Challenges in Developing Software for the Swedish Healthcare Sector

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Keywords: eHealth, Software Development, Exploratory Study, Empirical Study, Interview Study.

Abstract: *Context:* High-quality software is essential to the progressing digitalisation of the Swedish healthcare sector. Developing software with the desired high quality is far from trivial due to the sophisticated requirements of the domain. *Problem:* Studies on healthcare digitalisation challenges in Sweden and other countries, however, largely focus on the perceptions of healthcare professionals and patients and less on opinions of IT professionals. *Method:* In this exploratory study, we conducted semi-structured interviews with nine IT professionals about observed challenges in developing software for the Swedish healthcare sector. A qualitative analysis was performed to identify common themes. *Results:* We identified the prevalent challenges to be related to data integrity, privacy and security, rules and regulations, engineering usability, and software testing. *Conclusion:* The results suggest that further research is required regarding agile methods, efficient requirement engineering, and testing in eHealth as well as in privacy and usability engineering.

1 INTRODUCTION

Since the late 1990s (Della Mea, 2001), modern information and communication technology has been used around the world in healthcare (Bhavnani et al., 2016). Electronic health records (EHR), patient portals, and mobile applications are just some examples of tools applied to manage and monitor patients' health (Ventola, 2014). Among the promises of the progressing digitalisation of the healthcare sector are increased efficiency, reduced administrative burden, better insights for patients into their health, and overall reduced costs for the public healthcare (Ventola, 2014). Studies also suggest that eHealth is likely to have a positive effect on the quality life both physically and psychologically (Wiklund Axelsson et al., 2013).

eHealth solutions have become an integral part of Sweden's healthcare sector, too (Bjorkman, 2019). For example, 95% of the documentation in the primary care is stored in EHR and 99% of pharmaceutical prescriptions are issued electronically (Bjorkman, 2019). Sweden spends approximately USD 1.2 billion annually for eHealth and has the strategic vision to become a "Health Tech Leader" by 2025 (Bjorkman, 2019).

The development of eHealth systems involves great responsibility as the patient's health and life may depend on them (PwC, 2016). This particularly applies to software, which is an essential part of almost every eHealth system (PwC, 2016). Developing software for the healthcare sector is very demanding due to diverse requirements that software solutions have to fulfill (Magrabi et al., 2019). The need to meet high demands regarding safety (Hollmark et al., 2015; Rydenfält et al., 2019; Frennert and Baudin, 2019), security (Jung and Loria, 2010; Hollmark et al., 2015; Östlund, 2017; Barkman and Weinehall, 2017), compliance with regulations (Hollmark et al., 2015; Östlund, 2017; Svanborg-Sjövall, 2014) and others require adequate methods and processes to deliver high-quality eHealth solutions (Hollmark et al., 2015). Failing to maintain software quality can result in severe danger to patients' health and life (Galin, 2005) as well as to the credibility of the software provider. For example, in a recent incident, recordings of patients seeking medical advice via telephone were openly accessible because they had been stored without proper encryption or authentication mechanisms (BBC, 2019). This incident did not only raise privacy and security concerns but also damaged the credibility of the organizations involved.

While the digitalisation of the sector progresses, investigating the challenges at hand as perceived by the relevant stakeholders may provide valuable insights in order to address open research gaps. Existing studies have mainly focused on the perceptions of healthcare professionals and patients as the main user groups of software in the domain. Studies that

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take into account the complementing view of software system and system providers are very scarce though.

In this study, we therefore describe the results of analyzing semi-structured interviews with IT professionals about their perceptions regarding challenges in developing software for the Swedish healthcare sector. The objective is to identify potential shortcomings and research gaps in software development methods applied for the healthcare domain.

The outline of the paper is as follows: In Sec. 2, we will discuss related work. In Sec. 3, we explain the chosen research methodology. Sec. 4 reports on the findings of the study which are then discussed in Sec. 5. The article ends with concluding remarks and an outline of future work in Sec. 6.

2 RELATED WORK

For this section, published studies on the challenges of using, developing and implementing Swedish eHealth solutions/services were considered relevant.

In 2007, a qualitative study was conducted among Swedish tele-nurses who were interviewed to explore reasons for decision aid software not being used as intended (Holmstrom, 2007). It was found that among the most important reasons were usage for assessment only due to insufficient decision making support, inconsistencies with clinical practices, and difficulties in learning how to use the system. As a consequence, participants reported to often discard recommendations provided by the system and using self-care advice to a large extent.

Jung and Loria conducted interviews to identify barriers and intentions in the acceptance of Swedish eHealth services by the elderly (Jung and Loria, 2010). They concluded that ease of use, trust in service, and compatibility with citizen's needs were the main acceptance factors. It was added that better information about eHealth services are needed to increase awareness for these services such that elderly people can optimally utilize them.

In 2015, a study reviewed the literature to discuss challenges for implementing eHealth in Sweden and efforts done to overcome them (Hollmark et al., 2015). General problems were identified similar to those that other researchers reported around the world, such as interoperability, reimbursement, regulatory, and usability issues. The authors concluded that interoperability efforts and standardization, better communication between developers and stakeholder, and developer expertise in safety, security and privacy would be crucial for success.

In 2016, PwC conducted a survey involving doctors and nurses from Sweden to understand their willingness, needs, and perspectives regarding the transformation of traditional healthcare to digital healthcare (PwC, 2016). According to this report, healthcare personnel fear the loss of face-to-face contact with patients, and both care-givers and care-receivers are worried about the potential negative impact on the quality of care by using virtual care. Respondents also have serious concerns about the failure of such systems as the patient's health can suffer badly. Researchers suggest, at all levels, clear leadership is needed, creating opportunities for better collaboration between different healthcare provides and educating and supporting staff to achieve a common goal, i.e. Sweden's 2025 vision.

In 2017, Östlund discussed challenges in digitizing healthcare in Sweden based on her experiences in that domain (Östlund, 2017). She in particular noted that requirements are often not gathered from the actual end-users, especially the elderly, and stressed that active involvement of older users, and proactive and cooperative efforts are crucial for the digitization of healthcare. Moreover, she expressed that the healthcare sector needs to deal with the challenges of digital arenas that would foster a better understanding the effect digitalisation in a controlled setting much closer to the real environment.

Barkman and Weinehall conducted a comparative study in Ethiopia, Ghana, and Sweden, comparing the policymakers and mobile-based healthcare (Barkman and Weinehall, 2017). According to the researchers, despite the well-developed system, Sweden faces few challenges: integration of health data, use of digital decision support to develop personalized medicine, future funding, and quality and efficiency of healthcare systems.

Öberg et al. conducted focus group interviews to identify Swedish primary healthcare nurses' concerns and perceptions regarding the implementation and usage of digital healthcare systems (Öberg et al., 2018). Nurses were concerned because of the scope of their operational responsibilities would potentially expand and the need to adopt to new practices and policies associated with digital healthcare. The researchers concluded that there is a dire need to educate and train nurses so they can be involved in the eHealth implementation.

In 2019, a survey was conducted to study Swedish home care nursing providers and found that respondents have more expectations with remote monitoring and automation (Rydenfält et al., 2019). It was highlighted that a lack of suitable infrastructure, systems' inability to adjust the context of use, and usability are currently primary challenges in implementing

and adopting eHealth services. Furthermore, the authors predicted that the digitalisation may massively affects the workflow in healthcare organizations.

Frennert and Baudin performed a survey study among representatives of different professions working within Swedish municipal eldercare (Frennert and Baudin, 2019). It aimed at identifying challenges and opportunities related to welfare technology in Swedish municipal eldercare. The results show that despite the fact that welfare technology is considered reliable and secure, it still faces many challenges that slow down its implementation. Lack of funding and infrastructure, high staff turn-over, uncertainties about responsibility and laws, and difficulties with procurement are key found challenges. Among other mentioned challenges, resistance to change is the same factor as identified by other researchers (Jung and Loria, 2010). Lack of structured implementation processes, availability and usage differences between municipalities raise further issues.

This summary of related work shows that a significant amount of work has been carried out to explore challenges regarding digital healthcare in Sweden. This body of work mostly focuses on healthcare professionals and their perceptions, such as literature review about politicians, regulators, and policymakers and their rules, regulations, and policies, interviewing or surveying doctors, nurses, or other staff members and comparative analysis between Sweden and other countries' eHealth sector. All work presented vital insights, but to the best of our knowledge, no paper is concerned with challenges as perceived by IT professionals producing systems for the healthcare sector. This is a gap that we intend to bridge to see whether and which software development methodologies and techniques should be potentially adapted/refined. That's why this paper is first of its kind; a comprehensive study conducted to explore challenges in eHealth domain.

3 RESEARCH METHOD

The motivation for this study is to explore challenges in developing software for the Swedish healthcare sector as perceived by IT experts in order to identify potential directions for research related to software development methods. For this purpose, a qualitative research design was chosen (Berg, 1989) as it allows for a systematic exploration of the area based on people's opinions and experiences (Holmstrom, 2007). Semi-structured interviews were chosen as mean of data collection as they provide the flexibility to follow up on thoughts and ideas not envisaged upfront (Corbin and Strauss, 2014). In the following subsections, we describe the applied research protocol in detail.

3.1 Participants and Setting

The participants were selected through purposive, snowball (Oates, 2005) and opportunistic sampling, aiming at getting the preferred level of participants having a wide range of experience related to the development of Swedish digital healthcare solutions. The respondents were informed that their participation was completely voluntary and anonymous. All information from the interviews was be anonymised before the publication of any results. Table 1 gives an overview of the participants (detailed table[1]). Eight interviewees were employed by in total six different companies. Another participant worked as independent developer. Participants P1-P6 and P8-P9 belong to national and international organizations, interacting with distributed stakeholders and software development teams. Eight male (P1-P6, P8-P9) and one female (P7) of variant backgrounds were interviewed for approximately one hour on their opinions, experiences, and knowledge of challenges faced during the development of digital healthcare and welfare systems or services. Participants have a combined experience of approx. 34.75 years (mean= 3.86, median= 1), experiences ranging from 4 months (P5) to 15 years (P1), roles ranging from a software developer (P3-P6) to CEO (P1) and responsibilities ranging from software development (P3-P6) to managing teams (P8) in Sweden's digital healthcare and welfare sector.

All participants except P4 and P5 have played more than one role or responsibility during working in digital healthcare and welfare. Moreover, all participants had the experience of working in different roles with diverse responsibilities in additional domains other than the digital healthcare and welfare sector. We considered this diversity among the interviewees essential to gather well-founded and representative insights regarding the domain of interest.

3.2 Data Collection

Data collection was done through semi-structured interviews for which we developed a protocol with top-level themes. These themes touched upon perceptions of challenges and their priorities as well as potential solutions while leaving enough space for more specific follow-up questions. Each interview took

[1] https://drive.google.com/file/d/1CmzAIlsHYL0fv6DP5u0TX4BYB7DMZzkn/view.

Table 1: Participant Information.

P. ID	Domains/Systems (Other)	Role (eHealth)	Responsibilities (eHealth)	Experience (eHealth/Total)
P1	Finance Gaming	Business Developer CEO	Domain Exploration Market Survey	15/15 years
P2	Education Telecom	Software Tester Team Lead	Planning & Impl. Test Testing Support	6/20 years
P3	Commercial Apps Navigation	Software Developer	Requirement Elicitation Software Development	4/5 years
P4	Commerce Education	Software Developer	Software Development	<1/5 years
P5	Real Estate Finance	Software Developer	Software Development	<1/9 years
P6	Navigation Finance	Software Developer	Design Architecture Software Testing	1/4 years
P7	Gaming	Researcher Software Developer	Research Software Development	<1/10 years
P8	Commerce	Business Analyst	Analyze Business Software Testing	1/2 years
P9	Business Intelligence Word Processor	Software Tester Test Lead	Test and Report Software Quality	6/22 years

about one hour and were carried out via remote audio or video calls between February-May 2019 and January-March 2020. The interviewees gave their consent to be recorded such that the participating researcher could transcribe the interviews. All interview transcripts were cross-reviewed by the second author. During the interview, participants were allowed to call for a stop of the recording if they felt uncomfortable with being recorded.

3.3 Data Analysis

The interpretation and analysis of research data are comprised of epoche and bracketing (Braun and Clarke, 2006). We tried to minimize the involvement of our biased knowledge, and synthesis was done using thematic analysis (Braun and Clarke, 2006). Micro-analysis (open and axial coding) was conducted to identify in-vivo codes (MacLure, 2013), and meaning coding categories emerged from the data during the analysis. In the inductive analysis, a mixed model of open coding and pre or initial coding list was used for overall analysis. The pre-coding list acts as the initial point for discovering deeper ideas from the research data and was later transferred into the axial coding. We used the NVivo12 tool to perform the analysis (Walsh, 2003). All coding types, including open and axial codes, were tracked and mapped, highlighting the codes, their connections, and emergent codes.

We followed several stages to conduct qualitative analysis. In the first stage, authors read the free-text answers of each interview separately to familiarize with data and to get a bigger picture of the interview responses. In the next stage, the first author generated initial codes by analyzing text in-depth and assigned applicable codes to them (Charmaz, 2014). Meanwhile, the second author kept reviewing codes and the initial analysis done by the first author. Then comments and suggestions were made where required, refining the overall analysis. In the next stage, the first author performed the axial coding, and the second author reviewed it in a similar routine. Interviews and analyses were iteratively reviewed and discussed during meetings between the authors. After agreeing upon different comments and opinions, changes were made. In the next stage, the authors analyzed for the addition of new or deletion of old codes. In the final stage, authors searched for themes, reviewed them and then classified and characterized identified codes into different themes.

3.4 Ethical Considerations

We have followed the guidelines given by the Swedish Research Council for research ethics (Gustafsson et al., 2017). Information gathered or observed during the interview is reported and analyzed accurately and honestly.

4 FINDINGS

The analysis of the interview data revealed challenges that were categorized into five main themes. In the following subsections, we present the findings for each of the five themes.

4.1 Challenges Related to Integrity, Privacy, Protection and Security

Data is considered a key component and that can be used to automate systems and services in the digital healthcare sector. More and more data is stored and available for processing. Hence, five out of nine participants (P2, P4, P5, P8, and P9) discussed challenges related to data, i.e. data integrity, privacy, data protection, and security.

P2, P8, and P9 rate data integrity as one of the most critical challenges faced during the development of eHealth systems. P2 and P9 noted that patients, especially doctors, have concerns about the integrity of the data because it is essential for making decisions in many health-related processes. P2 stated "*...really important, the personal integrity and security for the patient*" because the health of individuals or even lives may depend on critical data (as P9 stated). P8 added that IT professionals need to consider various aspects related to data integrity, such as how data is handled in an organization because handling data will affect the integrity of the data. P9 referred to a problem of doctors having incomplete data about patients nowadays as an example of the challenge of data integrity: "*Today we don't have all data in Sweden... the doctors are not sure that they see everything about the patient... that could be a problem*". Complete patient information should be available to the doctor because a system based on incomplete data will have bugs, and it does not optimally support professionals and patients as P9 explained "*we can't miss the big bugs that could affect the decision of a doctor...*".

Three participants, P4, P5, and P6, talked about challenges related to data protection but P6 did not perceive this as a high priority challenge and hence did not consider it for further discussion. P4 discussed issues that need to be taken into consideration after receiving patient data. IT professionals need to ensure that data is protected from any loss or unauthorized access such that patients can trust the system. P5 also stressed the potential impact on market reputation and expressed: "*if you lose that (patient) data, I think you lose your reputation within the market, since no one is able to trust you guys, not your app, not your company*".

Two participants P4 and P5, perceived data privacy as one primary challenge faced during the development of eHealth systems. Patient data is very confidential, especially information regarding their disease history. They expressed concerns about the consequences of leaks of personal data that could like illegal sharing of patient data or offenses like blackmailing. This challenge affects decisions taken regarding the process and approach taken for handling patient data. While talking about PDA (Personal Digital Assistants), P4 gave an example: for "*generating an email... we should only use our mobile side, no data should be kept at the server side due to the privacy*", to deal with such circumstances P4 mentioned to use decentralized architectures.

According to participants P2 and P4, data security is as important to the patient as the integrity of the data. IT professionals have to ensure data security to satisfy patients. Giving an example of data security, a data-related challenge, P5 discussed the need to put extra efforts during software development. If the system lacks data security, it becomes a threat not only to the organization but also to the patient. To ensure data security, IT professionals need to add some additional security layers.

Interviewees have a several recommendations on how to address mentioned challenges. IT professionals need exhaustive software testing to ensure data integrity, P9 stated "*We need to do more and better testing...*" to make sure "*... that the data isn't lost or transformed in some other way. It's one typical, very important testing*". The P8 recommends that the software development team include people with good knowledge of data integrity laws. This can help in developing a product that complies with different laws, regulations, or standards. The P8 spoke on data handling and said that the workforce should be made aware of the security rules and in compliance with various regulations, especially the GDPR (EU's General Data Protection Regulation). So, IT professionals can ensure the security, accuracy and consistency of data over its lifetime.

According to P5, decentralized architectures are recommended to overcome data protection challenges as there will be no single point of failure: "*If one server is compromised... 4 servers remain... if it's distributed. But you have to apply the security layer on all, and you have to keep monitoring*". P6 briefly added a common known solution to address data protection challenges by implementing data encryption.

P4 mentioned that developers should be given clear instructions on technical protocols to ensure the privacy and security of the developing system. While giving an example of how to send data from a system,

P4 explicitly mentioned that HTTP protocols should be used: "*... for the protocols such as HTTP should be used to send (data)*". In addition, other business or administrative policies that may affect privacy and security decisions should be clearly communicated by the hospital or the client. Close collaboration between solution providers and stakeholders can help to address such privacy and security challenges.

There are many security protocols available, P5 thinks that by following the security protocols and using them, IT professionals can ensure data security. P5 suggested that centralized architectures should be used to ensure data security: "*Whenever you get the data, it should be centralized somewhere*". Among other solutions, as P6 mentioned about data protection, P5 also mentioned that data encryption and multiple security layers are needed to ensure data security in a system: during the development cycle, data "*has to be secured with... password protection and there should be multiple layers*" of security.

The interviewees experienced most of the challenges mentioned above in other domains, too. As compared to the banking sector and other domains, P4 and P5 perceived the severity of data privacy challenges as higher in the eHealth sector. P5 perceived severity of data protection and data security challenges high in the eHealth sector compared to the banking sector. P8 perceived data integrity challenges to be of higher severity than in other domains while P9 had not faced such challenges in other domains so far.

4.2 Challenges Related to Software Testing

Four participants (P2, P3, P7, and P8) discussed software testing challenges. According to P2, the Swedish healthcare sector has experienced significant digital innovation, however, quality assurance and testing were not taken seriously enough. This, according to P2, resulted in poorly tested systems: "*quality assurance and testing of these systems weren't prioritized*" and "*systems in this business (were) so untested*".

Access to the real patient and other critical data is often desirable for proper testing which is rarely granted due to privacy and security concerns. As P7 stated "*doctors were not willing to give me information and of course I understand security reasons*". Developers often use synthetic data for testing, which carries the risk of not representing reality thoroughly. This affects the efficiency of software development as the creation of proper test data consumes significant time. Regarding test environments, P9 said, if there are many different systems under the control of different stakeholders (public and/or private) then it will be a major challenge to access patient information for creating test environments without spending more time and money on this task.

P3 additionally highlighted the lack of testing instruments, especially medical hardware or equipment that could be used for real environment testing. Due to this challenge, solution providers are unable to provide accurate results during software testing and cannot predict the actual performance of the system. Buying medical hardware for testing purposes will increase production costs: "*This was really costly for me.. and I bought... just for testing purposes*".

Having multiple and different stakeholders creates communication problems, P8 said. It becomes difficult to collaborate and communicate within the company or with other stakeholders: "*a lot of the stakeholders... want to (get) stuff (done) and it's hard for every sector... of the company to cooperate and communicate...*". P8 added, it also becomes hard to get and set functional requirements as companies set higher demands. Due to unclear functional requirements and unrealistic deadline organizations often sacrifice testing periods, so solution providers may not meet the demands and software quality. There will be bugs in the delivery system and it will not work as intended. P8 stated "*... their requirement increases... (and) buggy system can... not save people's lives... (we) need more longer tests period*".

According to P2, lack of quality assurance and software testing prioritization has created an opportunity for companies to enter the eHealth domain but companies need to take quality assurance seriously and quality needs to be prioritized to overcome such challenges. If IT companies have close collaboration and patient data-sharing agreements with stakeholders then companies can overcome the lack of access to patient information challenges. P7 stated, "*coming up with this idea to do agreement... can easily access the information or data they (developer or researcher) want about the patient and use for their research*".

For P3, with increased collaboration between developers and stakeholders, availability and access of medical hardware for testing, IT professionals can overcome challenges related to the lack of testing instruments: "*bridge between developers and the sector (is needed), (in) which developers get access to more hardware and sensors..., like for testing of eHealth systems or apps*". P9 assumes that this will take time, but by working closely with different stakeholders and developing or integrating pre-existing test environments, IT professionals can overcome the problems related to the test environment. P8 added that

more time needs to be spend on exhaustive testing to ensure the correctness of the system. Moreover, IT professionals can use agile practices to bridge the stakeholder communication gap.

According to P2 and P7, the lack of software testing prioritization and lack of access to relevant patient data are high in the eHealth sector as compared to the telecommunication domain. Participant P3 mentioned that the lack of testing instruments was a less pronounced challenge when testing navigation systems and/or applications other domains he had worked in before. The lack of testing environments are high in the eHealth sector than in other domains, perceived by P9. According to P8, the gaps in communication with stakeholders are equally common in other domains.

4.3 Challenges Related to Usability and User Experience

Three participants (P4, P5, and P7) discussed challenges of usability and user experience in detail. P3 and P6 also briefly touched upon these topics. According to P4 and P5, IT professionals aim to make applications easy to use but face some major challenges in the eHealth sector, especially for elder or disabled users: "*have to consider the old people as well (as) disabled people... so I think the user experience matters a lot*" as both groups may be affected by poor eyesight, hearing problems, and other conditions requiring special support for using software systems.

P5 went as far as to say that lacking usability defies the whole purpose of applications in this domain. According to P7, the language barrier is an additional usability and user experience challenge, especially for newcomers to Sweden. Regarding usage problems P3 said, if IT professionals have less or missing information about usage perspectives then it would also decrease the usability of the software or system.

According to P4, P5, and P7, user interface design and other usability aspects need to be emphasized already early in the development process. P4 mentioned, these challenges will affect the development process during prospective design. P5 said, IT professionals need to research how they can improve usability and user experience, and seek constant feedback from customers, consumers, and user experience (UX) teams. However, P5 also highlighted that time constraints in development might restrict the effort that could be spent on usability engineering. Additionally, P5 elaborated on another challenge for healthcare system providers, i.e. the need to guide and train patients, doctors, and other professionals on how to use novel applications. This would make systems easier to use and affect their acceptance positively but would require extra efforts from system providers.

P7 added, IT professionals need to involve end-users in the design phase from the beginning and work closely with them: "*user involvement is very important, extremely, especially in the first phase of the design*". According to P5, IT professionals can keep stakeholders on-board during the development lifecycle. IT professionals need to collaborate with stakeholders to better understand problems as it is important to get feedback from customers on a regular basis. P5 thinks, if IT professionals can provide better user experience then they would have to put less effort into training users.

P5 said, nowadays every company has specialized UX designers and with their help developers can think more about users and develop user-oriented solutions. For P4, there should be clear design guidelines regarding making the application more useful and IT professionals need to follow those guidelines to enhance user experience. P6 added, thinking about different user perspectives, user experience, and usage scenarios, IT professionals can produce a product that fulfills user's needs. Also IT professionals need to involve special user interface (UI) designers to enhance usability and user experience. P5 believes that beta testing can also play an important role to understand and mitigate flaws in user experience.

P4 perceived challenges related to usability high in the eHealth sector as compared to other domains but P7 has no experience of usability challenges in other domains. P5 perceives user experience challenges high in the eHealth sector as compared to the banking sector but has no experience with other domains. P5 perceived the same severity of user training challenges in the eHealth sector as compared to software for the construction, banking, or other domains.

4.4 Challenges Related to Rules and Regulations

Four participants (P1, P2, P8, and P9) discussed challenges related to rules and regulations. P8 states, providing digital healthcare solutions has become more challenging due to a variety of requirements caused by administrative or legal constraints: "*A lot of organizations (have) a lot of requirements regarding how to develop solutions*". The digital healthcare system involves many different stakeholders which makes managing systems challenging.

This is especially true for Sweden's decentralized administration of the healthcare sector, which to a large degree, is in the hands of the 21 counties. According to P9, this leads to integration issues: *"...have*

a lot of systems that are interconnected and... different people would be responsible for different things... the challenge will be to make sure that we have as many real integrations as we can within reasonable resources". P1 added that the development of software solutions is often delayed because the systems to be developed have to be adapted to the regulations in different counties. In the same way, P9 said that implementing the technical means to ensure interoperability between different systems is not the main challenge but the large number of stakeholders operating the systems that adds to the complexity of designing a system. IT professionals need to plan how complex rules will affect the integration of different systems and the exchange of data between them. These challenges are not difficult to tackle, but they demand extra time and resources, P9 stated "*it takes time and money to make the data available in the right format*".

P1 additionally highlighted that having complex regulations and administrative decisions in each individual county multiply the effort required to adapt to changes in the regulations. This is not only true for existing companies in the healthcare sector but in particular for new and small companies trying to enter the healthcare domain in Sweden and improving it with new innovations. They have to either face the issue of having to comply with a large set of regulations or limit their product to counties with similar regulations which may not be feasible. P1 summarised:: "*It makes Sweden unattractive... because the market will be so limited...*".

The lack of technical knowledge or consideration of technical stakeholders during political decision-making in healthcare was perceived as another challenge. P1 referred to the example of one county that decided to force all healthcare providers to use one specific EHR system, effectively putting them into a vendor lock-in and shutting out other solution providers from this market. The decision was motivated by the believe that this would increase the data security. However, according to P1, this would have been solved in a more sustainable and less market-restricting way instead by an administrative decision on technical standards regarding secure storage and processing of EHR.

With their experience with working in agile settings, P1 and P8 discussed how issues are raised if stakeholders or organizations are following different software development practices. P8 said, the software development industry is working in a modern agile way, but the government organizations that formulate and govern the regulations lack agility, making it difficult to cooperate and work effectively: "*They're not that agile, so it's hard for them to take on changes. Two systems have different development life-cycles...*".

According to the P2, due to different rules and regulations, developers also lack knowledge about laws. Always there remains a gap between knowledge about different laws applying to different types of users: "*Different laws are applicable to different cases... the same information, but different laws*". Sometimes laws are too rigid, perhaps unintentionally, preventing innovation but IT professionals need to comply with laws otherwise they will face legal issues.

According to P1, to overcome these challenges, IT professionals need to understand the market to know the boundaries that have been set by politicians for the healthcare system. Hence rules and regulations will become very clear. P8 added some regulations are outdated and do not reflect the way new technology is applied in healthcare and stressed that more agility among those deciding on regulations would be desirable. P2 expressed the opinion that in order to overcome challenges regarding lack of knowledge about laws, some regulations need to be relaxed by the authorities. He added that software companies need to educate teams about rules and regulations, follow regulations especially GDPR. In order to overcome the interoperability challenges, P9 recommended close collaboration with the different stakeholders in the Swedish healthcare system. Furthermore, P1 proposed to intensify the efforts in establishing interoperability standards.

According to P1 and P8, following rules and regulations is more challenging in the eHealth sector than in finance and other domains. For P2, challenges regarding the lack of knowledge about laws are high in the eHealth sector as compared to the telecommunication domain. P8 mentioned, due to different stakeholders and systems, challenges of interoperability are high in the eHealth sector as compared to finance and other domains. P9 said that the involvement of and dealing with different stakeholders in the eHealth sector is more challenging than in other domains.

4.5 Challenges in Problem Domain Analysis

Two participants (P3 and P6) discussed challenges in problem domain analysis. Lack of documentation related to the problem domain and code pose further challenges during the development phase. P3 reported an example in which an existing system they were asked to maintain was extremely difficult to comprehend and hard to be run due to lacking documentation. P6 added, IT professionals need better insight into the area of expertise or application to understand

and solve the actual problem. P6 highlighted that developers start developing an application with less information about the problem domain and ended up with a faulty or incomplete system. Getting feedback from customers at the end of the development phase consumes more time to rectify issues. Moreover, both participants stressed the importance of an elaborative requirements elicitation, P3 stated "*if the requirements aren't clear for each perspective, then how can you (IT professionals) develop the entire application or software*".

P3 discussed developer perspective and their limited knowledge of the medical domain, a major challenge related to developer's perspective during the development of the eHealth system. The mobile application developer's perspective focuses more on better managing healthcare application platforms. IT professionals have difficulty learning medical ideas and their understanding of the medical domain becomes limited. As P3 said, things are getting better day by day, and over time, IT professionals became aware of the flow of the project. But we (authors) believe that it has steep learning curve that uses critical time that could be used to develop or test software or systems.

According to P3, collaboration between stakeholders and stakeholders on-board can help to better learn and understand the domain of the problem: "*to overcome this challenge..., on-board stakeholders needed...*". P6 added that once the requirements are elicited, instead of working directly on a project, IT professionals need to do brainstorming and build a prototype. Moreover, instead of getting feedback at the end do it early to avoid time loss.

The eHealth sector lacks documentation related to problem domains more than finance and other domains. P6 added that the challenge is almost the same, but IT professionals need to be more careful in eHealth as they are dealing with important real-life situations.

5 DISCUSSION

5.1 Discussion on Integrity, Privacy, Protection and Security

In eHealth, data is being used to provide useful information not only to care providers but also to care receivers (Frennert and Baudin, 2019). Challenges regarding incorrect or incomplete data were previously reported when observing the use of the software by tele-nurses (Holmstrom, 2007). Our findings confirm that this issue is considered a general challenge by IT experts, too. Based on the replies of our participants we assume that such issues are only partially due to the complexity of the domain but are rather caused to a large degree by incomplete requirements elicitation, testing, and lack of knowledge about laws related to data integrity. Further research is needed on how these activities can be improved and proactive solutions can be taken in eHealth.

Challenges related to data integrity, privacy, and security were also reported by other researchers while mentioning the importance of reliable infrastructure and trust in healthcare, respectively (Östlund, 2017; Jung and Loria, 2010). Additionally, we found that private companies or organizations have to put extra efforts to build such confidence. We noticed different perceptions of potential architectural solutions (centralised vs. decentralised) to privacy, data protection, and security which might point at the need to clarify the properties of different architectures and the quality attributes they support.

Additionally, several participants stressed the need to use data encryption for data protection, which seems surprising as this is a commonly known technology. Poor encryption are among the security concerns and researchers also recommended the need to encrypt data in eHealth, especially for transmitting data over insecure public networks (Al-Issa et al., 2019; Sahama et al., 2013). It seems worthwhile investigating to which degree sensitive data is actually encrypted in the software landscape of the Swedish healthcare sector.

We also recommend investigating standardized methods, architectures, and additional security layers (like HTTP over SSL) that are needed to be implemented during the development phase to solve current theme challenges. A survey paper also suggests several possible solutions related to current theme challenges (Al-Issa et al., 2019). Furthermore, we suggest exploring privacy by design approaches or any conceptual framework to analyze privacy and security threats and develop secure applications in the healthcare domain (Al-Issa et al., 2019).

5.2 Discussion on Software Testing

Our finding on low testing prioritization is in line with previous research, which reported that testing budgets are often limited and testing periods are short (Frennert and Baudin, 2019). This was confirmed in particular by participants responsible for testing. It seems hence worthwhile, to ensure the quality of eHealth solutions in the future, to investigate possibilities of test automation. The feedback provided by our interviewees also points to improving the efficiency and accu-

racy of other development activities, such as requirements engineering, in order to allow for more time for testing. Many requirements engineering practices have been ineffective in real world projects and yet have been a problem in eHealth (Fricker et al., 2015). It seems worthwhile to investigate which methods in particular for requirements engineering are commonly used in the domain of interest and how their efficiency can be increased.

We found that most IT professionals and researchers do not have access to real data due to privacy issues. We suggest investigating potential challenges associated with patient data-sharing agreements. What will happen if data owners belong to different companies or countries that have different or even conflicting rules regarding data sharing? We recommend exploring a better way that not only ensures the privacy and protection of personal data, but also gives access to patient and critical data to IT professionals and researchers working in the eHealth sector as, for example, proposed by Frotoni et al. (Frontoni et al., 2014).

Our finding shows that a lack of access to testing instruments makes it challenging to test systems. In addition to that, a researcher mentioned, the lack of knowledge about social contexts also affects the testing of eHealth systems (Östlund, 2017). We suggest exploring different solutions for better access to testing instruments like efficient and safe testing of systems outside the controlled environments and simulation of required instruments, for example, digitizing new arenas (Östlund, 2017). We recommend exploring better ways of test prioritisation while keeping medical testing instrument availability challenges in mind. Relevant techniques could be risk-based testing (RBT) and cost-oriented prioritisation of test cases (Huang et al., 2012).

Our finding shows that stakeholders' communication issues are perceived as one cause of faulty systems. Considering the example of tele-nurses, software programs were not fully up-to-date, inconsistent with current practices, and much information was missing (Holmstrom, 2007). Such issues can be caused by unclear functional requirements, higher demands, and unrealistic deadlines raised due to communication gaps found during our findings. Our finding recommended agile approaches to ensure well-structured teams and processes, better cooperation, and work efficiency. Customer collaboration depends on the application under development and organisational context of development (Robinson and Sharp, 2010). Therefore, we recommend further research, whether agile practices help collaboration and communication, or consume more resources than benefits in eHealth.

5.3 Discussion on Usability and User Experience

We found that challenges on usability and user experience were also reported by (Svanborg-Sjövall, 2014; Hollmark et al., 2015; Östlund, 2017; Öberg et al., 2018; Rydenfält et al., 2019; Frennert and Baudin, 2019) in their studies. It is difficult to ensure the usability and user experience for the elderly and disabled. In addition, our research highlighted language barriers and usage perspective challenges that can lead to difficulties in using eHealth systems or software. We suggest that more efforts be made to investigate the reasons for ignoring input from elder or disabled people. Furthermore, we found that sometimes usefulness is considered more important than the usability of eHealth, also reported by (Jung and Loria, 2010; Östlund, 2017; Öberg et al., 2018). Therefore, we recommend exploring testing strategies to evaluate the usefulness of eHealth systems or services. Eliciting design requirements is beyond the usability knowledge of most developers, requirements engineers, and users (Juristo et al., 2007). We therefore recommend further investigation to determine who is responsible for providing clear design guidelines and whether this always guarantees the usefulness of the application.

There is a belief that usability concerns can be considered in the final stages of the development process (after testing), as it should not take time to rework for this quality attribute (Juristo et al., 2007). But our research and literature emphasizes the need to ensure usability during the early stages of the development process. We recommend inquiring whether IT companies in eHealth focus entirely on user interface design and leave usability and user experience during the design phase or if there are any other unexplored issues.

Furthermore, we suggest investigating how to keep elderly and disabled users on-board from the beginning of development and get constant feedback as multiple challenges are associated with it. In addition to guidelines (Smeltzer et al., 2017), implemented practices in the IT sector can be explored for better collaboration. Further research is needed to explore better methods for usability engineering in the eHealth sector, as there is a belief that there should be usability engineering throughout the lifecycle of an eHealth application (Price et al., 2016).

Sometimes usability testing is confused with beta testing and the first is believed to be sufficiently covered if integrated in the latter stage as users are al-

ready involved in beta testing. However, usability and beta testing are very different as developers and testers can ask questions on the fly during usability testing but not so much in beta testing (Decker, 2014). Moreover, beta testing is used to be performed towards the end of application development while usability should be evaluated continuously throughout the design phase. That's why we recommend exploring how beta testing would be helpful in understanding and mitigating flaws in the user experience.

Some research studies have highlighted the challenges of educating consumers to use healthcare software programs (Holmstrom, 2007) and (Öberg et al., 2018). Our finding also agreed to this challenge and discussed the additional efforts that IT professionals put into training users and considering their usage perspectives. We have found that usability is indirectly proportional to efforts to train consumers, but still, further investigation is needed to conclude.

5.4 Discussion on Rules and Regulations

We found challenges related to the fragmented and distributed administration which was also referred to in previous studies (Wadmann et al., 2009; Hollmark et al., 2015; Barkman and Weinehall, 2017; Östlund, 2017; Frennert and Baudin, 2019). We have found that fragmented administration makes it difficult for all counties to develop the same system. We recommend looking for software product lines that can help IT professionals to understand the general needs of different counties (Strobl et al., 2010).

We found that there is a lack of technological understanding in political decision making. Sometimes complex and rigid laws prevent innovation in the eHealth domain. A study added that such challenges could result in time, cost inefficiency, and untested systems (Hollmark et al., 2015).

Furthermore, we have found that unclear and different regulations in different counties make it difficult for new companies to develop eHealth solutions. In general, administrative rules and regulations don't reflect technological advancements. Such issues raise interoperability challenges, loss of market, and customer issues. We suggest exploring standardisation efforts like HL7 and we have to find out what pieces are missing in current efforts for interoperability in the Swedish eHealth sector. Furthermore, we suggest investigating how understanding the market will help to raise awareness of the limitations that politicians have set on the healthcare system and how it will increase awareness and acceptance level among people.

Regarding the lack of agility in administration, we suggest that researchers need to explore how to handle the use of traditional software methods in government organizations. Furthermore, we believe that the transition from the traditional process to agility will present itself with a variety of challenges. If there is no other way than transforming, then how can this transformation be made in order to work effectively and efficiently with other organizations while keeping discovered challenges in mind.

Our findings show that knowledge of laws or standards among developers could be extended. Developers need to put extra effort and time to acquire such knowledge. We believe that higher staff turnover will create more problems, as the participant points out that the gaming industry is attracting more developers. Agile practices could help in better communication and early detection of issues. Continuous involvement of stakeholders would help to get a clear understanding of rules and regulations. Furthermore, we suggest investigating techniques that could efficiently solve problems of knowledge about different laws applicable to different users and regulatory compliance in the eHealth sector.

5.5 Discussion on Problem Domain Analysis

Our finding shows that if IT professionals don't have proper documentation, then it becomes challenging to understand and analyze the problem domain. This can lead to problems with implementation and usability, especially during the maintenance of a project. Our findings suggest requirement engineers need to ensure that developers must have complete information regarding the problem domain so that they can effectively meet customer needs. We recommend exploring efficient requirement engineering methods and domain-driven design and development concepts.

Our finding on lack of medical domain knowledge among developers is in line with previous research, which reported that tele-nurses believe that IT experts lack insight into the problem domain analysis and medical domain knowledge (Hollmark et al., 2015). We think teaching medical domain knowledge to every developer has a steep learning curve and it consumes essential resources that could be used for other important activities. Considering the case of P1 from our findings, software companies can dedicate a few key people responsible for having medical domain knowledge, and they will share it with IT professionals. Therefore, not every IT professional will need to have this knowledge explicitly.

On-board stakeholders, brainstorming, prototyping, and close collaboration may be solutions to the lack of medical domain analysis and knowledge chal-

lenges. Since these are key features of agile practices that most IT professionals apply, it seems worthwhile to investigate whether they actually work in the domain of interest of this study.

It can be seen, many of the recommendations found during our study were the most common in agile practices, but still, the eHealth sector faces various challenges. We suggest investigating this issue further, whether the technology or requirements are evolving or changing rapidly compared to the recommended solutions, or there is something else that is still unexplored.

5.6 Threats to Validity

One aspect influencing the external validity of a study is the number of observed cases (Yin, 1994). Eight cases are often considered a reasonable minimum threshold to draw generalizable conclusions in qualitative studies (McCracken, 1988). We hence believe that with the given number of participants (n=9), we managed to obtain generalizable findings about existing challenges in the domain of interest. However, a larger number of cases would be desirable to get a better picture of the prevalence of challenges. We deem the variety among interviewees regarding their level of experience and area of expertise to reflect the target population fairly and hence to support the external validity of the study.

The performed data analysis is heavily based on human interpretation of collected data. Therefore, it might be compromised by biases, inconsistencies, and missed aspects in the interpretation, reducing the reliability of the study. To counteract this threat, continuous mutual reviewing was performed by the authors to ensure the developed code and themes quality.

All interviews were conducted before the Covid-19 pandemic seriously affected the Swedish healthcare system. We are aware of potential shifts in the perceived challenges based on experiences with developing and operating eHealth systems during the pandemic. A replication of the study today might hence lead to slightly different conclusions. We believe though that the identified potential research directions are relevant in the long run.

6 CONCLUSIONS

It has been noticed that a lot of work has been done to explore challenges in the Swedish eHealth sector, but it was not done from the software developers' perspective. The results suggest that further research is required regarding agile methods, efficient requirement engineering, and testing in eHealth as well as in privacy and usability engineering. There are also some problems in realizing the vision, but better regulations, user-centric, pro-active, and collaborative efforts are needed to fulfill Sweden's 2025 vision. Other domains primarily, the banking sector is working hard to increase the effectiveness and quality of the service to increase customer satisfaction. We think there is hope, potential, and expectation that soon eHealth will have the same. Further research is required to look into how other domains in Sweden or digital healthcare solution providers in other countries are dealing with such challenges.

ACKNOWLEDGEMENTS

This work was funded by Region Värmland via the DigitalWell Arena project (Dnr RV2018-678).

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