One interviewee cautioned about the difficulty of restoring faith following an incident:

> "Even one scandal can make it very difficult to regain trust subsequently. [...] That's why we shy away from directly researching commercialized ehealth data. It could significantly erode trust." (HRE4)

In general, interviewees echoed this sentiment and also noted the importance of providing *transparency* on data descriptions and data providers:

> "Data solutions must be transparent and user-friendly, offering clear data type descriptions... awareness of the data providers and price variations is critical. I see a marketplace, akin to (name of a commercial marketplace), where users specify desired attributes to reveal relevant datasets."(PHP1)

Overall, these findings underscore the importance of a robust business model, standardization, regulatory compliance, transparency and trust-building in the development and operation of a successful health data marketplace.

Discussion and Conclusion

The findings from the interviews shed light on the key requisites for establishing a successful health data marketplace contributing to the literature on the development of niche data marketplaces (Bergman et al., 2022, Figueredo et al., 2022). Overall, the establishment of a health data marketplace can reduce the resources needed for data acquisition, storage, and exchange, contributing to innovation, sustainability and responsible data use (Pappas et al., 2023). Data marketplaces can also resolve tensions in the health data environment related to the need to engage with a wider digital ecosystem, share data and knowledge, and respond to demands around personal data and privacy (Meadows et al., 2022). A key insight from the study is the need for suitable business models that promote fair and transparent pricing, ensuring incentives for data providers while remaining affordable for researchers. This aligns with prior research which has shown that «vesting resources» to facilitate value appropriation must be in place (Aanestad et al., 2019). Furthermore, standardization at both the technical and semantic levels is essential for data exchanges in the marketplace. Standardization is pivotal for making data shareable and reusable (Vassilakopoulou and Aanestad, 2019). Regulatory compliance, particularly in terms of privacy and security, must be prioritized to adhere to stringent guidelines such as GDPR and the comprehensive Norwegian framework Normen. This finding echoes the insights from prior research on data governance within healthcare (Paparova et al., 2023) which highlights the role of regulatory frameworks shaping data exchanges. Providing transparency in data descriptions, recognizing data providers, and addressing potential price disparities were identified as crucial elements for fostering trust and promoting widespread adoption. This aligns with prior research on health data that points to the importance of arrangements that enable tracing, attribution, and rewarding of data contributions (Vassilakopoulou et al., 2019). Transperency is related to «discovering resources» that assist innovators in making sense of possibilities and limitations (Aanestad et al., 2019). Finally, trust-building emerged as a critical factor, emphasizing the importance of maintaining stakeholders' confidence and avoiding incidents that could erode trust in the marketplace.

The findings related to stadardization, regulatory compliance and transparency are well-aligned with prior research on data exchanges in healthcare (Aanestad et al., 2019, Paparova et al., 2023, Vassilakopoulou and Aanestad, 2019). However, there is limited prior work on issues related to business models for health data marketplaces and marketplace trust. Further research avenues arise from these findings. Exploring and refining business models that align with the unique characteristics of health data marketplaces is a key area for further research. Furthermore, exploring strategies to establish and maintain trust within data marketplaces, as well as examining the impact of trust on data sharing and marketplace adoption are critical areas for further investigation.

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AR in Medical Auscultation Training

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Abstract. The aim of "AR in medical auscultation training" is to use digital media to support and supplement medical knowledge transfer for auscultation. The focus is on the usefulness and supplementing, not replacing, teaching through digitalization. The prototype, created in practice, is intended to give aspiring physicians the opportunity to compensate the lack of practice time to train their hearing.

Introduction

Auscultation, a non-invasive and time-efficient technique, plays a key role in the diagnosis and monitoring of various medical conditions (Conn & O'Keefe, 2009). By listening to internal physiological sounds, healthcare professionals can quickly gather vital data to facilitate accurate diagnoses and therapeutic interventions, particularly in urgent clinical scenarios. Auscultation's simplicity, speed and broad cross-specialty applicability make it an indispensable tool in diverse medical settings and resource-constrained contexts. In recently conducted interviews one medical student said: "Honestly, we only learn this if we are lucky enough to end up in a pulmonary or cardiac clinic during our practical year [...]". Sentences like this came up often in interviews with medical students. The Federal Medical Ordinance requires a minimum of 5500 hours of study over six years to complete a medical degree. During this period, around 8 to 12 months are allocated for practical training, as stated in the Bundesärzteordnung (BÄO). Listening with a stethoscope is only a part of a three-hour course. Currently, practicing physicians often do not know how to listen (Mangione, 2001) because the differences between pathologic and physiologic heart murmurs are not easy to discern. Auscultation is not a simple procedure; it must be trained (Barrett et al., 2017). The application of augmented reality, "StethoSCOPE," was developed during this research and aims to provide assistance. This program will train students to identify the locations of auscultation points, different (heart) sounds, and provide an exercise module related to an anamnesis questionnaire.

Theorie

The theoretical part of the paper deals with auscultation, teaching auscultation, e-learning and augmented reality.

1) Auscultation

The fact that auscultation with a stethoscope is not to be neglected even in the age of sonography, echocardiography and computed tomography is already mentioned in the preface of one of the standard works on basic diagnostics. "Basisdiagnostik in der Inneren Medizin" (Basic Diagnostics in Internal Medicine) by Martina Kahl-Scholz (2018). According to Kahl-Scholz (2018), a well-founded anamnesis combined with a structured physical examination, even without apparative diagnostics, can result in a tentative or main diagnosis. Physicians rely on auscultation during home visits or emergency situations. Due to the demographic development towards multimorbid elderly patients, auscultation is a non-invasive and gentle form of diagnosis (Kahl-Scholz, 2018). At a cardiological auscultation various points on the torso with different heart sounds can be perceived. After the pulse has been determined, the listening points are listened schematically in parallel with the stethoscope (Kahl-Scholz, 2018). Physiological heart sounds are all sounds emitted by a healthy heart. In contrast, pathological heart sounds indicate abnormalities. Four heart sounds can be differentiated from each other (Kahl-Scholz, 2018). Heart murmurs are divided during systole (ejection phase) and diastole, (filling phase). To interpret the murmurs caused by vitia (heart defects), a precise idea of the blood flow or cardiac hemodynamics in systole and diastole is essential (Kahl-Scholz, 2018).

2) Auscultation teaching

Although only 20% of findings from stethoscope listening by students and practicing physicians are correct (Mangione et al., 1993). Several studies demonstrate non-mastery of auscultation: among hospital internists from the United States, Canada, and England, correct auscultation findings are only 22, 26, and 20 percent, respectively (Conn & O'Keefe, 2009; Mangione, 2001). As described, the practical part in medical schools is underrepresented. "Medical teaching in Germany is characterized by a deficit of practical relevance."(Huwendiek et al., 2006) In addition to the books, which illustrate the theoretical part of auscultation well, there are partial extensions by audio examples. However, these are recorded only as individual audios and neglect the various auscultation points, which are of great importance for a tentative diagnosis as described in the chapter "Auscultation". Physical manikins are also sometimes used, but they are very expensive (the cost of a MATT - Simulator for Auscultation, MedVision Group; SAM II® - Student Auscultation Manikin, 3B Scientific ranges from 13,000 to 17,500 Euros, for example) (*MATT - Simulator für Auskultation, MedVision Group*, n.d.; *SAM II® - Studentische Auskultationspuppe, 3B Scientific*, n.d.) and provide only on-site access. Delocalization is not possible. There are also e-learning platforms such as Amboss (*AMBOSS*, n.d.) or Thieme via medici (*via medici*, n.d.); similar to the teaching by books. They combine text with audio examples. Therefore e-learning platforms neglect the physical location of the sounds. Also smartphone apps, like from the stethoscope manufacturer Littmann, have the same problem.

3) E-Learning

The advantages of e-learning in the medical field are also decentralization and permanent access to learning content plus the integration of various media for improved retention. The design of such programs should consider didactics with meaningful learning objectives and media use, frequent interactions, appropriate complexity and information density, helpful feedback, high authenticity, user-friendliness and timeliness (Huwendiek et al., 2008). Digitization of teaching alone, as with asynchronous e-learning courses, have only moderate popularity among radiology students according to a survey. This dissatisfaction was based in part on the lack of practice (Volmer et al., 2021). As described in the constructivist approach to teaching, one learns by doing (Schulmeister, 1997). Therefore, the

StethoSCOPE application is intended to be highly interactive, as required by the quality criteria for e-learning programs (Huwendiek et al., 2008). Frequent didactic interactions promote active learning and critical thinking (Huang, 2005). According to Kulik, Kunert, Beck, and Fröhlich (2017), learning is largely driven by interaction with fellow students. Especially when it comes to interpreting complex and ambiguous information, "Direct student exchanges can help to consider multiple perspectives and confirm the likely interpretation."(Greenwald et al., 2017). In addition, face-to-face interaction and mixed-initiative communication promote ongoing discourse about a topic (Greenwald et al., 2017).

4) Augmented Reality (AR) and developed system

Augmented reality (AR) creates a closeness to reality that is not possible in classic textbooks (Barrett et al., 2017). As Karl Gerstner (2020) suggests in his book " Programme entwerfen" (Designing Programs), the third dimension, spatiality and depth of an object is opened up, thus the depicted is extended by another level of information (Gerstner, 2020). This third level of the StethoSCOPE application can help to assign and understand the anatomy and the sound signals emanating from it. What has already been written in a yet to be published paper on digitization in medicine, specifically electrocardiography, is equally applicable to auscultation: "So why should we continue to reduce the representation of such a complex organ to two dimensions when there is now also the possibility of representing the heart in 3D and anatomically correct? With the application, we want to give students the opportunity to learn directly on the anatomically correct heart. That would be a step in the right direction and a digitization where digitization is necessary. Merely putting the content of a book online should not be seen as progress or even digitization. It has never been easier to improve, or at least supplement, teaching methods such as electrocardiography with the help of programs."(Goetz, 2021) Augmented reality opens new collaborative scenarios in the course, while its flexible use allow students to train their hearing and expand their knowledge.

Our concept is based on auscultation on a virtual torso, very close to reality. For real heart sounds and murmurs, a recording procedure has to be developed for all six auscultation points simultaneously in order to exclude time delays between systole and diastole at the different listening points. The simultaneous recording of physiological heart sounds and pathological heart murmurs also serves to visualize the pulse. As described in the chapter "Auscultation", this is important for distinguishing between systole and diastole. As this cannot be felt in humans, a visualization method must be used here. The visualization should also offer the possibility to understand the cardiovascular system and the resulting flow sounds of the blood (Kahl-Scholz, 2018). With the application, a situation should be created, complemented and enhanced by digitality. To ensure this convergence, the torso must behave in its dimensions and physical properties (sounds of the heart) like patients. Through the digital layer of AR, two- or three-dimensional information can be inserted into the real space. Thanks to the technology of spatial mapping via infrared sensing, AR glasses, such as the HoloLens can virtually map real space and thus place objects on real surfaces (like on a table) (Zeller, 2023). Distances and proportions can estimated more easily, which is a basic prerequisite for auscultation with a virtual stethoscope. Beside tracking the room, the movements and gestures of the hands can also be tracked. Thanks to the improved tracking of the HoloLens 2, users can grasp and move objects naturally. (*HoloLens 2—Overview, Features, and Specs | Microsoft HoloLens*, n.d.). The user interface (UI) can operate directly without detours via controllers. Gestures are necessary for some interactions, such as for selecting objects/UI that are further than an arm's length away or for closing an application. Voice control also makes it possible to perform interactions simultaneously. Users could, for example, fade in the auscultation points or fade out the body shell of the virtual torso by voice command while placing the virtual stethoscope. Glasses such as HoloLens have the advantage of reduced motion sickness (the effect often occurs due to temporal delay of the organ of balance and virtual projection), which can be explained by a higher relation to reality. This allows for greater comfort and thus longer wear time, for a longer learning experience (Vovk et al., 2018).

Methods

The current prototype was implemented with Unity for the Hololens2. In the application, emphasis is placed on natural interactivity. The students can approach the virtual torso with a virtual stethoscope head and auscultate – like in reality. To increase the collaborative approach of the application, ideally multiple learners should be able to interact with StethoSCOPE together, strengthening their understanding of auscultation. The content developed collaboratively in the course can be reinforced through self-study; it serves as a knowledge base beyond the course. The prototype StethoSCOPE created for auscultation on the heart, depicts the functions to be implemented. These were discussed, evaluated and elaborated in several interviews with medical students. For now, auscultation is limited to the heart because it is much more complex to listen to than other organs. To reproduce the sounds as realistic as possible, a technique for simultaneous audio recording of heart sounds was developed. During the practical implementation, it shows that the Hololens2 is ideally suited for the implementation of the StehtoSCOPE application, as these augmented reality glasses can be used to display a virtual body in full life size. Another reason for the augmented reality implementation is to open up new collaborative scenarios in the course, while the flexible usage options allow students to train their hearing and expand their knowledge. To ensure the accessibility of the application for students outside the university, a smartphone application will also be implemented. This will include an AR mode, similar to the Hololens, in order to also be able to train listening via smartphone and to deepen the knowledge acquired in the course. Another digital extension is needed for the localization of the auscultation points. The points are determined using the intercostal spaces or ICS (the spaces between the ribs). These cannot be palpated in the virtual one and must therefore be displayed in another way.

Conclusion

The concept of the StethoSCOPE allows medical students to practice auscultation. Users can acquire knowledge and develop skills in cardiology auscultation through case-based examples. Auscultation can be practiced on a virtual torso using a virtual stethoscope. To support the process of diagnosing, users can request various tools. Apart from the anamnesis sheet that provides information on gender, age, and medical history including medications, the application also displays skeleton, heart, and auscultation points. Highlighting of locations where pathological heart murmurs are heard can be enabled when required. This feature enables users to locate the origin of the murmur. Identifying systole and diastole is an important factor in making a preliminary diagnosis, which the animated heart helps with. Thanks to a database of heart murmurs, users can "listen" to various heart diseases. The next step involves representing the blood flow at the open heart, which will help interpreting the origin of heart murmurs more effectively. The StethoSCOPE application will animate the anatomically correct heart simultaneously with the recorded heart sounds. In the future, the application will be established as a

platform for heart sounds and tones. As a result, a continually expanding audio library of recorded audio examples can be created, revealing new cases to all users. Furthermore, integrated machine learning will identify frequently made errors to provide optimized assistance. The data obtained can be utilized in teaching to identify sources of error from the outset. The AR app prototype was programmed for easy expansion to include additional listening points such as blood vessels, lungs, and intestines. The intention of multiple iteration cycles of usability testing and re-testing is to ensure that the application conforms to all usability criteria and other requirements. As HMDs like HoloLens are currently not widely available, a smartphone app is recommended as a transitional/supplementary measure. This could be structured in the same way, except for the mode of interaction.
The potential positive effects of knowledge transfer from the StehtoSCOPE AR app will be determined by utilizing a randomized controlled trial. Two groups (A/B) of medical students will receive auscultation training over a specific period. Group A (control group) will receive classical training material, while group B will receive the app StehtoSCOPE in addition to the classical training material. Before and after the implementation, the students' knowledge will be assessed through an auscultation test scenario.

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Fears about Social Robots in Nursing

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Abstract. As the nursing sector's shortcomings remain unchanged, social robots are becoming increasingly relevant. While real-life encounters are uncommon, the media and fiction continue to impact people's perceptions of robots. Capabilities and shortcomings are frequently exaggerated, producing a vision of automated technology that will replace human labor. This article focuses on the topic of worries associated with robot use. Most stakeholders are concerned about disenfranchisement and data protection. They create uncertainties about how the introduction of robots will affect people's lives and work situations. This article compiles the concerns of various parties and advocates for the transparent and participatory development of robots in nursing.

Introduction

Social robots are increasingly becoming relevant in the care sector. Many research projects have been carried out in care homes (Aarskog et al. (2019); Paluch and Müller (2022)) and in rehabilitation (Langer and Levy-Tzedek (2021); Feingold-Polak and Levy-Tzedek (2021)) with different robots they could show that the usage of such systems can be beneficial. The topic receives a lot of attention, to our knowledge for two reasons, for one the situation in nursing homes in Europe is not becoming better but worse, there is a lack of people willing to work under the given conditions in nursing, and at the same time a growing number of people in need of care. Robots are seen as one possible solution to the workforce's shortcomings. Second, there is a movement towards a higher degree of digital applications in nursing, but they are difficult to explain as code cannot easily be explained in the media. Robots are often used as examples of how the nursing sector increasingly uses digital assistance, even if they are not as common as other digital artifacts such as tablets. In the media, it is often portrayed as if the use of robots in nursing homes is on the verge of a significant breakthrough. Rarely are the limitations of such a system pointed out adequately. This leads to worries and fears among many actors in nursing homes about how this could change their lives and work.

Context

The presented fears in this publication are not the result of one particular study, they are a combined collection of previous work (see Carros et al. (2020); Unbehaun et al. (2019); Carros et al. (2022a,b, 2023d)). Experiences gained while working with robots in nursing homes for many years. The collections of fears that we present here have been written, weighted, and evaluated by an interdisciplinary team of authors who are practitioners and researchers. Our research is grounded in practice based research (Schmidt (2018); Ogonowski et al. (2018); Krüger et al. (2022)) and participatory design (Wagner (2018); Krüger et al. (2022); Weber et al. (2023)). For seven years (2017-2023) we have been using robots in nursing homes. We tested several robots and developed the capabilities of the robots with a design case study methodology Wulf et al. (2011, 2015); Kotthaus et al. (2023). In the first years we focused on the robot Pepper in nursing homes (Carros et al. (2020)) we later expanded this work to other robots such as AIBO (Helm et al. (2022)), Android robots (Carros et al. (2022d); Hille et al. (2023)) and worked together with other national and international research projects that worked with robots in nursing settings (Carros et al. (2022c); Chang et al. (2022)) and expanded our work to other disciplines like ethics Störzinger et al. (2020); Haberland et al. (2022). We have done hundreds of interviews, spent years with the robot in nursing homes, included citizens in our research (Carros et al. (2022e)) and are writing this study with an interdisciplinary team of practitioners and researchers.

Fears about Social Robots in Nursing Care

Over the years we have seen many positive reactions and emotions toward robots and their application in the field. However, there are also more critical voices. The topic of fears toward robotic systems in care is not completely new and we already addressed parts of it in previous work (Carros (2019); Habscheid et al. (2018)), others also did research on it, but with a quantitative approach while we use qualitative data (Coco et al. (2018)). However, after several years we see a need for an update to these, as the technology developed, and our experience has grown. We predominantly focus on fears expressed by people working in the field.

Fears of Residents

During discussions and interviews with residents of nursing home facilities and the people caring for them, four recurring fears emerged:

Cost-Saving Measures: Robots could be used to replace humans to make care homes more profitable instead of using them to assist human workers to enhance the quality of care.

Monitoring of Residents: It is unclear what happens with the data that the robot is recording. Bad actors might try to get access to this data.

Inhuman Interaction: Daily interactions become increasingly inhuman and are mostly done by robots. Human workers minimize contact with the residents and leave conversations and rehabilitation to the robots.

Loneliness: The replacement of human workers with robots could lead to less human contact.

Three of the four fears are about care being dehumanized by the use of humanoid robots. This clearly shows the importance of people and human warmth for the residents and that this cannot be replaced.

Fears of People Working in Nursing

A somewhat different picture of fears emerged among care workers compared to residents, but with a similar message at the core:

Work Replacement: The usage of robots could be intended as replacements for human workers, similar to the situation in some industries where robots take over the work of humans. Instead of being used to increase the quality of work.

Structuring Work: Robots are not as flexible as humans are, their abilities limit their flexibility, and they can often not read a room and act accordingly or go outside and search for someone who got lost. There is a fear that the structure that a robot needs to work properly is going to influence the work flexibility of care workers. They could be forced to amend to the needs of robots in order to work together, limiting the flexibility of the workers and effectively creating a hierarchy where workers have to cater to the needs of the robot.

Acceptance because of Resignation: Residents can feel helpless because they need help for their daily life due to their help condition. There is a fear that they accept the robot and its demands because they do not know what else to do or because they feel too weak to say no.

Manipulation by Mimicking Human Behavior: The imitation of human behavior that is sometimes shown in conversations by the robot when saying things like "I'm also feeling good" or "Should we do sport together?" is manipulating the capabilities of the robot. The robot does not feel and does not do sport. By mimicking this, the robot gives the perception to do and feel these things. This is done to create some kind of connectedness to the human interaction partner, but this connection is not real and to some degree manipulation.

Being Responsible for Malicious Systems: Residents are using robots because care workers say that it is safe to use them. Care workers lend trust to the robot. If the robot is using the data to manipulate the residents, if it uses the data for malicious practices, then there is a certain responsibility of care workers, because they convinced the residents to use them. Without the care workers, there would be no introduction of robots in care homes.

Monitoring of Nurses: Robots have cameras, microphones, and many other sensors. These constantly collect data for the robot to work. They are needed for the robot system, but they can also be used for other purposes. Management could try to gain access to this data to control care workers. Another possibility is that an algorithm is tracking the work of care workers and creating monitoring reports.

Wrongful Monitoring: If a robot creates monitoring reports about how long workers need for specific work steps and where they are doing these. There is a danger that this monitoring is naive and not aware of the complex work. If a care worker takes longer with one task (e.g., bathing) it is possible that it is not because the worker is slow but because the resident requires psychological assistance and is having a breakdown while bathing, resulting in a longer conversation while bathing.

Medical Profiles: Sound recordings and videos might be able to create medical information. Cameras could detect if a person has problems with their back by doing gait analysis. While this is a useful tool, this information could be maliciously used against the workers and be transmitted to management or third parties.

Psychological Profiles: Speech recognition and speech interactions could be used to generate psychological profiles of the care workers. These profiles could be given to management or be used by the robots to manipulate the care workers in doing work that is favorable for the management or the robot.

The fears expressed here focus on disenfranchisement and data protection. Incapacitation of one's competence to manage one's work and to be able to do this independently without supervision and feedback to the home's management. A gloomy picture of robots is drawn here, which seems like an extended arm of the management.

Fears of Relatives

Fears also arise among relatives of nursing home residents:

Changing Conversation Patterns: Conversations with robots are designed in order to be pleasant and avoid negative emotions. This bears the risk that the conversation patterns of residents change, as the robot will always simulate interest, even if the conversation is repetitive. The robot will also not react to aggressive or negative comments towards it. This could lead to a situation where residents get used to talking to a robot and unlearn human conversation patterns.

Data Security: Data recorded by the robot, such as camera images or audio recordings, could fall into the wrong hands. These data could be used against the interest of the residents.

Human Replacement: Robots should not be the only interaction partner for residents. It is important that humans take care of the residents.

The concerns are similar to the ones that residents and nurses expressed. Relatives act mostly as advocates for the residents and have fewer personal concerns.

Discussion

The fears of the various players have similarities at their core. Topics such as data protection and the disenfranchisement of human decision-makers are prevalent. This contrasts with the image that is painted through fiction and media, where robots are frequently depicted as powerful machines with various powers that overshadow humans. While fiction is often an inspiration for technology development Krings et al. (2023), it does not easily translate to the same results. Often missing from these is an examination of the tasks of people working in the field. Working with people in need of care is a complex profession that requires specific training and certain talents, such as emphatic intelligence (Teófilo et al.

(2019); Digby et al. (2016)) and domain specific knowledge. Abilities that are often underdeveloped in robotic systems (Pepito et al. (2020)).

We believe that it is important to know the fears of the different groups during development and to respond to them appropriately. Participatory design of software might be an answer to it, as well as long-term research, as other researchers also point out (e.g., Tuisku et al. (2019); de Graaf et al. (2019)), opinions about robots often change to a more realistic view that sees robots as recreational instead of a replacement. Developers need to closely work with the people affected by the technology, otherwise, the developed robots risk staying unused. We further see a need to explain technology, its abilities, and its limits. People working in the field do not have the time to understand each technical detail, and there is a need for easy explanations, otherwise, there is a risk of not being used because of not fully understanding the device. Lastly, we want to address the topic of manipulation. Robots simulate emotions and do not feel. Residents respond to the simulated emotions of the robot with real feelings. This is a one-sided emotion exchange that is simulated by a robot displaying behaviors that look like human emotions. There needs to be some degree of transparency, reminding residents that the emotions of the robots are not real ones.

Limitations

In our studies and practical experience, the robot was utilized to activate residents with recreational activities rather than functions that attempted to replace care workers. If other activities, such as medicine decision-making, are delegated to robots, people's perceptions of them may shift. We also generally worked with friendly-looking robots; anxieties may differ with other robots (for example, if the robot is tall and muscular). Finally, our findings are not representative. Our results are based on experiences in a few nursing homes and nursing institutions.

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Fostering shared responsibility – A socio-technical system to relieve caring relatives in rural areas

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Abstract. Local caring communities consist of professional providers, such as outpatient services, semi-professional providers, such as neighborhood assistance, and informal actors, such as active individuals who volunteer as caregivers. Until now, such local caring communities have often been left alone to organize and coordinate their services. In many cases, they are dependent on the commitment of individuals. This makes it difficult to take advantage of the opportunities offered by digital technologies to further develop their services, especially in rural areas. In this paper we present results of a project developing a concept of a regional socio-technical support infrastructure for caring communities, in which a strong network jointly addresses the issues of collaboration and technology use. Through a mixed methods approach (interviews, literature research, co-creative workshops) a solution was formed that empowers all stakeholders, fosters self-reflection and enables transparency in everyday care collaboration.

Introduction

Challenges of home caregivers

Family caregivers, as the mainstay of care, are exposed to multiple physical and psychological stresses (Müller, 2020; Gräßel and Behrndt, 2016). There is often a lack of personalized, easily accessible and flexibly retrievable support services that are geared to their living environments and the resources available locally. In rural areas, the burdens are exacerbated by a lower density of services and greater mobility needs. Caring communities therefore try to establish support networks that are as comprehensive as possible on site in the sense of a "help mix" to relieve informal caregivers (Kricheldorff et al., 2014; Renyi et al., 2017). The basis for this is a goal-oriented collaboration of municipal, professional, semi-professional, and informal actors and their sub-networks as a community of responsibility. If their relief potentials are to be made transparent, coordinated and tapped to the full extent and in their complexity, the systematic involvement of informal and semi-professional actors in particular and their linkage with professional and municipal structures still pose a particular challenge. Especially in rural and centralized areas, caring communities are confronted with the problems of better bundling their services, efforts and resources on site, coordinating them in a targeted manner, adapting the service structures to changing needs and making them available in a coordinated manner. They are often left to their own and remain dependent on committed individual actors. In addition, there is a lack of suitable information technologies and tools that are capable of supporting local caring communities (Kricheldorff et al., 2015).

The Kinzigtal – Study area

In the Kinzigtal (rural region in the Ortenau district in southern Baden-Württemberg), various initiatives have been active for over 30 years in order to assume responsibility for the community beyond standard medical care and to ensure that no one is left on its own. According to a comparison of the states by the Federal Statistical Office, Baden-Württemberg, along with Bavaria, will experience the highest relative growth in the number of people in need of care within the next few years. The number of people in need of long-term care will increase from 17% in 2021 to as much as 51% in 2055 (Statistisches Bundesamt, 2023). Despite (or perhaps because of) the many local efforts, the Kinzigtal is disproportionately affected by this. According to a report by the AOK, which was prepared specifically for the Kinzigtal region, the Kinzigtal has an increased proportion of insured persons with care degrees compared to the national average (AOK Bundesverband, 2023). The regional care support center has also seen a sharp rise in the number of care-related consultations. In the last 10 years, these have almost doubled (2012 = 772, 2022 =1358) (Springmann, 2023). Against the background of the complex organization of home care, it can thus be assumed that family caregivers within the Kinzigtal also have increased needs for support.

Target of investigation

Due to these circumstances, the region was considered to be an interesting study area. The goal of the study was the co-creative conception of an integrated, socio-technical care model for rural regions. The concept should enable and support local caring communities through an innovative regional socio-technical infrastructure. Through this the various types of support resources distributed at different levels should be made visible and more accessible. Their recombination according to informal caregivers' needs should be fostered, and thus new potential for relieving informal caregivers generated.

Method

The qualitative data collection process was designed as a co-creative participatory design process, in which generated interim results continuously served as a basis for further work and the model could be incrementally expanded and improved. Various qualitative methods were used for this purpose (see Table 1).

Table 1: overview over the research methods and the included participants

research methods	**count**	**involved actor groups**		
		caring relative	**structural actor**	**technology provide**
literature- and internet search	1	-	-	-
interviews	12	X	X	-
network analyses	14	X	X	-
workshops (e.g. World Café, focus group, how-might-we-method)	5	X	X	X

Since each care constellation has its own needs, the greatest possible diversity was taken into account when sampling the family caregivers involved. Thus, both caring partners and children caring for their parents were included. The youngest caregiver was 26, the oldest 80 years old (average: 54 years). Two of the seven caring relatives interviewees were already retired. None of the five who worked had a full-time job. The highest contracted workload was 32 h per week. Unfortunately, only women could be recruited to participate in the project. The acquisition was done in close consultation with the scientists via the local service providers. As a result, it was possible to integrate two people from the hard-to-reach group of people in acute crisis, in this case people who were taking part in a psychosocial support measure for acute overload.

On the part of the structural actors, both municipal actors, such as care support point and care social planning, representatives of the statutory health insurance in the form of a social advisor, semi-professional actors (coordinator of a neighborhood help) and actors of the free economy (care service and health advice) were included.

Representatives of the technology sector were found through market research and also participated in the project.

When choosing the research methods, it was paid attention to enable all stakeholders to participate according to their needs. Thus, interviews were conducted both on the premises of the caregivers, the consulting institutions, by telephone or video telephony. Workshop participation was enabled in a hybrid manner.

Results

In the rural region of Kinzigtal, family caregivers need relief and support in setting up and (re)stabilizing their individual care network. In the future, this is where specific counseling and support services of the local caring community should come into play. The concept must therefore start at the institutional and structural level of the caring community and should contain three modules (see Figure 1).

The modules aim to enable regional caring communities to jointly develop care options in the region. A suitable toolbox must be provided that strengthens the care communities themselves and at the same time enables them to support family caregivers by providing advice and guidance in establishing stable individual care arrangements. Relief potential for family caregivers results indirectly from this approach.

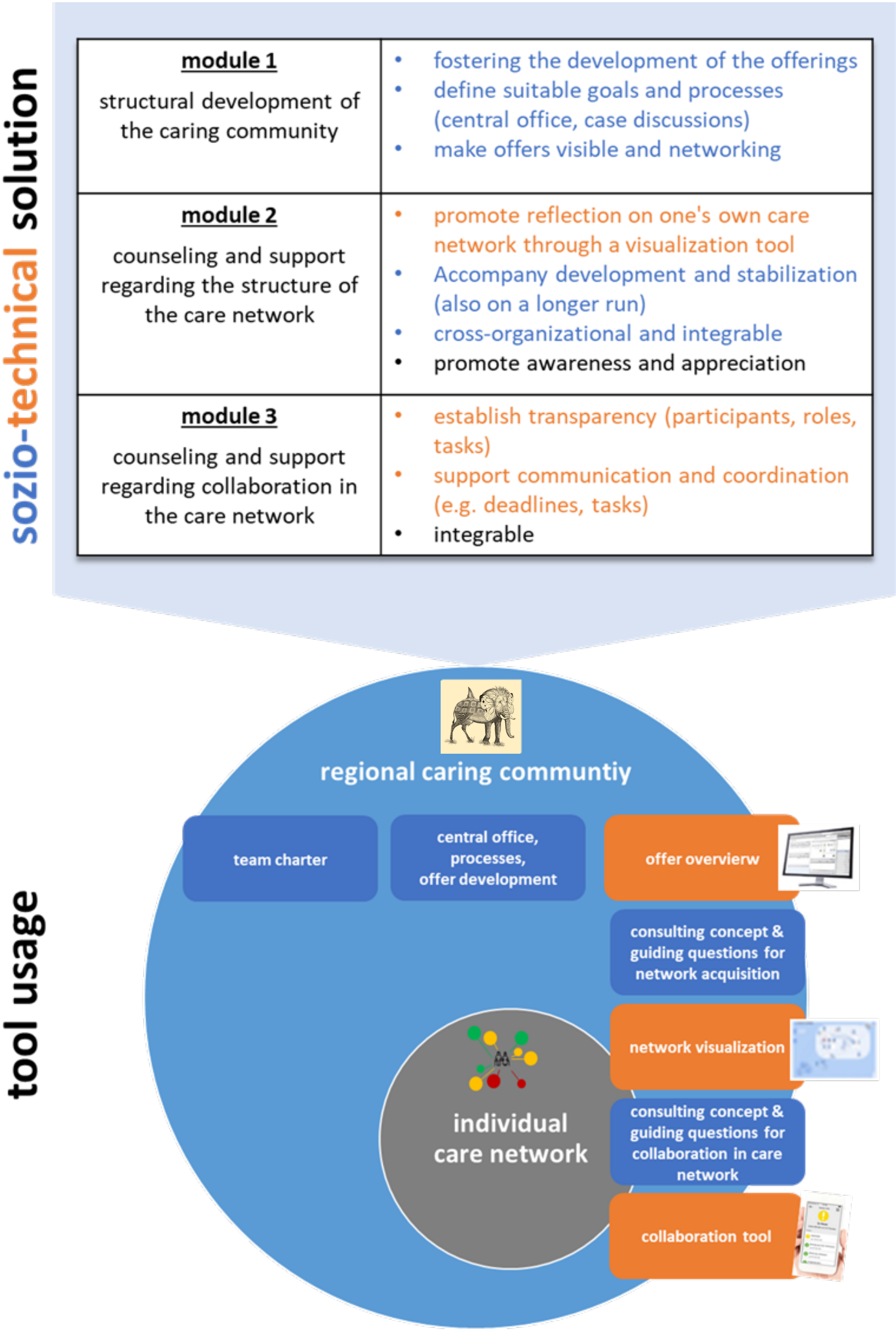

Figure 1: Sozio-technical solution scenario; dark blue: social components, orange: technical tools

Discussion

Outlook

If implemented, the concept would, among other things, strengthen the local caring community in the short and medium term by reinforcing shared values and goals. Cast into a team charter, in the long term, the jointly developed values and goals could be further expanded and stabilized. To this end, the forms of interactive networking required for the regional caring communities would also have to be explored in particular, and suitable work/organizational structures, competence/qualification profiles, technologies and business models would have to be developed and established on a sustainable basis.

The concept has a high transfer potential because it takes individual structural development into account by creating or docking with a coordinating structure in the social area. The intended care model improves transparency and accessibility and at the same time creates new forms of services to relieve informal caregivers. In this way, positive effects can be expected indirectly, and consequently also as a reduction in undesirable health economic and social follow-up costs.

Limitations

By applying different research methods, we tried to meet the central scientific requirements of validity, generalizability, reliability and reproducibility. Nevertheless, weaknesses of the individual methods must be clearly pointed out. Literature and internet research are snapshots and run the risk of being incomplete. The needs identified in the interviews and workshops cannot be reproduced 1 to 1 in another social area due to the changing nature of the problem. Nor can the concept per se be generalized to home care, since the focus of this study was on the care of older people.

Conclusion

In this contribution, a concept was presented for the development of a service offered by local actors in a rural caring community, which aims to advise and support family caregivers in the development and stabilization of their own care network. For the socio-technical toolbox, suitable digital support technologies as well as local structures have to be created, which are needed in the caring community in order to cooperate even better, which enables the identification of gaps in care and which favors the further development of offers in the future.

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Head-Mounted Display-based Intervention and Education Concepts for Patients Post-Stroke and Relatives in Domestic Care

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Abstract. This work presents a demonstration system that was developed as part of an interdisciplinary research project and aims to enhance health literacy and improve functional outcomes for patients post-stroke. The demonstration system consists of three parts: 1) a head-mounted Display and the connection to; 2) the electronic patient data management system and hospital information of the project partner. The system is able to initiate remote treatment and counselling, patient identification, remote mentoring, interactive control, and additional features like clinical assessment and documentation. It facilitates interprofessional information sharing, supports specific workflows (SOP), and enhances communication. The underlying project objectives are anticipated outcomes such as improved health literacy, functional outcomes, self-care abilities, and quality of life of patients and relatives. The study also aims to develop a care concept to prevent rehospitalization, examine the appropriation and acceptance of the system in daily clinical practices, and assess technology opportunities and risks. This work is an inspiration and

orientation for future research, development, and design of AR-based interventions in clinical contexts.

Introduction

Stroke is the leading cause of long-term disabilities, and within one year of experiencing a stroke, approximately 73% of individuals affected by stroke incidents will experience at least one fall (Denissen et al., 2019). Even less severe falls can result in activity limitations, reducing the overall quality of life and triggering concerns about further falls among affected individuals (Denissen et al., 2019). Falls after a stroke can lead to significant health complications, including injuries such as fractures, head injuries, and muscle strains, which can impair the mobility and independence of patients (Belgen et al., 2006). A systematic review and meta-analysis by Denissen et al. (2019) also found that falls in stroke patients were associated with an increased rate of hospital readmissions and poorer functional recovery. Previous falls serve as a predictive factor for future falls in stroke patients (Stolze et al., 2004; Veerbeek et al., 2014). Therefore, it is of great importance to prioritize measures for fall prevention and management from the early stages of the disease and integrate them into the rehabilitation and care of stroke patients. The use of health-related information and communication technology (ICT) such as exergames (Unbehaun, Vaziri, Aal, Li, et al., 2018; Unbehaun, Vaziri, Aal, Wieching, et al., 2018; Unbehaun, Aal, Wieching, et al., 2019; Unbehaun et al., 2020), health applications and wearables (Vaziri, 2018), as well as digital games and training programs (Brown et al., 2022; Raß et al., 2023; Unbehaun, Aal, Carros, et al., 2019; Vaziri et al., 2017) in different domains, shown to improve activity levels and offer valuable potentials. Recently, virtual and augmented realities (VR and AR) are becoming increasingly visible in the field of health-related ICT and Human-Computer-Interaction (HCI) (Janßen et al., 2021; Janßen & Prilla, 2022; Unbehaun et al., 2021). Our work presents a Head-mounted Display-based system to improve the health and care competence of patient/caregiver education and at the same time to minimize the risk of falls in patients with ischemic stroke. For this purpose, assisted reality glasses (AR) are integrated into the care-process by the professional caregivers during the acute stay on the stroke unit, individual care situations are documented and didactically prepared for the patient. In this work, we present an early prototype, illustrating the main features of the system. The overall system will be contextualized, designed, and developed in a participatory design dialogue with all actors and additional stakeholders.

Project Background & Methodological Framework

The methodological framework of the study uses a mixed-methods approach, involving a randomized controlled trial and a practice-oriented oriented research infrastructure within a university medical hospital in Göttingen will be deployed. By introducing a PRAXLABS-Infrastructure we will establish a close symbiosis between the respective field of application and the stakeholder-groups and potential users of the system (Aal et al., 2016; Ahmadi et al., 2018; Müller, 2014; Müller et al., 2015; Ogonowski et al., 2018). This participatory research or development approach enables a flexible development process and ensures the long-term commitment and sustainability of the innovations to be developed in practice via the PRAXLABS-infrastructure. Various qualitative methods of social research with a praxeological focus are applied in the PRAXLABS. An important role is played by ethnographic methods such as participant observation in order to empirically record social practices and possible changes in care processes. Our research approach will use qualitative methods (ethnographies: participant observation, interview methods, biographical methods). Furthermore, concrete practical problems are identified in joint workshops with various stakeholders and experts and addressed in the co-design and technical development process. The insights gained from case studies in the context of qualitative methods will be tested on a broader basis in quantitative studies.

The objective of the randomized controlled trial is to compare the care concepts of the existing therapy with the support provided by the data glasses and gather information on fall prevention during the education process. Patients will be randomly assigned to two groups (1) group 1 will receive the project's care concept, including patient and caregiver education using digital assistive technologies such as the data glasses and (2) group 2 will receive the current standard therapy as outlined in the Stroke Manual.

Technical Infrastructure

The HMD system, designed and developed for the purpose of educating adapted to the needs of patients and caregivers following an ischemic stroke within the framework of care management, consists of a range of interconnected components. The core elements of this technical infrastructure include augmented reality (AR) glasses, and a smartphone, offering diverse multimodal input and output functionalities, such as gesture and voice control.

Various digital, medical, and nursing information will be collected based on different scoring systems. These findings will be compared with clinical parameters routinely obtained during the conventional treatment on the stroke unit.

Additionally, the collected criteria will be documented and presented through questionnaires in the follow-up care.

The usage of the data glasses follows predefined scenarios.

1. ***Baseline assessment:*** The interdisciplinary team analyzes care requirements based on patient and social history. Inclusion/exclusion criteria are verified, and patients and caregivers are informed about the study. Motion analysis using video recordings through data glasses is performed with patient and caregiver consent. The expert standard procedure to prevent falls (from our <anonym> hospital partner) is documented and processed according to data protection requirements. Questionnaires are administered to familiarize participants with the study procedures and data glasses technology.
2. ***Education using data glasses:*** Data glasses are used for patient and caregiver education from day three of the hospital stay. The assigned nursing professional utilizes data glasses to address care needs in the acute setting. Daily live video streams are transmitted to caregivers after obtaining consent. Nursing interventions for fall prevention, as outlined in the fall SOP, are demonstrated using data glasses with virtual presence of caregivers via conference calls.
3. ***Continuous data glasses use:*** Weekly consultations by the nursing professional address individual care needs for caregivers, implementing fall prevention measures through instructional videos created during the acute stay. Quarterly evaluations occur through counseling and surveys. Individual training sessions with data glasses are provided if needed and documented. Workshops during the rehabilitation clinic stay cover care basics and data glasses applications.

Figure 1: Data glasses -RealWear Navigator 520

Integration into Care and Case Management

The system will be used to provide support in various ways in a hospital setting.

Remote treatment: Through data transmission, information about caregiving activities can be shared. Remote assistance can be requested for specific questions or rare caregiving tasks that require specialized knowledge per video or live-chat.

Patient data: Using barcodes or other recognition methods, the glasses can identify patients and document care report by voice message.

Remote mentoring: The glasses can provide step-by-step guidance for specific workflows using text, images, or videos (such as endotracheal suctioning, fall management).

Interactive control: The glasses can display real-time data e.g. from the bed (such as pressure sensors) to show the patient's positioning or repositioning until, for example, pressure ulcers are relieved through changes in positioning (visual monitoring).

Additional functions: Teleconsultation assistance, multiple devices/participants per session, user management and dialogue design, predefined voice commands, camera orientation, support for various languages, shared workspace (photo board, virtual finger, screen sharing, commenting functions

Conclusion and Outlook

The use of data glasses is anticipated to offer numerous advantages for various stakeholders: (1) patients can receive tailored care, minimizing the risk of falls, preventing health issues, and enhancing opportunities for rehabilitation and social integration, thus improving the overall quality of care they receive. (2) Relatives will benefit from an increased flow of information and improved safety measures. (3) The broader society stands to gain from individuals being able to stay at home for longer periods, reducing the burden on family caregivers, improving the quality of care, and alleviating strain on healthcare personnel, that includes positive economic consequences. However, it is essential to consider potential risks, including ethical, legal, and social implications, as well as issues related to privacy, data security, and the evaluation of the impact of these applications.

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Aydin Coskun, David Unbehaun, Tom Fritz, Patrick Kaiser & Christoph Mall (2023): Enhancing Physical Activity Engagement through Sensor Technology-driven Musical Systems: A Pathway towards an Active Lifestyle for Health Promotion with "BeatSense". *9th International Conference on Infrastructures in Healthcare. DOI: 10.48340/ihc2023_pd023*

Enhancing Physical Activity Engagement through Sensor Technology-driven Musical Systems: A Pathway towards an Active Lifestyle for Health Promotion with "BeatSense"

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Abstract. Promoting physical activity has become a significant global health priority in recent years. Sedentary lifestyles and their associated health risks have become a significant concern, necessitating innovative approaches to encourage individuals to adopt and sustain active habits. Integrating technology with physical activity interventions has

shown promising potential in addressing this challenge. In this context, the emergence of musical devices influenced by sensor technology represents a novel avenue for enhancing movement engagement and fostering a more active lifestyle. Within this work we will present an interactive prototype, consisting of sensorized artefacts that are connected with a software to create music in a social sense.

1 INTRODUCTION

The motivation of this work results from rising collateral health problems and medical progress in last centuries that lead to an older - more health-prone - society due to increasing life expectancy. Physical Activity as well as sports connect people in many ways and play an important role in everyday life of many people: physical activities have a positive impact on physical and mental health (e.g., (Ahn & Fedewa, 2011; Biddle et al., 2019; Penedo & Dahn, 2005) and make a valuable contribution to social participation and individual mobility (e.g., (Becker et al., 2018; Corbett et al., 2018; Schmid, 2015). In contrast, a wide range of positive effects on health, cognition, and learning levels have been shown for the passive stay in as well as the physical-sportive active use of urban and rural open green spaces (Becker et al., 2018; Dadvand et al., 2015; McCormick, 2017; Mnich et al., 2019; Stevenson et al., 2018) or by using music-oriented interventions (Biehl et al., 2006; Fritz et al., 2018; Rehfeld et al., 2022; Unbehaun et al., 2020). Digital technologies have been used in the context of sports before for several purposes (Raß et al., 2023; Taugerbeck et al., 2019; Unbehaun, Aal, Carros, et al., 2019; Unbehaun, Aal, Wieching, et al., 2019; Unbehaun et al., 2021). Very acquainted are the traditional step counters, which use pedometers to detect daily step counts to assess and motivate PA behaviors (Tudor-Locke & Bassett, 2004). The goal of 10,000 steps/day gained popularity with the media and in practice because it appears to be a reasonable goal to benefit health (Kang et al., 2009). However, pedometers are not as accurate as accelerometers, which are the current standards to collect PA data and are therefore used in smartwatches and modern fitness trackers (Henriksen et al., 2018). Most accelerometer-based fitness wearables can be used to estimate the type of movement, count steps, calculate energy expenditure (EE) and energy intensity, as well as estimate sleep patterns and more (Henriksen et al., 2018). Another digital device that is used in the context of PA is the heart rate monitor that only includes a wristwatch. These watches can accurately detect the heart rate to monitor the training intensity, given training effects, as well as the safety of an individual during a training session. Tying in with new hybrid forms of digital exercises as seen in the genre of Exergames (Unbehaun, Aal, et al., 2018; Unbehaun, Vaziri, et al., 2018) and the example of Pokémon Go (Aal & Hauptmeier, 2019), the field of Computer-supported collaborative sports tries to make use of new technologies by expanding sports experiences through digital Augmentations (Unbehaun, Aal, et al., 2018; Wulf et al., 2004).

This demo paper presents the potential of musical devices influenced by sensor technology in promoting physical activity for health purposes. By synergistically incorporating movement-tracking sensors and responsive musical elements, these devices aim to augment the enjoyment and motivation of exercise, ultimately leading to increased adherence and sustained engagement in physical activity routines. The interactive nature of the sensor band-driven music device "BeatSense" transforms movement into an immersive, multi-sensory experience. As individuals engage in physical activities, the device seamlessly captures and interprets their movements, translating them into real-time musical rhythms, melodies, and harmonies. This real-time auditory feedback enriches the exercise experience and establishes a clear link between movement and music, tapping into the inherent human inclination to respond to rhythmic stimuli. By leveraging this innovative technology, the "BeatSense" system facilitates enhanced physical activity engagement, motivation, and enjoyment. The dynamic interplay between movement and music aims to create a sense of flow and synchrony, enabling individuals to explore the full potential of their bodies while simultaneously experiencing the emotional and cognitive benefits of music. Through real-time data collection on metrics such as heart rate, calories burned, and distance covered, individuals can gain deeper insights into their physical exertion levels and progress toward achieving their health goals. This valuable feedback contributes to self-awareness, facilitates informed decision-making, and empowers individuals to optimize their exercise routines for improved health outcomes. This work aspires to pave the way for evidence-based interventions and recommendations that promote physical activity and facilitate a healthier, more active society by offering insights into this emerging technology's theoretical underpinnings, practical implications, and potential limitations in multiple research areas.

2 PROJECT AND SYSTEM OVERVIEW

"BeatSense" incorporates sensor bands and mats from the project partner German Institutes of Textile and Fiber Research Denkendorf to capture movement data, which is then used to influence the generated music. Additionally, the System integrates the "Jymmin" software a novel technology and training concept that merges musically expressive performance with physical exercise, creating a unique musical-feedback-training experience (Strong et al., 2022). Integrating music and sensor technology within the System serves multiple objectives in promoting physical activity. Firstly, synchronized music enhances enjoyment, reducing the perceived effort and monotony often associated with exercise. Secondly, real-time feedback reinforces positive behavior and provides a sense of accomplishment, promoting self-efficacy and intrinsic motivation. Additionally, the System aims to facilitate cognitive engagement and coordination by integrating rhythmic and melodic elements, promoting mind-body synchronization during physical activity. The captured movement data serves as input for the music generation component of the System. The System employs algorithms that convert movement patterns and intensities into musical elements, such as rhythm, tempo, melody, and harmony. By mapping movement data to musical parameters, the System generates a unique and synchronized musical composition that dynamically responds to the user's physical activity. The System employs a musical-feedback-training approach to enhance physical activity sessions. As users engage in exercise routines, the generated music provides immediate auditory feedback, synchronizing with their movements and intensities. This real-time feedback facilitates a deeper connection between physical exertion and musical expression, creating an immersive and engaging experience. The music acts as a motivational tool, encouraging individuals to maintain and improve their performance levels, resulting in increased adherence and enjoyment of physical activity.

3 TECHNICAL INFRASTRUCTURE AND APPLICATIONS

The System utilizes wearable sensors, sensor bands, and mats (Figure 1) to detect and capture movement data during physical activity. These wearable sensor bands are placed on various body parts, such as wrists, ankles, or torso, while the sensor mats are placed on the floor or exercise equipment. The sensors within the bands and mats track and record motion, intensity, and other relevant movement parameters, providing real-time data feedback.

Figure 1: Sensor mat and bands

3.1 SENSOR BANDS AND MATS

The System's technical foundation lies in the sensor bands and mats which are connected to the Jymmin System. (Figure 2) These components are equipped with motion sensors, accelerometers, and additional biometric sensors to capture movement data accurately and in real-time. The sensors detect and measure parameters such as position, velocity, acceleration, and intensity of physical movements. These sensors should be designed with precision and accuracy to ensure reliable data collection, and they should support wireless communication protocols to transmit the captured data efficiently.

Figure 2 - Simple test sensor successfully connected to the Jymmin system.

3.2 DATA PROCESSING AND ANALYSIS

The collected sensor data serve as inputs for data processing and analysis algorithms. These algorithms interpret the raw data and convert them into musical parameters. Complex algorithms may map specific movement patterns, intensities, and temporal dynamics to corresponding musical elements such as rhythm, tempo, melody, and harmony. The processing should occur in real-time to provide immediate feedback to the user, creating a seamless integration between movement and music.

3.3 MUSIC GENERATION AND INTEGRATION VIA JYMMIN

The generated musical elements must be synthesized, mixed, and integrated into a cohesive musical composition that aligns with the user's movements. This process may involve digital sound synthesis techniques, music composition algorithms, and music production tools. Integrating the music with the user's movements should be seamless and synchronized, allowing for a fluid and immersive musical experience that enhances the engagement and enjoyment of the physical activity. The System may also offer customizable musical styles and genres to cater to individual preferences and optimize the user experience. The technical infrastructure supporting "Jymmin" technology entails specialized exercise equipment, such as "music-producing fitness machines." These devices should be designed to respond to the user's exertion and movement by producing real-time musical sounds and effects. Embedded sensors in the equipment detect force, pressure, or movement, triggering music production in a manner that reflects and complements the user's physical performance. The technology behind "Jymmin" necessitates robust hardware integration, responsive sound generation algorithms, and precise synchronization between physical exertion and musical output.

4 CONCLUSION AND OUTLOOK

Developing a musical system that supports individuals in adopting and sustaining an active lifestyle through sensor technology and musical feedback training holds tremendous promise in health promotion. This endeavor has shed light on the potential of such a system to revolutionize how people engage with physical activity, making it more enjoyable, engaging, and conducive to long-term adherence. Integrating sensor bands and sensor mats within the System has proven instrumental in capturing and transforming movement data into musical elements. By converting physical activity into an interactive musical experience, individuals receive real-time auditory feedback that enhances their engagement and establishes a profound connection between movement and music. This innovative approach addresses the challenge of sedentary behaviors by infusing exercise routines with playfulness, motivation, and emotional resonance, thus captivating users and encouraging them to move more frequently and vigorously.

Implementing musical feedback training as a core system component has proven to be instrumental in facilitating positive behavior change. Real-time auditory feedback is a powerful motivator, reinforcing individuals' efforts and achievements during physical activity. By bridging the gap between effort and musical expression, this training approach nurtures a sense of accomplishment, self-efficacy, and intrinsic motivation, promoting sustained exercise engagement. The immersive nature of the music-driven feedback fosters a flow where individuals are fully absorbed in the activity, resulting in enhanced performance, reduced perceived effort, and increased overall satisfaction.

Looking ahead, there are several avenues for future exploration and improvement of the musical System for promoting physical activity. One potential direction is to refine the algorithms and mapping mechanisms that convert movement data into musical elements. Further research can explore the impact of different musical styles, genres, and personalized preferences on engagement levels and adherence. Additionally, advancements in sensor technology can enable more precise and comprehensive movement tracking, allowing for a more nuanced and immersive musical experience.

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Robotic-Based prevention and health Promotion in Care Facilities – Interactive Design for Group Sessions

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Abstract. Robotic-based technologies may support older adults, people in need of care and relief professional actors in the health system. In this demonstration paper, the authors present a robotic-based system designed for individual and joint activities in care-facilities. Empirical insights and results from a 14-month participatory design study focusing on ideation, participation and evaluation of Socially-Assistive Robots for both, older adults in need of care and professional caregivers in different care and medical settings were considered. This work aims to be an inspiration and orientation for future research, development, and design of gamified robotic-based exercises in care.

Introduction

As the need for professional and institutional care grows and the number of qualified caregivers declines, governments and society are seeking innovative solutions to support professional care activities and the independence of those in need of care (Aal et al., 2016; Komendziński, et al., 2016; Ten Haken et al., 2018). The use of information and communication technologies (ICT) whether in the documentation of information, assistance systems, videogame-based interventions or socially-assistive robotics (SAR) has the potential to deliver such support as digitalization in the healthcare sector continues to progress rapidly (Carros et al., 2020; Fasola & Mataric, 2012; Feil-Seifer & Mataric, 2005; Müller et al., 2015; Unbehaun et al., 2018, 2019, 2020). Robotic-based interventions may support people in need of care and help them to maintain or improve their physical abilities and their activities of daily living. As shown by Kachouie et al. (Kachouie et al., 2014) or Abdi et al. (Abdi et al., 2018) the use of **socially assistive robotics (SAR) in elderly care** had some limited positive effects in affective therapy, cognitive training, social facilitation, companionship and physiological therapy (Abdi et al., 2018; Kachouie et al., 2014) could **improve the overall well-being of people in need of care and enhance the quality of care** (Carros et al., 2022; Raß et al., 2023).

Our work presents a Robotic-based system to foster physical activity, facilitate social interaction as well as create an innovative interface to promote active participation across all ages and abilities. In this paper, we present a Robotic-based System aiming to provide physical training activities and combine them with socio-creative elements such as music-based group activities or quiz-games to create cooperative and interactive scenarios. The developed robotic-based applications aim to promote health prevention and enable social interaction between people in need of care and SAR by creating a playful atmosphere that motivates them and to support professional care givers in their daily work routines. The study setting and framework is part of the German research project "ROBUST" that is founded by the Association of Substitute Health Funds (in German: Verband der Ersatzkassen e.V. (vdek). This Association represents the interests of overall six substitute health funds in Germany and also acts as their service provider. As the successful introduction new technologies depends on early involvement of the users personal and interpersonal needs and expectations, we followed a participatory and user-centered research and design approach to support the appropriation process of people in need of care and their caregivers (Schuler & Namioka, 2017).

Project and System Overview

The system was conceptualized and developed in the project *ROBUST* with overall four care facilities, integrating the voices and perspectives from residents, caregivers, managers and additional stakeholders. The System and its components games described in the paper are the outcome of a co-design process conducted by using in a LivingLab environment (Ahmadi et al., 2018). The purpose of the underlying concept was to provide a suite of digital activities that could give residents of care-facilities support gamified health prevention across their activities of daily living (ADLs). We conducted different long-term studies in that we focused on the relevant aspects and sustainable effects of the digital intervention on individual performance and social interaction and re-integrated the findings and observations into the design and development process. The robotic-based activities took place in various group settings from 3 to more than 20 participants. The robotic-based applications are designed in a participatory and user-centered approach including practical experiences and feedback from people in need of care, professionals, and their social networks.

TECHNICAL INFRASTRUCTURE AND APPLICATIONS

As a technical infrastructure, “Pepper” is used as robotic system. The robot is mainly used in group sessions for physical exercises, cognitive training, and socio-emotional support to encourage residents to engage in physical activity and improve their overall quality of life. The final system contains several technical components that are displayed in Figure 1. The components were organized around the humanoid robot pepper, which is designed to interact socially with humans and have an expressive appearance. Pepper is equipped with several sensors that ensure its safety and the safety of people and those that enable autonomous navigation.

Figure 1 The Humanoid Robot Pepper

With the help of these sensors, it is also possible for the robot to recognize people, movements as well as emotional states. However, to use such robotic systems in more complex scenarios, programming of these systems is required. This programming of different applications was done using standard development environments such as Choregraphe and Android Studio. Choregraphe is a Softbank-developed graphical software that can be used to create applications on the Pepper robot. An application can consist of “boxes” that let the robot make movements and say things, turn on its LEDs, etc. Android Studio is a free integrated development environment (IDE) from Google and official development environment for Android software development. The menu interface was designed to be simple and easy to use for professionals and residents in care facilities (Figure 2; Figure 3). Additionally, the robot was programmed to demonstrate physical

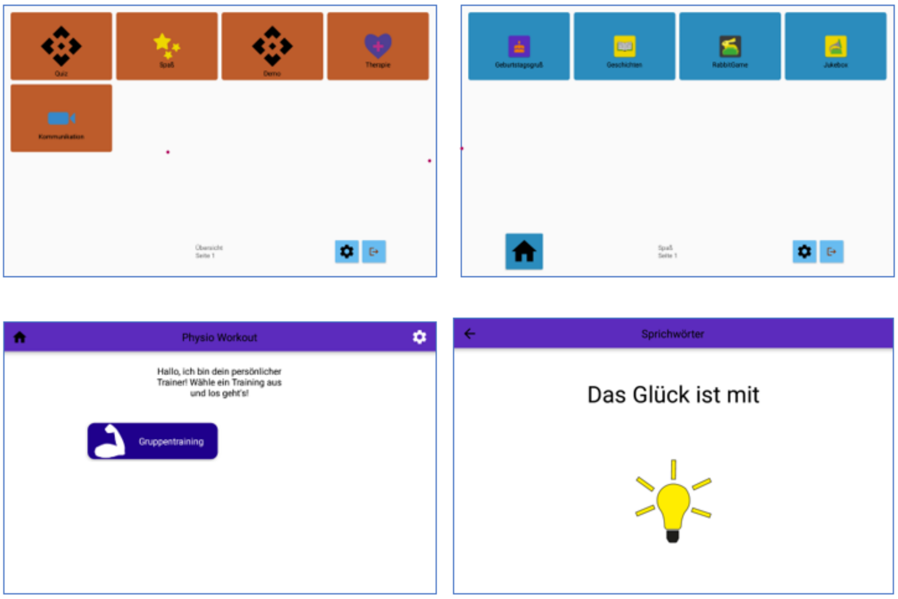

Figure 2 Interface Design

activity and movement exercises such as raising arms, making fists or bending forward the upper body. The exercises were designed in cooperation with physiotherapists and practitioners in the care facilities. As Pepper can only move his arms, movements performed or demonstrated by "Pepper" focus on upper limb muscles that are important during functional movements, walking, and recovering balance. Due to technical limitations, Pepper cannot demonstrate exercises for the lower limb. To compensate this issue, "Pepper" explain these exercises and participants were asked to repeat these exercises.

The applications developed for cognitive activation include playful exercises for memory training, quizzes, or interactive puzzles. A jukebox app was developed to play music before, between or after cognitive or physical exercises (ex. Figure 4) to improve psychological well-being and promote engagement during robotic-based group sessions.

Figure 3 Robotic-Based Activities for Residents - Exercises for Physical Activation

The following table lists a selection of exemplary applications and their short descriptions, as a short description of the cognitive, physical, and socio-emotional activities.

Table 1 List of exemplary applications

Physio app:	The robot demonstrates various upper body exercises (including arms and hands) that the user should imitate. The app includes individual exercises and pre-made workouts for different levels of physical mobility and activities.
Jukebox:	The application includes different songs organized into categories for playing and singing along. The robot can also perform dance moves and spin. This App is often used to start and end a group session.
Chess:	The user can play chess against the robot on the tablet following official rules. Pieces are moved by tapping, and the robot provides motivation and encouragement.
Rabbit Game:	The user must catch rabbits that appear on the screen. By tapping on the rabbits on the screen, they disappear, but appear faster and faster over time. If too many rabbits are not tapped, the game ends.
Meditation/dream journey:	The app offers a selection of meditations and dream journeys. Contents can be played under each category.
ABC app:	With the push of a button, the application generates a random letter and reads it aloud twice, optionally with or without an alphabet chart. The user can then draw a new letter or have the letter read aloud again.
Proverb quiz:	The robot states the first part of a proverb, and the participants must complete it. On command, the robot reveals the solution, which is the complete proverb. The quiz is divided into different categories of proverbs

Conclusion and Outlook

While the robot Pepper has proven to be a useful tool for engaging with elderly individuals in care facilities, it is not without its limitations. For example, its speech capabilities can be too quiet or too fast for individuals with hearing impairments. Additionally, the robot focuses on physical exercises primarily for the upper extremities, which may not provide a well-rounded approach to physical therapy for all individuals. Furthermore, the execution of these exercises may not be analogous to human movements, as residents may rely on eye contact to confirm they are performing the exercises correctly. These limitations of the robot "Pepper" underline the importance of human support during the group sessions. The applications in the project are therefore designed to be used in a human-robotic collaboration and to promote social interactions between people in need of care and caregivers.

In the following course of the project, the existing apps will be improved in close cooperation with the users – people in need of care, relatives and professional caregivers who also support and participate in the development and design process of new applications based on their needs and ideas. In perspective, we thus create a pool of applications for cognitive, physical and socio-emotional training for people in need care from which professionals can compile robotic-based group sessions.

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Erinnern Sie sich noch? A Storytelling Game with Pepper for Older Adults' Memory Training

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Abstract. Providing care for older adults in Germany is becoming increasingly challenging due to current demographic and social trends. To address this issue, technologies, such as robot-based, are being used to develop and test new ideas on how to provide nursing care. Moreover, many older adults can be affected by memory loss problems. Memory training can play a crucial role in helping ameliorate these issues, improve memory performance, and connect with others. This project aims to offer a memory game that provides residents with a meaningful activity, such as memory training, that they can enjoy and in parallel it may support nursing staff and caregivers in a retirement home through robot-based assistance.

Introduction

Germany's current demographic and social trends pose increasing challenges to providing care for older adults (Statisches Bundesamt, 2022). In response to this, digital technologies are being harnessed to explore innovative approaches in nursing care provision. The objective is not to replace face-to-face care work but rather to enhance and supplement it (Abdi et al., 2018). Given the complex nature of this situation, the role of academia has become indispensable in analyzing potential strategies to support the health of older adults, including the utilization of robot-based assistance (Carros et al., 2020). This technology aims to provide social companionship to older adults, in addition to the physical aid typically provided by caregivers (Broekens et al., 2009). Furthermore, it holds the potential to improve the well-being of older adults and alleviate the workload of caregiving staff (Kachouie, 2014). Moreover, memory training has been recognized as a crucial element in assisting older adults in mitigating memory loss problems (APA, 2022), enhancing their memory performance (Blue et al., 2020), and fostering social connections (Broekens et al., 2009).

This student project is situated within the broader context of the e-ViTA (EU-Japan Virtual Coach for Smart Ageing) (e-ViTA, 2023) research initiative. e-ViTA research aims to develop virtual coaching devices that empower fit older adults to be more active and healthy (Naccarelli et al., 2023). The storytelling memory training game "Erinnern Sie sich noch?" primary objective is to extend support to nursing personnel and caregivers within a retirement home through the implementation of robot-assisted aid. In addition, the project seeks to enhance the quality of life for residents by offering engaging and purposeful activities, such as memory training. These activities are designed not only for enjoyment but also to foster motivation and potential collaboration among residents.

Related work

The study explored key aspects related to older adults' memories, medical causes, professional practices, and the potential of technology for memory training, including robot-based technology for support. Aging can lead to changes in specific brain areas, affecting personal reflections on the past and future during conversations (Wank et al., 2020). Memory difficulties in seniors may stem from the accumulation of a vast volume of memories rather than an inability to remember (Thompson et al., 2022). Recall and sharing of memories are important for older adults, promoting brain training, social connection, and meaning in life. Reminiscing is considered beneficial in psychological practice with older adults, as highlighted in the American Psychological Association's guidelines (APA, 2022). Reminiscence therapy, utilizing life histories, has shown positive effects. The development of technology, such as smartphone-based cognitive assessment, offers precise estimation and tracking of cognitive abilities, potentially aiding in early detection of conditions like Alzheimer's disease (Grilli, University of Arizona, 2020).

Robot-based assistance is another strategy to support older adults' health, providing social companionship and reducing caregivers' workload (Carros et al., 2020; Broekens et al., 2009; Kachouie et al., 2014). These insights and the potential of technology have influenced our design concept.

Methodology

Data collection and analysis

To deepen our comprehension, we conducted a sequence of semi-structured interviews involving 4 older adults and 1 caregiver residing in a care home. The primary objectives were to elicit insights into the following dimensions: 1) The daily routines and experiences of older adults living in a care facility, 2) The catalysts that evoke and sustain their memories, shedding light on the mechanisms of retention, 3) The individuals with whom seniors opt to share their reminiscences, along with the underlying considerations, and 4) The level of trust older adults place in technology, particularly their perceptions of Pepper, the robotic assistant. Importantly, most residents and caregivers in this facility are familiar with Pepper due to prior University of Siegen studies (Carros et al., 2020; Schwaninger et al., 2023; Carros et al., 2022). This background sets the stage for our exploration of their perceptions and experiences in this research.

All participants received an explanation of the study aims and signed informed consent documents about their participation. The participant demographics were recorded to provide a better understanding of the population under study (Table I).

Participants	Interview ID	Age	Gender	Role	Familiarity with Pepper
P1	1	~65	F	Older adult	familiar
P2	1	88	M	Older adult	familiar
P3	2	~65	F	Older adult	familiar
P4	3	92	F	Older adult	not familiar
P5	4	N/A	F	Caregiver	familiar

Table I. Participants of semi-structure interviews

Findings

Upon transcribing the interviews, we used a thematic analysis approach, which led to the identification of themes across diverse dimensions of the interview questions.

Regarding daily routines and experiences of older adults living in a care facility, it revealed that most older adults displayed a keen interest towards engaging in physical activities, irrespective of their physical limitations. Furthermore, a notable proportion of participants enjoyed socializing over afternoon coffee with a small group of friends, providing an opportunity for engaging in discussions.

Turning to memories and reminiscing, it emerged that all older adults frequently engaged in reminiscence, displaying a strong desire to share their cherished life moments with others. Among the various topics discussed, beautiful travel memories emerged as the most popular. Notably, photographs served as the primary method for archiving and preserving these treasured memories.

Lastly, with regard to the perception of technology trustworthiness and attitudes towards Pepper, certain older adults perceived robots as mere machines, associating their function solely with manual tasks. Nevertheless, a significant majority found Pepper's humanoid appearance to be appealing and expressed a genuine affinity towards it.

Concept & testing

Based on the insights garnered, it becomes apparent that there exists a desire to share memories among friends within the care facility. Simultaneously, this presents an opportune moment to create an interactive and fun memory training game suitable for their leisure time.

Consequently, several requisites were identified, the conceptual framework ought to be tailored for small group contexts, as interactions with peers have the potential to stimulate active participation among older adults. Moreover, it should actively promote the recall of specific memories that engage participants emotionally, thus estimulating cognitive capacities. Additionally, the program must take into account popular interests and inclinations of older individuals, such as trips, to curate a personalized memory training experience. Lastly, a focus should be placed on building a trusting and reliable rapport between participants and the Pepper robot.

Subsequently, a game concept was formulated, capitalizing on the interactive capabilities of the Pepper robot to attain its goals. This game entails Pepper showcasing pictures of shared experiences of the residents (e.g., care home-organized summer trips) on its tablet. Moreover, Pepper narrates these experiences, prompts participants with specific questions to recall details from their memories employs voice recognition technology to distinguish correct and incorrect responses, and provides continuous encouragement. Furthermore, the humanoid appearance of Pepper, complemented with crafted dialogues, along with positive tones and body language, seeks to establish a sense of friendship and familiarity, thereby motivating older adults to perceive Pepper as a companion. The pictures employed in the games were from group activities held by the nursing home, where all participants have taken part, no private pictures, nor sensitive data included. It is important to note that the nursing home willingly provided both the pictures and the associated details for the service, maintaining a commitment to ethical practices and data sharing.

The prototype of the concept featured two distinct storylines based on past experiences, such as a trip to a zoo[1] and a small celebration[2] of the Cologne carnival in the nursing home. The game utilized images from these activities, and implemented by the Choreograph software and installed on the robot. Choregraphe is a visual programming language implemented by Softbank robotics to program the NAO and Pepper robot (Subedi et al., 2021; Pot et al., 2009). An interface for the tablet was designed using HTML and CSS to showcase the event pictures and support storytelling.

In order to enhance the concept, a series of testing sessions were carried out. The majority of these sessions took place in a robotics laboratory to address initial concerns including adjusting voice recognition sensitivity and iterating on the interface and storyline design. Following this, the game was introduced to a different nursing home for additional testing sessions with residents using Pepper. These sessions were scheduled during leisure hours, gathering further feedback and valuable insights. It is noteworthy to mention that the residents and caregivers at this facility possess minimal to no familiarity with Pepper.

Discussion

The interviews with residents and caregivers provided valuable insights shaping the program's concept and implementation. However, the sample size was limited and it considers the perspective of a single care facility.

Participants' attitudes during testing sessions indicated notable curiosity and engagement with Pepper, as one participant stated, *"Now that's something different!"* Nevertheless, as mentioned before a broader participant pool is necessary for a more comprehensive evaluation.

The humanoid appearance of Pepper was well-received, fostering a friendly atmosphere. Additionally, the tailored storylines using pictures and brief notes received a positive response, prompting lively discussions about past experiences. Moreover, the older adults seemed motivated to receive positive reinforcement for answering quiz questions correctly.

However, it was discussed that newcomers or individuals without past group activities may face challenges engaging with the game. This due to their lack of familiarity and/or absence of personal pictures. Furthermore, displaying pictures of recently deceased individuals may cause confusion and emotional distress, requiring further research on how participants perceive such situations, especially residents with dementia or diverse emotional vulnerabilities.

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[1] *The nursing home organized a trip to the zoo, where residents had the opportunity to visit, socialize, and learn interesting facts about the animals there.*

[2] The nursing home hosted a *traditional* Cologne's carnival celebration where the residents dressed up, gathered together, and enjoyed the festival while also learning about the carnival's history.

Limitations surfaced in the context of direct interactions with the robot, often requiring assistance for comprehending instructions and maintaining smooth conversations. Although the "Help" option was programmed to assist residents by providing hints without providing a solution, managing interactions within group settings remained intricate. This complexity occasionally led to frustration among participants, as expressed by one individual's remark, "*...(robots) are something for the future...*".

Adjustments to the voice recognition system are necessary to accommodate older adults' voice capabilities. Pepper's functionalities could be constrained when addressing issues like visual impairment or difficulties in adapting to technology. The role of caregivers support and the potential for multimodal interactions may serve to address such challenges.

Ethical considerations are vital in implementing digital technologies for older adults, prioritizing their needs, autonomy, and right to refuse technology use. Hence, while Pepper could serve as a companion, thereby helping to alleviate the limited caregiver availability in nursing homes, its purpose is to support the care provided by them rather than replace human interaction or the role of caregivers.

Conclusion

The Pepper robot-incorporated storytelling memory game exhibits potential in enhancing memory and cognitive function among older adults through visual reminiscing. However, a comprehensive, extensive observation involving a larger group of participants is necessary to determine its impact on brain performance.

Memory games and social activities hold great importance for seniors in retirement homes. However, staff shortages may result in activity cancellations. Encouragingly, participants warmly welcomed Pepper as a potential companion, thus offering a possible opportunity to support caregivers. Consequently, the integration of robotics and consistent cognitive training could potentially alleviate this challenge.

Looking ahead, transitioning from sole voice recognition to a multi-modal approach, could provide an opportunity to better suit diverse older adult capabilities, augmenting the concept's care home support.

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Embedding Artificial Intelligence into Healthcare Infrastructure for Prostate Cancer Diagnosis

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Abstract. Early detection and diagnosis of prostate cancer are of utmost significance for effective treatment, and artificial intelligence (AI) has the potential to assist radiologists in this area by analyzing medical images and improving diagnostic accuracy, especially given the scarcity of radiologists. This article outlines our ongoing research, focusing on designing a human-centered AI system to aid radiologists in detecting and diagnosing prostate cancer and integrating it into the existing infrastructure. Through qualitative field research involving observations, contextual inquiries, and interviews, we examined current practices, workflows, and usage contexts in German radiology centers. Our study reveals inconsistencies, barriers, and communication gaps among specialists in the diagnostic process. Based on this, we explore the potential benefits and obstacles of incorporating AI into prostate cancer diagnosis while emphasizing human-AI interaction.

Introduction and Background

Artificial Intelligence (AI) has made its way to a diverse range of healthcare sectors and is driving a technological shift in medical infrastructures. It has been

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progressively developed, and its adoption is becoming the standard in many healthcare sectors, including primary care, unique and severe illnesses, emergency care, biomedical research, and public health (Lekadir et al., 2022).

AI has the potential to revolutionize prostate cancer diagnosis by assisting radiologists in improving the accuracy, consistency, and efficiency. It can be integrated into healthcare infrastructure, especially through medical imaging, where it plays a crucial role in enhancing the precision and competency of image analysis and interpretation. By analyzing medical images such as the magnetic resonance images (MRIs) used for prostate examinations, AI has the prospect to assist radiologists in detecting abnormalities and diagnosing diseases more accurately (Bardis et. al, 2020). We are currently working on the design of an AI-powered demonstrator that assists radiologists in analyzing multiparametric MRIs (mpMRIs). This technology aims to detect patterns and anomalies in prostate images that may be challenging for human eyes to detect without AI assistance, leading to improved early detection of health conditions like prostate cancer.

Although healthcare practitioners are open to incorporating AI technology in their practices, its availability is still limited to specific team members and departments. Previous research has shown that different parts of an organization's structure are connected through standard connections, enabling employees to benefit from reflexivity and versatility (Pipek and Wulf, 2009). Understanding how these connections are made and how the interactions between social and technical aspects contributes towards the establishment and use of infrastructures is key for the design of technologies that can indeed support the practitioners.

Here we argue that AI can serve as a unifying force, bringing together various components within healthcare infrastructures to contribute to the early detection and diagnosis of prostate cancer. AI technologies can help seamlessly integrate disparate systems, data sources, and processes, supporting teams of physicians, including radiologists, in their work. In particular, AI can play a pivotal role in optimizing healthcare infrastructure, enhancing efficiency, interoperability, and decision-making, ultimately improving the delivery of healthcare services.

Developing any new technology can be challenging, especially in a robust infrastructure like healthcare, where physicians must make immediate decisions with potentially far-reaching implications (Ontika et al., 2022). Furthermore, there exist several barriers that may hinder the widespread adoption of AI in healthcare, including the lack of a practice-centered approaches for the design of such technologies, the complexity and unpredictability of the final applications, the limited involvement of humans in the development process, and the lack of explainability for professionals (Abdul et al., 2018). Hence, despite notable advancements in AI for healthcare, only a few AI systems have effectively transitioned into medical practice due to the lack of human involvement during development (Ontika et al., 2022). This highlights the need for a more human-centered approach to AI, one that combines technological capabilities with humanistic considerations (Shneiderman, 2022). Successful adoption of AI in the healthcare sector and by practitioners heavily relies on its seamless integration into existing infrastructure. If the implementation of AI is not smooth, it can introduce additional complexities and significant challenges can arise.

Additionally, the healthcare sector, with its established infrastructure, poses difficulties in the development and acceptance of new technologies. We argue that a practice-centered approach combined with a human-centered AI (HCAI) focus can help designers to identify opportunities for the integration of AI in current practices of medical teams and avoid barriers to medical acceptability to foster a transformative human-AI collaboration. Practice-centered computing take into consideration not only users, technologies, and the interactions in place, but also the practices that users engage in and the extent to what such technologies can really support them with their work (Wulf et al., 2018).

In our ongoing project, we are dedicated to designing a HCAI solution specifically tailored for radiology. Considering that HCAI systems can be effective and that, in our context, sensitive medical data is used, an extensive assessment of ethical and responsible design is necessary to develop technologies that accurately reflect human intellect. Our focus is on understanding human practices and identifying opportunities for the effective integration of AI in medical settings, with the aim of fostering a collaborative environment between humans and AI. Moreover, we don’t want to add just another tool to the market; rather, we'll be focusing on how our system can be embedded into the current infrastructure of the diagnosis process, ensuring a seamless transition.

Methodology

Over a period of five months, we conducted extensive qualitative field research, immersing ourselves in the environment of four distinct radiology centers (RC) across Germany. To gather comprehensive data, we employed contextual inquiry (Beyer and Holtzblatt, 1997) as one of our research methods. This approach involved eight inquiry sessions accompanied by in-depth interviews with five experienced radiologists who work with prostate cancer patients. Each observation session spanned three to five hours, while the semi-structured interviews lasted between 40 and 80 minutes.

Our primary objective throughout this research endeavor was to gain a profound understanding of the radiologists' existing practices. We aimed to delve into their professional experiences, workflows, interactions with various tools and stakeholders, as well as the challenges they encounter in their daily work. Moreover, we sought to explore their perspectives on working with AI for cancer diagnosis. We conducted thematic data analysis (Braun and Clarke, 2006) to extract meaningful insights from our data. In the following section, we will highlight some of the noteworthy observations that emerged from our research.

Results and Discussion

During our field research, we have comprehended that, although the exact steps and processes may vary depending on the institution, radiologists typically follow three significant blocks of action in their daily diagnosis of prostate cancer: patient data and image acquisition, image interpretation, and reporting. This diagnosis process can be seen in Figure 1. The radiologist begins by examining the patient's data, including clinical history, symptoms, laboratory results (such as prostate-specific antigen (PSA) values), previous and/or relevant medical records, and images obtained through imaging modalities such as mpMRI. All this information provides important context for the interpretation of the imaging findings to the radiologist for the next step, where s/he carefully analyzes the images to identify any suspicious lesions or abnormalities within the prostate gland. This process involves assessing the shape, size, and signal characteristics of the lesions, as well as their location within the gland, to determine the likelihood of cancer, its aggressiveness, and then classify them according to the PI-RADS scheme, which is a standardized classification system used for interpreting and reporting prostate MRI findings, aiding in the detection and characterization of prostate cancer (Leitlinienprogramm Onkologie - Oncology Guideline Program, 2021). Finally, the radiologist prepares a comprehensive report summarizing the findings, including the description of any detected lesions, their characteristics, and the overall assessment of the likelihood of malignancy, and clinical recommendations for further diagnostic steps, such as targeted biopsies or additional imaging studies.

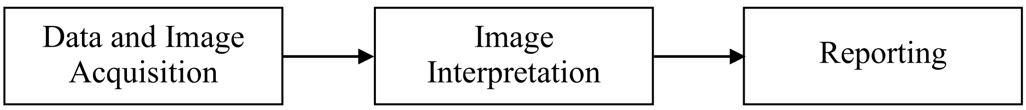

Figure 1. Main phases of the diagnosis process of prostate MRIs by radiologists.

Considering the challenges, including the image quality coming from the image provider artifacts and the heterogeneity of the prostate and prostate cancer, the diagnosis process is very complex. It is also very time-consuming, especially considering the limited number of radiologists in Germany, accounting for only 2.29% of all doctors (Bundesärztekammer - German Medical Association, 2021). We have also noticed that the interpretation of imaging findings can vary among radiologists due to differences in expertise, experience, and subjective judgment. Different radiologists may have varying levels of familiarity with prostate imaging, leading to discrepancies in lesion detection and characterization.

Our observations also revealed significant variations in the practices and utilized artifacts among different RCs. A critical distinction emerged in terms of whether the diagnostic process was conducted individually or through double analysis. Notably, RCs with two radiologists faced time constraints, leading to the first radiologist providing a summary to the second. This practice introduced bias as the second radiologist may not thoroughly analyze the images. Compounding this issue, limited resources often resulted in a single radiologist handling the entire prostate diagnosis, disregarding the recommended double analysis (PI-RADS, 2019). Decision conflicts among radiologists further prolonged examination times as they strived to reach a consensus. Furthermore, we observed that different RCs yielded divergent results for the same patient, highlighting decision discrepancies stemming from subjective interpretations of imaging findings. Such variability in diagnosis and treatment recommendations raised concerns about the reliability of the process.

Our investigation also unveiled numerous manual tasks and redundancies inherent in current practice. These tasks included manual calculations of prostate size, volume, and PSA density, as well as redundant work steps in reporting and data transfer. Apart from consuming additional time, these manual processes raised valid concerns about human errors, data loss, and inaccurate diagnoses. Interestingly, when queried about the potential for an AI system within their workflow and its trustworthiness, the radiologists responded positively. They acknowledged the scope for automation and expressed that such a system would enhance their daily work, provided it could demonstrate accuracy and efficiency.

Communication among the involved doctors is essential not only for discussing cases but also for validating their previous work. However, we discovered a communication gap in the process. Although radiologists request additional tests to confirm their findings, they rarely receive feedback from patients or referral doctors such as pathologists, and urologists.

Based on our empirical findings and our combined HCAI and practice-centered approach, we identified real user needs and gained a lot of insights about the doctors' current practice, workflow, and existing infrastructure. It is evident that radiologists can benefit from the integration of AI to assist in their diagnoses. Such a system would provide supplementary information and analysis of medical images, addressing the issues identified in the current practice. Our envisioned tool, PAIRADS, aims to mitigate the aforementioned challenges through the utilization of AI. By reducing the risk of human error and ensuring consistency in diagnoses across different radiologists, PAIRADS becomes particularly valuable in the realm of prostate cancer, where the interpretation of imaging data is subject to individual interpretation. By leveraging AI into their existing infrastructure, radiologists can make more accurate and prompt diagnoses, ultimately leading to improved patient outcomes. Our overarching goal is to enable humans to comprehend and interpret AI-generated outputs through Explainable AI, supported by visualization techniques. This approach ensures that human intelligence remains central to the decision-making process, resulting in the realization of hybrid intelligence (Jarrahi et al., 2022).

AI has the potential to be integrated into the diagnosis procedure in all the three steps that we mentioned before. However, in our current project we are primarily focusing on the middle phase, namely image analysis, as shown in Figure 2. Our system focuses on several key functionalities, including the accurate localization and segmentation of the prostate in MRI images, automated detection of abnormalities within the prostate, automatic calculations of relevant parameters, and the provision of a comprehensive result to end users. By presenting visual representations of the results as part of explainable AI, users can potentially identify patterns, trends, and anomalies in the data easily and quickly, enabling them to make informed decisions based on the algorithm's output.

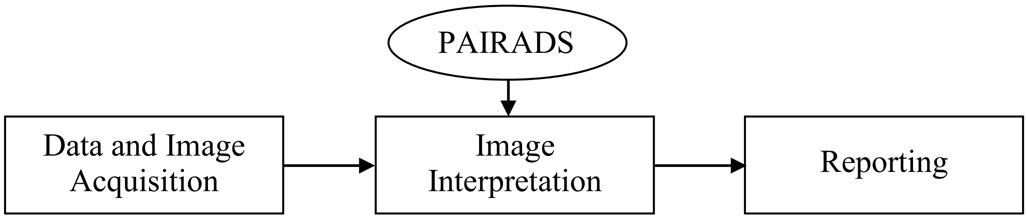

Figure 2. Embedment of PAIRADS into the diagnosis process of prostate MRIs by radiologists.

Our preliminary findings demonstrate the importance of adopting a human-in-the-loop approach to actively involve radiologists in the AI's learning process. This approach ensures that the model learns from real and relevant data, corrects errors, identifies biases, leverages domain expertise, and builds trust with users. By incorporating human intelligence into the process, the AI model can improve its performance and effectiveness. It is important to note that while AI can bring numerous benefits to healthcare infrastructure, it should primarily be used as a support for healthcare professionals and adhere to ethical and regulatory guidelines to ensure patient safety and privacy. However, addressing critical trade-offs involving accuracy, explainability, and trust in AI is essential to foster a transformative human-AI collaboration embedded within the existing healthcare infrastructure, a perspective widely supported in the current literature.

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Designing an infrastructure for sharing of data generated by welfare technologies.

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Abstract. The analysis of WT-generated data holds significant potential to enhance care quality, well-being, safety, efficiency, and decision-making in healthcare settings. This ongoing research focuses on investigating the key challenges associated with designing an infrastructure for sharing WT data in Swedish municipalities. Our findings highlight various obstacles, including conflicting stakeholder needs, limited experience in data analysis and visualization, unclear ownership of data and systems, and the complexity of the technical environment. The implemented WT systems consist of alarm solutions with additional optional features and a data platform that presents information to stakeholders based on the providers' chosen aggregation and interface. To effectively utilize WT-generated data, a viable approach for municipalities is to assume overall responsibility for a governance model encompassing both social and technical aspects. This approach aligns with the perspective of service innovation and service logic (Lusch and Nambisan, 2015), which emphasizes the value derived from usage and focuses on the processes of serving rather than product exchange.

Introduction

European countries face challenges due to an aging population and limited resources, jeopardizing existing care systems. To address these challenges, governments have prioritized digitalization in elderly care. Welfare technologies (WT), such as digital safety alarms, monitoring devices, and sensors, are now widely implemented (Scott & Mars, 2013; Heine & Winther Wehner, 2012), generating vast amounts of data that often remain underutilized in care institutions. Effectively managing WT-generated data represents the next phase of development, with the potential to enhance care quality, safety, and efficiency, as emphasized in strategic EU documents (European Commission, 2018) and national initiatives like Sweden (SKR, 2022).

Existing research on WT for elderly care primarily focuses on technological aspects, addressing physical issues and individual safety (Frennert & Östlund, 2014; Yu et al., 2018; Liu et al., 2020). However, there is limited understanding of value creation and the use of WT-generated data to support decision-making at the organizational level. Bridging this research gap is crucial as analyzing WT-generated data has the potential to enhance care quality, well-being, safety, efficiency, stress reduction, and decision-making in both practice and management.

This research-in-progress aims to explore the challenges in designing a data sharing infrastructure for WT-generated data in Swedish municipalities. Elderly care in Sweden is government-provided, based on a state responsibility model that emphasizes equality, social inclusion, and the universality of public services (Dykstra, 2018). Sweden exhibits a high level of digital development at a macro level, with relatively high digital literacy among older adults. The Swedish government has actively promoted the digitalization of the care sector.

Digital infrastructures

An infrastructure serves as a community resource (Ribe and Finholt, 2009) by enabling local practices through a larger-scale technology that can be readily utilized (Star and Ruhleder, 1996) to fulfill user values. Infrastructures exhibit characteristics such as openness to diverse users, interconnected modules and systems, and an evolving range of services within an ecosystem shaped by existing systems and practices (Monteiro et al., 2012). Key qualities of an infrastructure include adaptation to its environment and longevity in an ecosystem by fulfilling a specific role over time (Henfridsson and Bygstad, 2013).

Referred to as digital infrastructures (Henfridsson and Bygstad, 2013; Constantinides and Barrett, 2015), information infrastructures (Hanseth and Lyytinen, 2010), or e-infrastructures (Ribe and Finholt, 2009), these infrastructures are characterized by a shared, evolving, and heterogeneous installed base of IT capabilities among multiple user communities, based on open and/or standardized interfaces (Hanseth and Lyytinen, 2004). A key aspect of such infrastructures is their incorporation of both social and technical components (Hanseth and Lyytinen, 2010; Vaast and Walsham, 2009). Therefore, the design of an infrastructure for sharing WT-generated data must consider both the technical and social aspects, which we explore in this study.

Research design

This research-in-progress is part of a larger project conducted in collaboration with practitioners using an Action Research (AR) approach (Susman & Evered, 1978; Davison et al., 2004) in Sweden. The focus of this paper is on the initial step of the AR project, referred to as the Diagnosing phase, which aims to understand and define the problem of utilizing WT-generated data for improving quality, safety, and efficiency in elderly care.

Following the principles of AR, this study involved in-depth qualitative research conducted in close collaboration with various stakeholders, including managers, therapists, nurses, residents, carers, IT department, and landlords. Qualitative methods such as document analysis, focus group interviews, individual interviews, and observations were employed to collect data, enabling a comprehensive understanding of the technical and social challenges related to sharing and utilizing WT-generated data. Data was collected at both the micro-level (care institutions) and macro-level (municipality).

Two specific WT implementation cases were followed in the studied municipality: Tena Identifi and Oxevision. These implementations were observed over periods of one month and six months, and data was collected through interviews with nurses, occupational therapists, and care institution managers, as well as through focus group interviews, observations, and document analysis of technical descriptions, statistics, policies, and work descriptions.

Tena Identifi is a sensor-based solution that aids incontinence assessments by recording an individual's urine leakage over a 72-hour period. The system generates a detailed report that provides insights into individual leakage patterns and urine volumes, which can be used to inform decision-making regarding care activities, customization of care according to residents' needs, selection and use of incontinence protection, and staff planning.

Oxevision, on the other hand, is a sensor-based solution incorporating a regulated medical device with an infrared-sensitive camera. It helps staff visually confirm patient safety, measure pulse and breathing rates, and respect residents' privacy and sleep. The system can be customized to meet individual needs and generates various types of data, including activity reports and statistics. These reports enable staff to understand residents' movement patterns and plan activities accordingly, supporting care planning, medication administration, and overall care provision.

Current socio-technical infrastructure

In the investigated municipality, there are 25 nursing care homes operating independently. Landlords are responsible for the physical infrastructure in the buildings, including door opening systems, fire alarms, and analogue networks. All care homes have alarm systems for resident safety in emergencies. Currently, 22 out of the 25 care homes use an outdated analogue alarm system.

Alarm system providers are now transitioning to digital systems with advanced features like camera monitoring, door unlocking, positioning sensors, and fall prevention. Consequently, the outdated alarm system in most care homes will soon need replacement. However, the municipality lacks a unified strategy for the replacement process, leading care institutions to take individual initiatives. Three care homes recently implemented new digital alarm systems from different providers.

Figure 1 illustrates the socio-technical infrastructure of one care home that implemented the Oxevison system, representing the overall situation in the municipality.

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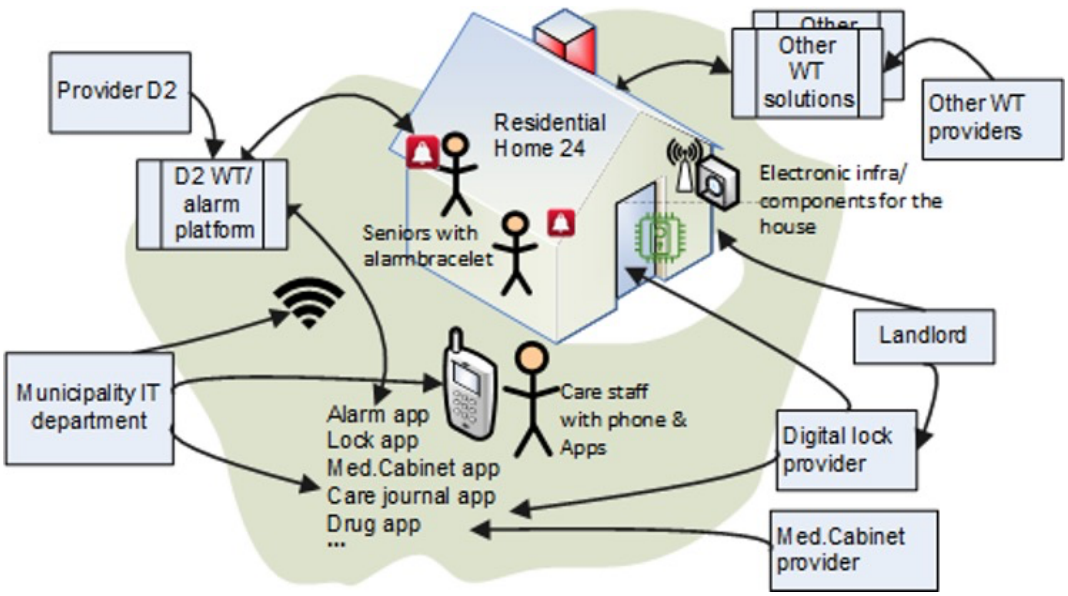

Figure 1. The socio-technical infrastructure at one of the care homes

As mentioned, the landlord handles the building's physical infrastructure, while the municipality's IT department manages the technical infrastructure, including WiFi, administrative systems, and mobile devices for staff. The IT department is not responsible for primary maintenance of the new alarm system (D2 WT/alarm platform). Instead, each care home collaborates directly with the alarm system provider (Provider D2). Care home managers currently face challenges in formulating requirements and procuring the new alarm system due to limited technical understanding and integration needs. Additionally, besides evolving alarm systems, other WT solutions like Tena Identifi (mentioned as "other WT solutions" in Figure 1) offer opportunities to enhance care quality and resource management.

Based on the analysis of the existing socio-technical infrastructure in the municipality we have identified a number of challenges for designing an infrastructure for sharing of data generated by WT on both social and technical levels as for instance:

- Diversified and complex technical environment.
- Inflexible technical infrastructure provided by the municipality, which hinders the addition, modification, alteration, and removal of wearable technologies (WTs) to meet different needs.
- Lack of standardized functions for data aggregation, interface, and visualization.
- Unclear responsibility and ownership structures.
- Unclear legal requirements regarding the sharing of WT-generated data.
- Lack of knowledge and understanding among key stakeholders regarding the potential use of WT-generated data to enhance care quality and efficiency.
- Lack of a tradition in using WT-generated data for decision-making purposes.
- Lack of tradition of using of WT-generated data for decision-making

Future work

To enable the municipality to utilize WT-generated data, a recommended approach is to adopt a governance model that encompasses both the social and technical aspects in line with the service innovation and service logic perspective (Lusch and Nambisan, 2015). This model should include standards for WTs and infrastructure, define roles, responsibilities, and processes, and provide guidance and contracts for interorganizational cooperation and interfaces.

The service logic emphasizes the concept of "value in use" and focuses on the serving processes rather than the output in form of a product. This perspective aligns with the values of public sector care for the elderly. Service innovation complements the socio-technical perspective and supports the design of a socio-technical infrastructure by shifting the focus from user-specific solutions within separate organizations to value creation within a community of actors with a shared worldview.

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Facilitating Responsible Use of Artificial Intelligence in the Public Sector Through Guidelines for Human-AI Interaction

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Abstract
When developing Artificial Intelligence (AI) systems and implementing them in public services, guidelines for human-AI interaction can be instrumental in ensuring responsible use of these systems and AI intelligibility and responsibility, protecting the citizens' rights and interests. Although there are as of yet no such guidelines established that are directed at the public sector, tech companies like Microsoft have established guidelines for the commercial sector. To investigate how commercial guidelines may help guide the development of public services that utilize AI, we have explored how *Microsoft Human-AI Interaction Guidelines* can be amended and used to guide the development of a sick leave duration prediction service. By developing a web application prototype for the specific case and conducting usability testing, we found that the guidelines needed amendments to better ensure responsible use of AI in a public service. Three considerations were discovered to be important when amending them: (i) *the way users interact with the AI system*, (ii) *the diversity of citizens making use of the service*, and (iii) *the public service context*.

Introduction and background

The utilization of Artificial Intelligence (AI) is increasingly being introduced to the public sector, and its use may improve the delivery of public services to citizens. In the commercial sector, prominent actors such as Microsoft, Google and Apple have crafted AI guidelines to ensure responsible and human-centered development and implementation of AI systems. There is a lack of guidelines and regulation aimed at implementing AI in public services, and the need for such guidelines is more urgent than ever. Recently, members of the Norwegian Parliament issued a proposal to ask the Norwegian government to introduce a moratorium in the public sector on adopting new commercial tools based on AI, until regulations for the introduction and use of such tools have been developed (Fylkesnes & Hussein, 2023). This paper aims to contribute to a research effort addressing the need for such human-centered guidelines for the implementation of AI systems in public services. Specifically, as actors in the commercial sector already have established such guidelines, our research question is: *How can commercial AI guidelines be used to facilitate the responsible use of AI in public services for citizens?*

The empirical case for this study was an online public service related to receiving support during sick leave. Specifically, it addresses a scenario where a public service offers utilization of an AI system to predict sick leave duration, to better plan for long term support. The central issue was how to design, with AI intelligibility and responsibility in mind, a user experience where users would receive information about personal information used, the process depending on the user's choice, how the AI system works, and finally choose to consent or dissent to the utilization of the AI system. The Norwegian Labour and Welfare Administration (NAV) has expressed an intention of implementing the utilization of an AI system in such a public service (NAV – sluttrapport, 2022). Currently, in accordance with Norwegian law, human case handlers at NAV must decide nine weeks in advance whether follow up meetings are necessary. The prediction of sick leave duration is an important factor with regards to this decision and could be made more efficient and accurate with AI. An increase in accuracy would be to the benefit of both the citizen and the public service provider by reducing the number of superfluous meetings, thereby saving time and resources for both actors.

Schmager (2022) addresses a similar case and explores how Google's PAIR guidelines can be amended to the public service context. Our research addresses the application and amendment of commercial guidelines for developing public services. The novelty of our research is a specific consideration of the *Microsoft Human-AI Interaction Guidelines* (MHAII guidelines). These guidelines were chosen because of their emphasis on user interaction and basis in academic literature, as Wright et al. (2020) indicates in a comparative analysis.

Our research is a subproject of the AI4Users project, consisting of researchers from the University of Agder (UiA), the University of Oslo (UiO), and the

Norwegian University of Science Technology (NTNU). The research and work of the AI4Users project addresses the responsible use of AI in public services, especially the aspects of intelligibility and accountability, in relation to the needs of different user groups (Vassilakopoulou *et al*., 2022).

Methods

The research follows an Action Design Research (ADR) methodology, and our focus is the stage of ‘Building, Intervention, and Evaluation’ (BIE) (Sein et al., 2022). To evaluate how the selected MHAII guidelines would work in a public service, we used them to guide development of a prototype for the empirical case and conducted usability testing to evaluate both the prototype and guidelines. This cycle was repeated for iterative development and evaluation. The prototype was developed as a web application by using an agile approach that facilitated regular user testing of new features and adoption of the protype.

Three iterations of usability testing provided insights into usability and the effects of using the guidelines in the different iterations of the prototype and were performed in two ways. The first approach was to share a link to the prototype hosted online, letting the users test the prototype on their own. The second approach involved usability testing in a semi-controlled environment, usually in person in the user's home or through digital communication platforms Users were asked to be transparent about their thoughts and intentions, in line with the *Think-aloud technique* (Sharp *et al.*, 2019). A facilitator would observe and log comments and the user's interaction with the prototype. Both approaches ended with the user filling out a questionnaire that was specific to the functionality implemented and the guidelines used in each iteration of the prototype. Questions were either open ended, dichotomous, or using a five-point Likert Scale (Sharp *et al.*, 2019). The method for selecting participants for the usability tests was convenience sampling (Sharp *et al.*, 2019). The first, second and third round of usability testing had 11, 23 and 24 participants.

Findings

We found that the guidelines helped narrow in on features to implement in the prototype, and how these features should be designed. It was however discovered a need to amend the chosen guidelines to better fit the nature of the empirical case. We also found that the MHAII guidelines were not sufficient in accounting for all ethical and legal considerations of a public service. For example, as Schmager (2022) points out, the government-citizen relationship includes rights aimed at protecting the citizen. Also, since public services are meant to address citizens' needs, they must account for a diverse range of administrative and technical literacy. Rights are not mentioned in any MHAII guideline, and accounting for a user group's diversity in administrative and technical literacy is not mentioned explicitly. Taking this into account, we found three considerations to be particularly important when amending the guidelines: (i) *the way users interact with the AI system*, (ii) *the diversity of citizens making use of the service*, and (iii) *the public service context*. The amendments were stated in a table (see table 1.1), together with what features in the prototype adhered to the guideline and the source of the guideline.

Table I: An example of an amended guideline.

3	*Avoid impeding refusal* To ensure the users' freedom of choice, the user should not feel disincentivized towards declining the usage of the AI system.	-Not mentioning downsides of rejecting the usage of the AI model. -The buttons for consenting and not consenting have the same visual hierarchy. -The summary page provides a description of how the user can change their choice.	MHAII Guideline 8: *Support efficient dismissal.*

Usability testing also provided interesting findings. In usability testing iterations 2 and 3, users were asked what feature of the prototype was most instrumental for the user to understand how the AI model worked. In iteration 2, the share of users that thought illustrations, a sandbox feature or the textual content was most instrumental were almost equally large, with 35%, 35% and 30% in favor of each category, respectively. In iteration 3, we added feature importance charts to the prototype and changed the question to multiple choice. 54% found illustrations instrumental, 50% a sandbox feature, 25% a description of feature importance, and 63% the textual content. The user's correct understanding of who or what was responsible for the usage of the AI system and its results gradually increased with each iteration, from 64% in iteration 1 to 74% in iteration 2, and finally 96% in iteration 3. 52% answered that they felt an incentive to accept the usage of the AI system in iteration 2. In iteration 3 we changed the phrasing of the question, and 33% answered that they felt pressure to accept.

Concluding discussion

The resulting prototype based on the case, the selected MHAII guidelines, and user feedback, indicates that commercial responsible AI guidelines can be used in the public sector, but must be amended to ensure AI intelligibility and accountability. The first amendment consideration (i), *the way users interact with the AI system*, was necessary because the MHAII guidelines assume direct interaction between the AI system and the user. Our empirical case does however not include direct interaction between the citizen and the system. Instead, the user consents or dissents to a case handler's usage of such a system to process the user's personal information. This consideration led us to reformulate guidelines that address direct usage in a way that kept their essence intact, attempting to instead address the act of deciding whether to allow such a system. The second consideration (ii), *the diversity of citizens making use of the service,* was deemed necessary as none of the MHAII guidelines specifies how information should be conveyed to accommodate for diversity. Because many public services are used by a wide range of users, the guidelines were amended to emphasize the need for information and interactive elements that take this into account. The final consideration (iii), *the public service context*, was necessary since the MHAII guidelines were developed for a commercial context, which differs from the Norwegian public service context in multiple ways. For example, the government-citizen relationship makes the importance of citizens' rights in relation to the service important to highlight, and the MHAII guidelines have no mention of rights. Public services are also less avoidable than commercial ones. For instance, people on sick leave might be dependent on receiving support to cover fundamental needs. We accounted for this in the amendment of our chosen guidelines by being transparent about benefits and disadvantages of allowing the usage of the AI system, both in the public and individual context.

The usability test results confirmed the importance of some guidelines, and the amendments of these. The close to even distribution of users that found text, illustrations, or interactive sandbox most instrumental for understanding how the AI system worked underlines the importance of providing different explanations of AI system behavior suited for users with varying degrees of previous knowledge. One particularly interesting guideline throughout the project was MHAII guideline number 8, *"Support efficient dismissal"*, which emphasizes the ability to dismiss or ignore undesired AI system services when the system is not working as expected (Guideline 8: Support efficient dismissal, 2019). In relation to consideration (i), we amended this guideline to instead underline the importance of making it easy to dismiss the service altogether. Usability testing iteration 3 found that many users (33%) felt pressured to consent to the usage of the AI model. In light of consideration (iii), there are two main concerns. The first being the EU right to not be subjected to a decision solely based on automated processing which produces legal effects (Guidelines on Automated …, 2018). The second being the societal benefit of utilizing AI systems in a public service, which in turn also benefits individuals. The question then becomes, how much pressure to consent to the usage of AI is an admissible amount for the user to feel, considering the public benefits? We settled on amending the guideline to emphasize not disincentivizing declining the usage of the AI system, to still allow information about the benefits of using the system to be presented. In our final prototype, these considerations are taken into account by making the buttons for consent and dissent equal in visual hierarchy, and by explaining the benefits of the usage, such as shorter processing time.

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A Mixed Reality Approach for Enhanced Understanding and Empathy: Simulating Auditory and Visual Phenomena in Schizophrenia

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Abstract. Simulation-based learning using virtual reality (VR) or augmented reality (AR) provides an immersive experience for teaching practical skills. While widely used in healthcare and workforce training, AR/VR simulation in mental health is still emerging. Research suggests that these simulations can offer a unique perspective on mental illness and reduce stigma. However, the results are mixed, and further research is needed to understand the underlying mechanisms. Factors such as empathy, knowledge, and visual design play a crucial role in successful interventions. Augmented reality allows for a more realistic and integrated experience. This article presents the development of a simulation aimed at reducing the stigma associated with mental illness, focusing on symptoms of schizophrenia spectrum disorders. A literature review, existing simulations, and the experiences of affected individuals were used to inform the content of the simulation. Expert validation was carried out to ensure its accuracy and effectiveness.

Introduction

Simulation-based learning, such as through virtual or augmented reality, provides a learning experience that puts theory into practice (Pottle 2019). Therefore, it is particularly suitable for teaching holistic skills, such as practical skills for future careers, and it is increasingly being used in the health sector (Foronda et al. 2020; Guinea et al. 2019) and education workforce training (Kourgiantakis et al. 2019; Thompson et al. 2019). Virtual reality as a learning technology allows for flexible access and cost-effective integration into everyday practice, whether for undergraduate or postgraduate students (Pottle 2019).

AR/VR simulations are still in their infancy in the mental health field, but studies to date have shown promising results (Han 2019). For example, simulations can be used to experience symptoms of mental illness from one's own perspective. Such perspective-taking is already made possible and accessible to the public through video platforms and social media. The reality of life for stigmatized people, such as those with mental illness, is thus made tangible. People with mental illness, especially those with schizophrenia, have to deal with stigma in addition to the stress caused by the illness (Vistorte et al. 2018), both from the public and (health) professionals (van Dorn et al. 2005). For example, people with schizophrenia are perceived as dangerous and unpredictable. These stereotypes can lead to fear or discriminatory behaviors, such as refusal of help or avoidance (Corrigan and Shapiro 2010; Fox et al. 2018). According to previous studies, direct or media-mediated contact and knowledge transfer seem to be the most effective intervention methods to reduce stigmatizing attitudes and the desire for social distance from affected individuals. However, there is still a lack of stable long-term effects (Mehta et al. 2015; Morgan et al. 2018).

Researchers are also exploring the use of VR/AR technologies as an intervention approach for various stigmatized groups (Banakou and Slater 2014; Herrera et al. 2018). Previous research suggests that (VR) simulations can reduce stigma and have a positive impact on both empathy towards affected individuals (Herrera et al. 2018; Tassinari et al. 2021; Yee and Bailenson 2006), and stability of effects (Herrera et al. 2018). However, simulations can also increase the desire for social distance (Ando et al. 2011). These heterogeneous results suggest that more research is needed to identify the mechanisms of action.

Empathy, knowledge, and affect are thought to mediate between intervention and stigma components (Banakou et al. 2020; Kalyanaraman et al. 2010; Pettigrew and Tropp 2008). At the same time, content and visual design appear essential for successful intervention (Rüsch and Xu 2017; Tassinari et al. 2021). In addition, factors such as the perspective taken, the experience of presence, or the sense of embodiment are likely to affect virtual reality (Yuen and Mak 2021).

Augmented reality has the advantage that users are not isolated from their external world as in VR, but virtual and real objects can be combined in a real-world environment (Akçayır and Akçayır 2017). This may make the simulation perceived as closer to reality and less artificial. With this in mind, the simulation on which this article is based aims to reduce the stigma associated with mental illness.

Content Development of the Simulation

To develop the simulation content, symptoms of a schizophrenic spectrum disorder were identified. When reviewing the literature, particular attention was paid to which AR technologies could represent symptoms. For example, schizophrenia can cause changes in auditory and visual perception (hallucinations) that are particularly intense or persistent. What the voices say tends to be perceived as real and meaningful (in the sense that there are real spoken words) (McCarthy-Jones et al. 2014). However, the hallucinations' content varies considerably from person to person. The voices can be neutral as well as negative or positive for the person (Boer et al. 2022; McCarthy-Jones et al. 2014). In most cases, the content of the experienced verbal hallucinations falls into one or more of the following themes: (1) belittling (of oneself), (2) cursing, (3) commentary voices, (4) command voices, but also several voices talking (about the affected person) (Banks et al. 2004; Boer et al. 2022; van der Gaag et al. 2003; McCarthy-Jones et al. 2014; Toh et al. 2020).

Another building block for developing the content of the underlying simulation was the analysis of existing simulations (e.g., Brown 2021; Kanary Nikolov 2016; Marques et al. 2022; Silva et al. 2017). These were cross-referenced with testimonials from video platforms and social media that give voice to affected individuals.

This work developed the content for a new simulation, which was reviewed, revised, and validated by independent experts (psychiatrists, social pedagogues with many years of experience working with people with schizophrenia).

Building the Holographic Experience

Based on the previous literature review and expert interviews, a mixed reality application was developed to authentically recreate the auditory and visual hallucinations associated with schizophrenia in a controlled environment.

Mixed Reality

The mixed reality (MR) concept, including AR and VR, refers to integrating virtual elements into the real world. Unlike VR, which creates a fully immersive digital environment, AR seamlessly blends digital content, such as virtual objects or graphics, into the user's physical environment in real-time, enhancing their perception and interaction with their environment (Milgram and Kishino 1994).

Project Setup

Hardware and Software Selection

The MICROSOFT HOLOLENS 2 head-mounted device (HMD) was chosen for its ability to add realism to the simulation. It uses a combination of cameras, sensors (e.g., infrared), and algorithms to track the user's environment (spatial mapping), enabling precise placement and anchoring of virtual elements in the real-world context (HoloLens 2 – Overview, Features, and Specs, n.d.). UNITY 3D and the Mixed Reality Toolkit (MRTK) were selected as the primary software tools. They are designed to work with the HOLOLENS platform and facilitate the development of AR applications. In addition, the integration of an external PC as a server allows seamless control and management of the simulation.

Simulation Design

Participants experience simulated visual and auditory hallucinations in an experimental setup while performing simple tasks over 7 minutes. To ensure that users cannot interact with the holograms, all types of interaction provided by the MRTK by default (such as gaze, speech, and hand tracking) were disabled. This approach mimics the intrusive and uncontrollable nature often associated with the perceptual phenomena of schizophrenia.

Spatial mapping is used to position and anchor visual components in the user's environment, while the simulation reproduces the perception of sounds emanating from specific locations, mirroring the experience of auditory hallucinations. This allows for a more authentic and engaging experience by providing an immersive encounter with schizophrenia-related phenomena while maintaining awareness of the real-world environment.

Visual and Acoustic Elements

Pre-designed 3D elements, dynamic sprite components, and pre-recorded sounds are used to simulate auditory and visual hallucinations associated with schizophrenia. Elements are programmed to appear and disappear according to a carefully designed timeline.

(1) An animated humanoid 3D figure reproduces the perception of a human shadow. Stencil shaders are employed to ensure accurate rendering of the dark figure against a surrounding light sprite to overcome the limitations of the HoloLens, which cannot display true black due to its projection mechanism (Color, light, and materials - Mixed Reality 2022). This technique effectively evokes the subjective experience of perceiving shadows. In addition, the character is programmed to automatically adjust to the user's height and line of sight.

(2) Virtual overlays create the illusion of changes to real-world paintings. These sprites, created using image editing software, are superimposed on physical paintings in the simulation environment using spatial anchors, resulting in a blended virtual and physical experience.

(3) Dynamic visual effects such as flashes and flickering lights are incorporated into the simulation to mimic the perceptual disturbances experienced by people with schizophrenia. These effects, generated using Unity's particle emitters, intentionally interact with the user's visual field.

(4) The auditory elements, emitted by the built-in HoloLens speakers and positioned for spatial perception, encompass a range of sounds associated with auditory hallucinations. These comprise unformed sounds like humming, hissing, or whispering, that lack clear vocal qualities, and distinct voices. Including female and male voices reflects the common occurrence of multiple voices with different characteristics in schizophrenic hallucinations (Larøi et al. 2012). A sound designer pre-recorded all auditory elements based on previous research, choosing human voices over computer-generated alternatives to increase the authenticity and relatability of the acoustic experience.

Potential Uses and Educational Benefits

The VR/AR approach outlined here has the potential to be transformative in healthcare education (e.g., Pottle 2019) by promoting empathy and understanding in a variety of educational contexts (e.g., Wan and Lam 2019).

Medical, nursing, and allied health education can use mixed reality simulations to authentically recreate the symptoms of schizophrenia, helping students to identify symptoms, provide empathic care, and hone their communication and crisis intervention skills while challenging stigma (e.g., Liu, 2019; Riches 2022). In addition, psychology and social work programs can integrate MR scenarios to provide hands-on experience to improve counseling skills and inclusive strategies for clients with schizophrenia.

Furthermore, VR/AR technology can be used for psychoeducational purposes (Freher et al. 2022; Tay et al. 2023), benefiting both patients and their families. Patients can better understand their personal experiences through simulated scenarios, potentially improving their self-management strategies. Relatives of people with schizophrenia can also benefit from virtual immersion in the challenges faced by patients, leading to increased empathy and more informed support.

Beyond education, VR/AR can enrich public awareness campaigns by promoting open discussion about mental health, encouraging advocacy, and fostering empathy (comparable to using VR as a disability advocacy tool, Jiang et al 2023).

Conclusion and Future Work

The process of content research and development of the simulation has provided valuable insights into the potential of immersive technologies in recreating the experiences associated with schizophrenia.

Moving forward, several avenues for further work can be explored to improve the simulation and its impact. Obtaining feedback from individuals with schizophrenia would provide invaluable insight into the accuracy and effectiveness of the simulation. This feedback can help fine-tune parameters and ensure the simulation aligns with diverse personal experiences.

Expanding the range of experiences that can be simulated is another important direction for future research. Schizophrenia is a complex disorder with diverse symptomatology, and incorporating additional sensory, cognitive, or emotional aspects into the simulation could provide a more comprehensive understanding of the condition. Machine learning algorithms could be used for dynamic and personalized simulations, including real-time analysis of the user's behavior and environment to adapt and customize the experience.

In addition, conducting empirical studies to evaluate the impact of the simulation on various outcomes is crucial. This could include assessing changes in attitudes, knowledge, and empathy towards people with schizophrenia before and after exposure to the simulation.

To conclude, developing the simulation is essential in promoting empathy and understanding, and reducing stigma towards people with schizophrenia. Further work should include gathering feedback from people with lived experience, expanding the range of simulated experiences, investigating the integration of machine learning, and conducting empirical studies to evaluate the simulation's impact. These efforts will help to advance research, improve the effectiveness of the simulation, and ultimately foster a more inclusive and supportive society.

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A serious game for health prevention campaigns on teenage pregnancy - experiences from Ghana.

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Abstract. As in many West African countries also in Ghana there is a high rate of teenage pregnancy, which creates great political concern. This problem found major attention in the context of the FACIL-ICT project[1] conducted by the University of Siegen, Germany in collaboration with two Ghanaian districts (Nsawam Adoagyiri and Suhum). In order to curb the high rate of teenage pregnancy, a game titled "Amanda's story" was developed to test the use of a serious game for health prevention campaigns on teenage pregnancy in Ghana. Below is an image of the main menu of Amanda's story illustrated in figure 1.

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[1] https://www.facil-ict.com

Figure 1: Main menu of the Amanda's story

1 Introduction

In developing nations, around 12 million teenagers between the ages of 15 and 19 years get pregnant each year and give birth to an estimated 21 million babies (*Ghana | Data*, 2021). This is often caused by factors such as poverty, lack of information on sexual rights and family planning methods, inappropriate use of contraceptives among others (*Toolkit - Adolescents, SRH, SGBV*, 2018). The negative effects of teenage pregnancy does not only affect the mother's health, but also the child, society and the economy at large. Teenage pregnancy is a term used to describe pregnancies that occur in girls aged 19 years or younger (*Toolkit - Adolescents, SRH, SGBV*, 2018).

A study conducted by the Ghana Health Service District Health Information Management Health System (DHIMS) between 2016 and 2020 showed that there were 13,444 pregnancies among early adolescents aged 10 to 14 and 542,131 pregnancies among girls aged 15 to 19 years (*Adolescent Pregnancy in Ghanaian Communities – A Worrying Trend Amid MTCT of HIV*, 2022). The number of teenage pregnancy cases in Ghana are unevenly distributed across its 16 regions. Between 2016 and 2020, the Ashanti region recorded the highest number with 2,165 cases of teenage pregnancies. This was followed by the Eastern region recording 1,528 cases (*Teenage Pregnancies in Ghana Hit 555,575 in Five Years*, 2021). This paper is based on a study conducted in Nsawam-Adoagyiri and Suhum districts, both located in the Eastern region of Ghana, where the rate of teenage pregnancy is prevalent. The Republic of Ghana is an independent nation with a population of approximately 32 million people as at 2021 (*Ghana | Data*, 2021).

Ghana is a country in West Africa that borders Burkina Faso to the north, the Republic of Togo to the east, La Côte D'Ivoire to the west, and the Gulf of Guinea to the south. The population of the nation is primarily young; as of 2010, 38.3 percent of people were under the age of 15 years. Adolescents make up one in five people (22.4%), which is a sizable portion of the overall population. Once more, 62 percent of Ghana's population is under the age of 25 years. Therefore, it's crucial to look at concerns affecting teenagers and young adults (*Adolescent Pregnancy Strategic Plan_new.cdr*, 2017).

In view of these high occurrences of teenage pregnancy in the Facil-ICT-project regions, there was the suggestion to consider a serious game in the form of a visual novel titled " Amanda's story". The visual novel was supposed to serve as a campaign tool that could be embedded in communication and preventive strategies for teenage pregnancy of the Nsawam-Adoagyiri and Suhum health offices. Serious games are games that aim at other positive goals besides entertainment (Shoukry et al., 2014). Serious games are used for education, health promotion, behavioral change etc.

This article starts with the review of existing work that has been done in preventing teenage pregnancy in Ghana, followed by examples of how serious games have been implemented in the domain of healthcare for behavioral change. It also explains the method that was used to develop the novel, the plot and messages of the novel. Furthermore, it presents a reflection on the prototype of 'Amanda's story' and the feedback from end users and other stakeholder groups. Summarizing it outlines some possible challenges and limitations of such an approach and recommendations for future research.

2 State of Art

While there have been many activities done by governments, individuals or Civil Society Organizations in educating adolescents and the public on Sexual Reproductive Health and Rights (SRHR), there are still many cases of early and unwanted early pregnancies. Various sub organizations of the United Nations in Ghana such as the United Nations Children's Fund (UNICEF), United Nations Populations Fund (UNFPA) have been actively involved in such work. The Ministry of Gender in Ghana, in collaboration with UNFPA and the Ningo-Prampram District of the Greater Accra Region trained a number girls on sexual rights to curb the high rate of teenage pregnancy in the region and evaluated the results (*Adolescent Pregnancy in Ghanaian Communities – A Worrying Trend Amid MTCT of HIV*, 2022) .

Teenage pregnancy has effects on the health and well-being of mothers and children and also on psycho and socio-economic domains of their biographies. In order to reduce the high rate games have shown to have a positive impact in behavioral change and supported advocacy and awareness raising. E.g. (Vugts et al., 2020) conducted a study on how well a serious game intervention worked for people with chronic pain or fatigue symptoms. The findings showed that such forms of gaming increased individuals' levels of physical activity, self-efficacy, and functional capacity.

In Ethiopia, a serious game was used to educate people who are illiterate and have little to no prior experience with digital games to educate healthy eating and wellbeing habits. Findings from this study showed that serious games are a great tool for education (Font et al., 2017).

Viamo is an international social enterprise that leverages mobile technology for social and behavioral change communication mostly in developing countries. Viamo in partnership with other organizations developed a Wanji game to drive behavioral change for finance, climate, and health behavior change in 20+ countries including Ghana. This Wangi game allows players to make their own choices to determine the story's outcome. It is accessible to players for free in different languages. Evaluation results indicated that players learn more about varieties of topics by choosing endings of the story (*Award-Winning Edutainment Game Drives Behavior Change in Over 20 Countries*, 2022).

UNICEF, UNFPA in collaboration with other partners in Ghana developed a board game for raising awareness about adolescent sexual and reproductive health, sexual and gender-based violence (SGBV), including challenges adolescents face such as teenage pregnancy, where they can seek information and support. This board game is called "the protection snake and ladder game". This game is presented in different color patterns. It can be played by four people or four small teams. It is designed to be played with adolescents but it could also be adjusted to be played with adults (*Toolkit - Adolescents, SRH, SGBV*, 2018).

Beyond such approaches there has been an intense use of analogue content such as posters, leaflets, brochures or videos for media campaigns on teenage pregnancy . However, there is no systematic reflection or research on how visual novels can be used for preventive measures in teenage pregnancy campaigns in Ghana.

3 Methodology- steps to realization

During this study information was to be collected on local situations and life conditions of young people, support services and health agencies. This information had to be transferred into a script. The next step was exploring existing technology and software that best suit requests for prototype development. In developing the novel, Amanda's story, a participatory design approach was used which involved stakeholders throughout the research phase. These stakeholders included researchers, end users/community, health practitioners, social welfare officers, CSOs, and stakeholders from the municipalities. There were a number of meetings and workshops held in-person, virtual and hybrid. This procedure was divided into three main phases of predesign, design; technical development and prototyping, testing and implementation.

Pre-design

Design thinking methods of design were used where researchers from Siegen university and stakeholders from Ghana participated in a hybrid meeting. This was a two-day workshop where participants began with the step of understanding the problem of the high rate of teenage pregnancy in the districts. This was based on a presentation from a health officer from one of the Ghanaian districts, followed by ideation, where participants brainstormed possible solutions that could be helpful in solving such a problem. They rated the use of visual novels as a tool that could be embedded in a campaign of health promotion. The team prototyped this visual novel in PowerPoint slides.

Amanda's story – Developing plot and messages

"Amanda's story" was developed to be a gamified information video that follows a virtual female youngster of 16 years, on her various steps from having sex with "Mark" her former neighbor, to being afraid of being pregnant, to communicating within the family and making the decision on how to go on, while involving the potential father Mark. The key idea is to provide reliable information on every step of the script. This information involves both medical and social content that is mostly taken from the well-respected Marie Stopes Ghana[2]. It also comprehends addresses of municipal services and counseling agencies of CSOs in Nsawam-Adoagyiri and Suhum and other local contact points that might be helpful.

Normative messages of the novel

It was necessary to reflect on the normative messages of the plot. The novel includes information on current preventive measures and practices available in the districts, like sex education to parents and their wards through, Radio and Television health talks, ward education and ANC/PNC visits sharing of maternal and child health records booklets to pregnant mothers, formation of Adolescent Health Corners in the various health facilities in the districts, School Health Services, and the provision or offering of modern family planning commodities.

Furthermore, it also communicates the two possible decisions that a young pregnant woman like Amanda will be confronted with in such a situation. These two possible decisions are either becoming a young mother or going in for safe abortion. This can become a challenging decision for a female teenager and other people involved, also the potential father and his responsibilities. The novel includes possible

[2]https://www.mariestopes.org.gh

questions to consider when making any of these decisions. For example, when deciding for motherhood, one could think of questions like; “Would I raise the child myself?”, etc..

Design; technical development and prototyping

There was a further elaboration of “Amanda’s story” with a typical local setting. A further step was taken into the technical design and development with a higher fidelity prototype using Twine[3], a software for developing visual novels. This was iterated a couple of times and a more professional version of this was developed using Renpy[4], another tool for developing visual novels. As a result, the novel can be played both online and offline thus with or without internet connection. It can be accessed on Windows, Android and MacOS. It is also compatible with devices such as smartphones, laptops and tablets.

Testing and implementation phase

An in-person workshop was held in Ghana in April 2023 where a semi-final version of Amanda's story was tested and discussed with end users. The prototype was also evaluated with professionals from health, social welfare, civil society organizations and young people from the districts. A concept for a local prevention campaign was developed in which the visual novel could be embedded in the communication strategies of the municipalities.

4 Reflections and further research needs

During the testing phase of the prototype of Amanda's story, participants of the workshop including end users provided important feedback which emphasized the necessity of considering the social context of users when designing any socio-technical solutions like Amanda's story. Such feedbacks were referring to the cultural and social norm of design, e.g., a character named Mark, the man who impregnated Amanda at the wedding party was initially created with his hands in his pocket. During the testing of the prototype with the end users they indicated that it was not culturally accepted for Mark to have his hands in his pocket while speaking to the parents of Amanda as this shows a sign of disrespect. They further indicated that this could influence the player’s perception. Based on this feedback, Mark was recreated with his hands outside of his pocket in the current version of the novel.

[3] https://twinery.org/
[4] https://www.renpy.org/

In addition, users emphasized the importance of making the novel audio-visual. Therefore, it was decided to incorporate an audio in English and another audio option in “Twi” - the local language popularly spoken in Nsawam-Adoagyiri and Suhum - into the novel to promote inclusion. This was to enable persons with low-literacy backgrounds and different forms of sensory impairments such as hearing and sight to use this novel.

5 Discussion

The whole novel conveys several relevant information and recommendations to teenagers as its primary target group but also to parents, teachers, health and welfare professionals and other community members. In Ghana, most parents hesitate to explicitly educate their children on adolescent sexual reproductive health. This is due to traditional beliefs including the myths and misconception that when adolescents learn about this topic, they are likely to indulge in sexual intercourse at early ages. This sometimes makes the topic around adolescent sexual reproductive health a sensitive one.

On the other hand, teenagers are sometimes shy to ask their parents and professionals about this topic. While some of them lack the knowledge on where to find the right answers to this topic. They rather ask their peers, friends, and watch unapproved content online. However, information from these sources can sometimes be false and misleading.

The novel includes information on measures to prevent pregnancy, e.g. the use of contraceptives such as condoms, post pills, etc. are ways of preventing unwanted pregnancy and advise teenagers who indulge in unprotected sex. It teaches users that the use of contraceptives is not the task of just one partner but both partners involved in the sexual activity. This shows that gender stereotypes cannot be accepted when it comes to who takes responsibility. A text in the game " should contraceptives have been Amanda's task or mine task" illustrates thoughts of Mark after making love to Amanda.

Integration of female youngsters’ experiences teenage pregnancy into school or learning a trade

The story further advocates for support systems for early mothers who may become young mothers by reintegration into society by continuing their education or learning a trade. This is clearly outlined in the game where Amanda informed Mark and her family about her decision to become a mother. Amanda said “I said, I want to have the baby! I presented a suggestion on how I could have it and still finish school or learn a trade”. This message of integrating young mothers back into school falls in line with the “Objective 3 of the National Strategic Framework on Ending Child Marriage in Ghana 2017-2026 with the key strategy to support adolescent mothers' re-entry in school after delivery" (*Toolkit - Adolescents, SRH, SGBV*, 2018).

The advocacy for protected sex and safeguarding against sexually transmitted diseases.

Also, this novel promotes awareness for safe sex. It emphasizes the fact that protected sex does not only prevent unwanted pregnancies but also protects partners against sexually transmitted diseases (STDs) such as HIV/Aids. The appropriate use of condoms can reduce the risks of transmitting STDs during sexual intercourse (*Adolescent Pregnancy Strategic Plan_new.cdr*, 2017). The novel also strengthens the capacity of the players on how to use condoms by directing them to a website of Marie Stopes which shows how condoms can be properly used. This was illustrated in the novel as an advice: "Amanda and Mark, you must be careful when you make love! Think of contraceptives for e.g., condoms that can prevent pregnancy and also protect you against sexually transmitted diseases for e.g., HIV/AIDS, Syphilis, etc.! REMEMBER: IF IT'S NOT ON, IT'S NOT IN !!!"

The advocacy for safe abortion

According to (*Adolescent Pregnancy Strategic Plan_new.cdr*, 2017) young teenage girls indulge in unsafe abortion practices due to reasons such as poverty, stigmatization from the public, early motherhood, etc. Again, Post-abortion complications continue to be a problem because many abortion cases are performed outside of medical facilities by untrained staff. This sometimes complicates their health resulting in cases of death, diseases, excess bleeding, etc. The novel outlines safe spaces and professionals who can support and provide safe abortion for example hospitals, clinics, Marie Stopes, a recognized organization for performing safe abortion among others.

Promoting safe spaces for victims of teenage pregnancy

The novel promotes seeking advice from safe spaces and experts who can help anyone in such a situation. For example, it lays emphasis on the role of the social welfare officer, health officer and Civil Society Organizations like Marie Stopes which offer support to young people who find themselves in such a situation like Amanda or may want to learn more about safe sex.

6. Challenges and limitations

Although this novel has insightful lessons for users and different stakeholder groups it is likely to have some limitations and challenges as outlined in this chapter. The novel was developed in English, the official language in Ghana and "Twi", the most popular local language spoken and understood by most people in these two districts. However, there could be a population of this target group who can neither understand English or Twi.

Due to the participatory method design it was possible to observe that different stakeholder groups, consisting mainly of adult males, had conflicting perspectives of the messages of the novel. On that basis, a fruitful discussion could be initiated that supported reflections on traditional attitudes to deal with teenage pregnancy such as early marriages.

There are a variety of ways in which this novel could be used e.g., in classrooms. It is suggested that this novel will be adopted as part of campaigns by government authorities. However, some key messages in the visual novel may be in conflict with the thoughts of some users. We believe this is a liberal concept of sexuality that is assumed not to be shared by everyone.

7. Conclusion

This novel provides the option to be embedded in the national framework for communication and preventive strategies for teenage pregnancy. It could be translated into other major local languages for use. At this point the material is for a non-commercial use which means it is not meant to be sold or exchanged for anything in cash or kind. It is meant for a wide use of stakeholders and users.

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Designing a Vital Data Transmission in Rural Areas with Elderly Persons in Nursing Homes and at Home

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Abstract. In this paper, we present a vital data transmission system, which aims to support general practitioners (GPs) in the process of digital vital data acquisition. The system consists of (1) an app that displays the GP's prescribed vital signs and transmits the data recorded via medically certified devices to a medically certified cloud, and (2) a web interface through which the physician can create prescriptions and view vital signs. In addition, it provides further services such as a support functionality for patients and getting feedback from physicians on vital signs. It facilitates the GPs' work, as vital signs can be clearly displayed and classified immediately in digital form. Our study examines the acceptance of such a system by GPs and patients, but also other stakeholders such as the staff of a nursing home. We therefore conducted two long-term studies in which we uncover first insights about the issues of physician underuse in rural areas.

1 Introduction

Telemedicine has been extensively researched in various fields, offering promising applications in healthcare (El-Rashidy et al., 2021; Farias et al., 2020).

One notable example is the implementation of a telemedical system in Australia back in 2006. Due to geographical limitations, certain hospitals lacked specialized doctors, requiring patient transfers to regional centers. To address this issue, a system was developed to connect remote doctors with hospital teams through video and audio connections. Clinical parameters from surveillance monitors were also transmitted, and efforts were made to adapt the system to the needs of medical staff (Li et al., 2006).

This approach of remote guidance can be extended beyond emergency services to general medicine, especially in rural areas where access to physicians is usually limited. By connecting patients with their general practitioners, telemedicine bridges the gap and might reduce the workload on GPs (Martín-Lesende et al., 2017). Studies explored the impact of telemedicine on emergency department admissions, highlighting its potential to alleviate healthcare burdens (Zachrison et al., 2020). Denmark has been at the forefront of telemedicine implementation, particularly in diabetes care (Nøhr et al., 2015). A telemedicine system was developed to support patients at home, enabling video conferencing between trained nurses and diabetes experts. User-friendliness was a crucial consideration, leading to the use of more accessible videophones instead of laptops. However, challenges arose in terms of coordinating the timing of patient-nurse-doctor interactions (Sekhon et al., 2021). The target group of patients is mostly elderly patients, who place special demands on the systems (Harrington et al., 2018). Kanis et al. (2013) conducted real-life experiments in which they explored how sensors installed in the homes of elderly individuals helped them live alone for longer without assistance. This sensor network facilitated activity monitoring and potentially led to positive health outcomes (Kanis et al., 2013).

Mobile health data collection by patients offers opportunities to support their rehabilitation journeys. The objective is to automatically record vital data without requiring manual input from users, aligning with the principles of ubiquitous computing (Kjeldskov & Skov, 2007; Weiser, 1999). While this approach aims for seamless data collection, studies often still require additional user input. Economic considerations also factor into remote patient monitoring, making cost-effectiveness a significant aspect (De Guzman et al., 2022). Due to the close involvement of patients, especially older ones, in the measurement process, it is important to include them in the design processes (Clemensen et al., 2007; Duque et al., 2019; Randall et al., 2018; Righi et al., 2017; Vaziri et al., 2019).

In summary, telemedicine continues to be a focus of research and development, aiming to enhance healthcare delivery, increase accessibility, and improve patient outcomes through remote monitoring and assistance. In our paper we want to investigate how digital vital data transmission can be integrated into the everyday life of physicians, patients and caregivers, especially in rural areas.

2 Project Overview

Our study is part of a larger research project. Within the project, the consortium established a comprehensive framework for data-driven medicine aimed at alleviating the strain on healthcare provision. A key focus was directed towards rural areas, which present unique challenges due to a myriad of factors such as an aging population and inadequate access to medical services.

The primary goal of the project entailed the development of a robust, cross-sector approach to data medicine, necessitating the resolution of various challenges across multiple domains. Central to this objective was the acquisition and analysis of vital data, coupled with its seamless transmission to a secure cloud-based infrastructure. Moreover, a pivotal aspect involved engaging patients in the data evaluation process, fostering a collaborative approach towards healthcare management. Specifically, the project aimed to explore the methods for capturing and transmitting vital data to primary care physicians, thereby empowering them with actionable insights. Concurrently, the project sought to gauge the acceptance and usability of the implemented solution among all relevant stakeholders. It is important to note that certain complex elements, such as leveraging artificial intelligence for data analysis or integrating with existing telematics infrastructure, were deemed beyond the current project's scope and feasibility (Keil et al., 2022a).

The project's conceptual framework exhibited noteworthy features from diverse perspectives. The chosen region exemplified the characteristics of a rural setting, encompassing three localities in Germany. A macro-level analysis of the region's surrounding communities revealed an imminent threat of physician shortages, further underscoring the significance of the project's focus. Given the sensitive nature of medical data processing and storage, stringent security measures were imperative. The data protected under the stringent regulations of the General Data Protection Regulation (GDPR), mandated elevated privacy safeguards. Although the project's implementation afforded enhanced data security measures, it remained essential to diligently account for data protection throughout the design and implementation phases. Consequently, the association between vital signs and participants' personal data was exclusively accessible to the respective primary care physicians and project study doctors, ensuring strict confidentiality. Additionally, we employed pseudonymization techniques to safeguard individual identities, and used industry-standard encryption methods for data transmission (Keil et al., 2022b). By pursuing this comprehensive and scientifically grounded approach, the project aimed to pave the way for a data-driven revolution in healthcare delivery, particularly in underserved rural regions. The outcomes of this endeavor held the potential to enhance medical outcomes, optimize resource allocation, and ultimately improve the overall well-being of individuals residing in these areas.

3 Technical implementation

Since we aim to evaluate under conditions that were as real as possible, i.e., not just as a demonstrator, a technical concept for the transmission of vital data was developed at an early stage. The system is intended to function as a stand-alone solution and cannot be integrated into existing systems such as practice management systems, care management systems, or the telematics infrastructure (TI). Key components included a mobile application capable of seamless data recording and transmission to a centralized database, as well as a web-based interface that enabled bidirectional data interaction. Vital signs are recorded using measuring devices that transmit the data to an iPhone via a Bluetooth interface. From the iPhone, the data is then sent via WLAN or an LTE connection to a cloud server that is certified for medical data. The physician can retrieve the data via secure access to a web interface. The data is presented in the web interface. The app as well as the web interface for the physicians were developed in close cooperation with all stakeholders. The app was developed natively for iOS in Swift. In addition, a mobile device management (MDM) system was used to improve the usability of the iPhone by keeping the functionality to a minimum.

Despite the robustness of the underlying infrastructure, the project necessitated the consideration of certain technical intricacies. For instance, data transfer protocols encompassed both wireless local area networks (WLAN) and long-term evolution (LTE) connectivity. Significantly, accommodating the needs of older participants, some of whom lacked WLAN connectivity within their residences, entailed providing alternative backup options utilizing LTE connectivity.

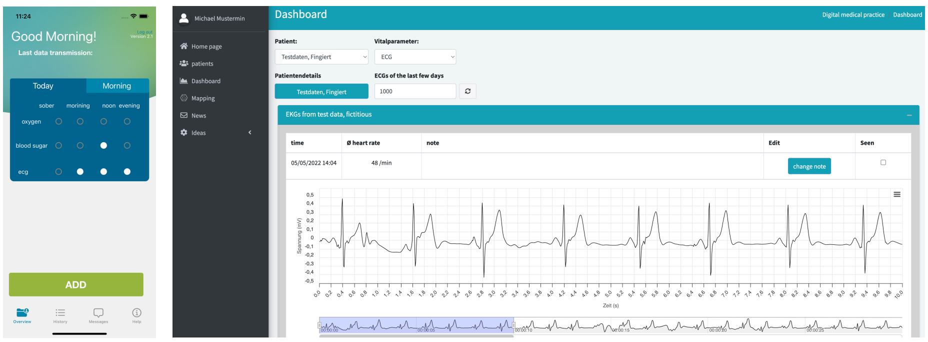

Figure 1. Screenshot of the applications for patients and GPs

4 Discussion and Conclusion

Despite some limitations and the constantly changing conditions caused by the Covid-19 pandemic, we were able to implement various measures. Through multi-stage iterations, the app and web interface for GPs and nurses were evaluated and adapted to the needs of the user groups. Close collaboration enabled the implementation of features that evolved only from conversations with stakeholders.

It became evident that different user groups have different requirements. While technology-interested patients were comfortable with the iPhone and wanted advanced features, technology-averse patients preferred a system without a smartphone. Connecting the meter directly to the cloud could be a simplification for this group. However, it is difficult to find a solution that meets all requirements. Therefore, different realizations should be considered to meet the needs of each subgroup. The choice of method and the usability of the system are important factors for the acceptance of the user groups. However, there is still room for improvement, and future developments should be done in close cooperation with the user groups.

The use of a flexible database system allowed the handling of different data types for the storage of vital signs data. A uniform definition of the data types would improve the interfaces between the different systems. A platform like a "digital twin" could give patients control over their data and provide access to healthcare stakeholders as needed.

On the front-end, measurement accuracy could be improved through various methods, such as gamification approaches involving contests and awards for reliable measurements and improvements in scores.

The project has faced some challenges, especially in terms of permanent funding. Public-private partnership approaches could play a role here, with companies providing support as part of workplace health promotion. The topic also opens avenues for further research in this area.

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DoReMiND - A Robotic Application for Singing with Older Adults

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Abstract. This work explores the possibilities of using a humanoid robot to support group singing activities for older adults in care facilities. The DoReMiND application was developed through an iterative design process involving user feedback and evaluation. The study successfully demonstrates that the robot can motivate older adults to sing, improving their well-being. However, challenges with voice recognition and group interactions were observed. The application's potential to promote emotional well-being and the positive effects of music and robotic interaction on older adults show promise for future developments in this field. Future work includes technical enhancements, shifting the target group, and addressing ethical considerations to create a more interactive and enjoyable experience for older adults.

Introduction

The increasing demand for care services and the decreasing number of professional caregivers in industrialized countries have put significant pressure on the care system (Carros et al., 2020). To address some of these challenges, researchers have turned to robotics as a potential solution. The interest in using robots in care facilities includes projects such as robotic suits to help care workers lift patients (Satoh et al., 2009) and robots that help elderly people wash independently (Werner et al., 2020). Additionally, there is research regarding how robots can provide entertainment programs and offer companionship (Carros et al., 2020).

Music has been extensively studied for its positive impact on the quality of life and well-being of older adults. Most of the literature focuses on making and experiencing music in a group setting, such as choirs and music therapy, usually led by professionals (Creech et al., 2013; Davidson et al., 2014; Galinha et al., 2021; Hays and Minichiello, 2005; Mileski et al., 2019; Mostaghel, 2016). There is strong evidence that music may continue to improve the quality of life and well-being of the elderly, regardless of cognitive capacity or musical background (Creech et al., 2013; Davidson et al., 2014; Elliott and Gardner, 2018; Mostaghel, 2016).

At the moment, however, there is a lack of research exploring the combination of music and robots in the context of elderly care. This paper aims to investigate the possibilities of using robots to support group activities like singing, focusing on the humanoid robot “Pepper”.

By combining the positive effects of music with the advantages that robots can offer, this research intends to create a more interactive and enjoyable experience for older adults, improving their quality of life and empowering them to take action.

Technical Infrastructure and Application

The system developed for this project involves a 1.2-meter-high humanoid robot, “Pepper”, with a tablet attached to its chest. The robot has the capability to play songs through its speakers while simultaneously displaying the song lyrics on the tablet. The objective is to allow older adults to interact with the robot and use the application independently, empowering them to benefit from the positive effects associated with music without the constant assistance of care workers.

To enable older adults in care facilities to engage in group singing activities independently, a musical application called "DoReMiND" was developed. The application was designed with a focus on accessibility and ease of use for older adults, taking into consideration limited mobility and visual impairments.

The application’s design adheres to the POUR (Perceivable, Operable, Understandable, Robust) principles (WAI), ensuring that navigation is visually and audibly perceivable, and users can operate it through speech or touchscreen. High-contrast colors and simple, commonly used text were incorporated to enhance understanding. The interface consists of large, rounded buttons to facilitate ease of use.

The application is accessed through Pepper’s tablet, which displays the homepage with four genres (hiking, folksongs, christmas carols, and church hymns), a “randomize” button, and the logo (Figure 1). Users can navigate to the information pages by selecting the logo. The information pages explain the robot’s capabilities and interaction options, allowing users to return to these pages at any time using the voice command "Info".

For the singing experience, users can select a genre and either play a random song from that genre or choose from a list of three song titles. Once a song is selected, the robot announces the song title and invites the user to sing along, providing preparation time before the song starts. During the song, the lyrics are displayed on the tablet, with video covering half of the screen and showing around four lines of lyrics per page (Figure 1). Users can adjust the volume and skip to thenext song using the provided buttons and via speech commands.

Figure 1. Homepage of the application and the song player.

The application emphasizes dialogue-based interactions, allowing users to control the application through voice commands. Pepper introduces itself at the start and responds to commands like "Menü" ("Menu"), "Übersicht" ("Overview"), or "Zurück" ("Back") to navigate through the application. Referencing specificgenres or song titles will lead to the respective song selection or song player pages. To add an element of fun and engagement, the application includes various dialogue portions where users can ask questions or request jokes and tongue twisters from the robot. The dialogue responses are scripted, allowing the robot to provide random answers for each interaction, enhancing the user experience.

The application's technical infrastructure involves using the Pepper robot and Choregraphe 2.5.5 for development, while the prototype for the tablet application was created using programs like Microsoft PowerPoint, Adobe XD, and Figma.

Overall, the DoReMiND application provides an interactive and accessible platform for older adults in care facilities to engage in group singing activities independently, promoting their well-being and enhancing their quality of life through the combined benefits of music and robotic interaction.

Conclusion & Outlook

The development and evaluation of the DoReMiND application for the Pepper robot have provided valuable insights into the potential benefits and challenges of using robots to motivate older adults to sing in care facilities. The results of the user studies indicate that the application was successful in engaging older adults in singing activities, with positive feedback on the song selection and display of lyrics. However, there were several limitations and considerations that need to be addressed for future improvements.

The pre-study revealed that older adults enjoyed singing but often lacked confidence due to changes in their voice with age. The idea of singing with a robot as a private partner was met with skepticism but was recognized as a potential opportunity for engagement. The evaluation of the first prototype highlighted difficulties with tablet interaction, leading to the addition of voice commands. The final evaluation further emphasized the challenges of voice interaction, especially in group settings, and raised concerns about the robot's appearance and sound quality.

Despite these limitations, the DoReMiND application demonstrated its potential to motivate older adults to sing, and the positive reactions during the evaluations were encouraging. To further enhance the application, several areas of improvement and future work can be explored:

- **Technical Enhancements:** Improving the speech recognition capabilities of the robot can lead to better interactions. Implementing context awareness and refining voice command options could enhance the user experience and reduce frustrations.
- **Tablet Interaction:** Providing touch pens or stylus could facilitate better interaction with the tablet, ensuring accurate touch recognition, especially for older adults with limited mobility.
- **Scalability:** Streamlining the process of adding new songs and genres to the application can make it more adaptable to different care facilities.
- **Target Group Shift:** Exploring the potential of the application with other user groups, such as children or people with intellectual disabilities, could open new avenues for engagement and interaction.

Despite the challenges and limitations, the DoReMiND application successfully demonstrated the potential for robot-assisted singing activities in care facilities. The application has the potential to improve the experience of listening to music and promote emotional well-being among older adults. As voice recognition technology advances and further refinements are made to the application, the interaction between robots and older adults can become more seamless and enjoyable. In conclusion, the project has shed light on the positive effects of music and robotic interaction on older adults in care facilities. While there are technical and social challenges to address, the potential for future developments is promising. As technology continues to evolve, the DoReMiND application can pave the way for more innovative and inclusive approaches to enhancing the lives of older adults through music and robotics.

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