Possibilities of Encrypted NFC Implementation
An exploratory study within Swedish healthcare

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Abstract

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This master thesis investigates the possibilities of using encrypted Near Field Communication (NFC) in Swedish healthcare. Issues such as lack of resources, high costs and inefficiency face not only the healthcare system but the Swedish society as a whole. A literature study as well as interviews and observations on five different public hospitals stand as basis for a prototype of a possible solution implementing the technology. By evaluating and discussing the results, an assessment of the future of encrypted NFC in Swedish healthcare is done. It is concluded that the properties of the technology in combination with the governmental goals and the optimistic approach of patients and visitors bring forth a promising outset for implementation of encrypted NFC in Swedish healthcare.
Populärvetenskaplig sammanfattning

Sverige är bland de världsslade länderna på många områden: innovation, tillväxt och jämlikhet för att nämligen några. Trots detta präglas svensk sjukvård av resursbrist och ineffektivitet. Detta är faktorer som är högst aktuella och diskuteras aktivt inom svensk media, politiskt, bland gemene man och på arbetsplatser. I jämförelse med andra länder med jämlika förutsättningar anses Sverige brista på dessa fronter. Denna studie ämnar undersöka möjligheterna att förbättra dessa omständigheter med hjälp av krypterad Närfältskommunikation (NFC).


Även om just denna lösning kräver vidareutveckling före implementering står den till grund för en studie som visat att möjligheterna för krypterad NFC inom svensk sjukvård är fördelaktiga. Det bådar gott inför en vidare utvärdering och utveckling av tekniken inom svensk sjukvård och skulle kunna bidra till en förbättrad situation för både patienter, anhöriga och vårdgivare på svenska sjukhus. Det finns även anledning att anta att en liknande lösning skulle kunna användas på andra problem inom svensk sjukvård eller till och med inom andra områden i samhället.

Studien genomfördes på basis av en kvalitativ metod och bestod av 35 intervjuer vid det undersökande stadiet samt 30 intervjuer vid det utvärderande stadiet; informanterna och respondenterna var säkerhetschefer, patienter, anhöriga och vårdgivare. I samband med det undersökande stadiet besökte tre svenska sjukhus i Stockholmsområdet och observationer gjordes. Dessa analyserades och sammanfattades i behov och krav som togs hänsyn till i en digital prototyp av lösningen. Efter utvärdering med patienter och anhöriga analyserades och diskuterades resultaten som avslutningsvis ledde till dragna slutsatser. Studien lämnar även utrymme för vidare forskning av krypterad NFC inom svensk sjukvård samt andra områden.
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1. Introduction

Technology is not the solution to all healthcare problems, but it can help to facilitate, improve and free space where there are no margins today. It can free up time that is currently used to look for information as well as complicated and time-consuming administrative tasks. Time that could instead be used for patients or to offer the staff some more margins in their busy schedules enabling them to use the toilet when they wish to and have lunch in peace. Although the problem is most often described as a resource shortage, there is reason to argue that a large part also derives from efficiency issues.

A Swedish doctor sees 692 patients per year while the same number is 2416 in Germany (OECD, 2017, p.171). The average for all countries treated in the report is 2295 patients per year, i.e. three times the number of treated patients per doctor and year as in Sweden. At the same time, Sweden is among the countries that have the highest expenditure on health care (Ibid., p.131). In order for society not to suffer from rampant healthcare costs, both increased efficiency of health care and development of new technology are required.

As encrypted Near Field Communication (NFC) is quickly becoming mainstream (Statista, 2019), the combination of properties such as low cost and secure data transfer provide an interesting study case for assessing how a system solution implementing this technology could contribute to the issues Swedish healthcare is facing today.

1.1 Study aim and research questions

The aim of this thesis is to explore and review the possibilities of using encrypted NFC in Swedish healthcare. On the basis of a literary and exploratory study including interviews and observations, the aim is to present a prototype in order to evaluate the possibilities of implementing a system of the kind. Furthermore, the prototype aims to act as base for evaluating the NFC technology and its possibilities in Swedish healthcare as a whole. Being only one out of many possible solutions, it enables implementation potentials of the technology to be examined.

The general research question in this study is:

- What prerequisites are there for digitalisation of Swedish healthcare?

But in order to investigate this empirically the question needs to be narrowed down. As the NFC technology is chosen as test case in this study, since it is a promising technology in the context of health care, the general research question is accompanied by the following more specific one:

- Can encrypted NFC be used in favour of solving issues facing Swedish healthcare?
In order to investigate this, there’s a need to understand the current attitudes toward NFC-solutions. Hence, this is where the main focus of the report lies.

1.2 Delimitations

Due to time constraints, only one area of improvement that could benefit from a system implementing encrypted NFC was examined. This also delimited the extensiveness of the exploratory study to five hospitals, mainly in the area around Stockholm. For the purpose of the research, the exploratory study has also been limited to public health care.

1.3 Disposition

The first section consists of two parts, the introduction where the work is introduced followed by the background. Section 2 is where relevant information about NFC is presented along with the process of digitisation of healthcare in Sweden. In addition to this a brief description of Cybercom Group AB is offered. Section 3 discloses the research methods used to fulfil the purpose of the study while section 4 presents the results of the literature and exploratory study. These are discussed in section 5 along with the choice of methodology. Finally, section 6 discloses the conclusions of the study.
2. Background

This section presents the development of NFC as well as an overview of the technological aspects. The actors and adoption of NFC in the world are described as well as the digitisation of Swedish healthcare. Finally, an introduction to Cybercom and their business concept, their customers and their relationship to NFC is given.

2.1 Ubiquitous computing

In order to best understand the technology and evolution of NFC, a presentation of the term ubiquitous computing follows. The expression Ubiquitous computing was coined 1988 by the data scientist Mark Weiser (Computer Sweden, 2013). In 1991 he further explained this as a vision of a world where IT is integrated in the environment and easily accessible (Weiser, 1991). He foresaw a future where computers, embedded in everyday items to become invisible, have replaced personal computers. Weiser argued that personal computers, though highly portable, do not fall under ubiquitous computing since they demand a focus that divest the users of their attention. Rather, he describes personal computers as ”only a transitional step toward achieving the real potential of information technology” (Weiser, 1991). In the last two decades there has been a vast development of information technology and the realisation a world where computers are seamlessly integrated in the human environment is underway. The computer mouse, touchscreens, mobile units, Bluetooth, wi-fi, and cloud-storage are all examples of innovations that have played a part in the transition to ubiquitous computing (Coskun et.al., 2012, p.41-42). Currently, NFC is one of the latest technologies enabling this transition as well (McHugh, S. and Yarmey, K., 2014, p.1-2).

2.2 Near Field Communication

2.2.1 Evolution and technology

Near Field Communication (NFC) is a technology for wireless information exchange over short distances. The technology was jointly created by Sony and Philips in 2002 and adopted as a standard by European Computer Manufacturers Association (ECMA) later the same year. Not long after, the adoption continued with International Organization for Standardization/International Electrotechnical Commission (ISO/EIC) and European Telecommunications Standards Institute (ETSI) (Coskun et.al., 2012, p.68-69).

NFC is an extension of radio-frequency identification (RFID) technology and is compatible with contactless smart card technology interfaces (Coskun et.al., 2012, p.71). The evolution of NFC can be seen in Figure 1 below.
RFID uses radio waves to identify devices and the system includes at least one tag (passive or active), a reader and an antenna (RFID Insider, 2013). The reader sends out a signal in the form of an electromagnetic field (radio waves), which in turn creates the necessary amount of power for a passive tag to be able to carry out the information exchange. RFID tags can also be active, which means that they have an internal power source and therefore are not dependent on power supply from a reader. This means active tags can transmit information over bigger distances than passive tags (RFID Insider, 2013).

RFID broadcasts over frequencies from 100 kHz-1 GHz, but mainly in low-, high-, and ultrahigh frequencies (LF, HF and UHF respectively) (RFID Insider, 2013). As seen in Figure 2, NFC broadcasts on the same frequency as HF RFID, more specifically 13.56 MHz (RFID Insider, 2013).
Similarly, NFC requires at least one reader with an antenna (initiator) and a tag (target) (McHugh, S. and Yarmey, K., 2014, p.5). The two devices must be set to the same radio frequency to be able to communicate. By emitting a radio wave at 13.56 MHz the initiator launches an NFC connection. The signal strength deteriorates quickly at this frequency and therefore requires the two devices to be within close proximity (typically a few cm) to establish an NFC connection (Ibid., p.6). This is called read range and is what near in Near Field Communication refers to. As soon as an NFC target is within the read range the field will activate the target, which in turn establishes a communication link. NFC communication is a one-to-one transmission rather than a broadcast (Ibid.).

2.2.2 NFC modes and devices

Only two NFC devices can interact with each other at a time (Coskun et.al., 2012, p.115). This entails, in the case of two or more targets within the field, that the initiator must select one target before any transmission is performed (McHugh, S. and Yarmey, K., 2014, p.6).

There are two modes of operation of data exchange defined by NFC standards: passive- and active communication (McHugh, S. and Yarmey, K., 2014, p.6). The kind of communication established depends on the mode of NFC devices. The mode can be determined by two aspects: power and algorithmic (Coskun et.al., 2012, p.73). Since the definition generally matches (Ibid.) in both cases this thesis will base the mode on power aspect. If a device has an embedded power source, and therefore is able to generate radio frequency, it is referred to as an active device. It will naturally initiate and lead communication (Ibid.). On the other hand, a passive device is defined by the lack of embedded power source and therefore is only able to respond to active devices (Ibid.). Based on this, the mode is active if both devices have embedded power sources and therefore generate a radio frequency field each. Passive communication is
established when one device is active but the other responds while being powered by the magnetic field from the active device (McHugh, S. and Yarmey, K., 2014, p.6).

A device can have two different roles, initiator or target (Coskun et.al., 2012, p.75). The device that initiates communication is called an initiator and is by definition an active device. The responding device is called a target and can be either a passive or active device. Possible NFC devices are NFC readers (always active), NFC tags (always passive) and NFC enabled mobiles (can act as both active and passive) (Ibid., p.74). For clarification Table 1 explains the different interaction styles of NFC devices and what communication type they establish.

Table 1. NFC interaction styles.

<table>
<thead>
<tr>
<th>Initiator device</th>
<th>Target device</th>
<th>Communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFC mobile</td>
<td>NFC tag</td>
<td>Passive communication</td>
</tr>
<tr>
<td>NFC mobile</td>
<td>NFC mobile</td>
<td>Active communication</td>
</tr>
<tr>
<td>NFC reader</td>
<td>NFC mobile</td>
<td>Passive communication</td>
</tr>
<tr>
<td>NFC reader</td>
<td>NFC tag</td>
<td>Passive communication</td>
</tr>
</tbody>
</table>

The second style showed in Table 1, where two NFC enabled mobile devises interact, is also called peer-to-peer mode (Coskun et.al., 2012, p.115). In this mode the NFC devises can exchange data with each other.

2.2.3 NFC tags

An NFC Tag is a contactless tag that is capable of storing NFC Data Exchange Format (NDEF) formatted data (HID, 2019). The many forms of NFC tags include tiny embeddable discs, ruggedized flame-resistant tags for industrial use, ISO cards, key fobs and printable on-metal stickers or clear labels (Ibid., Figure 3). The production cost of the tags varies depending on the type but is relatively low and decreasing as the technology develops. Recently, the two NFC tag manufacturers NXP and Identiv, announced a new pricing of only 0.05 $US per unit for NFC stickers (NFC World 2019).
### 2.2.4 NFC properties

NFC technology differs from other wireless communication technologies, such as Bluetooth and Wi-Fi, in several ways.

Apart from the range (NFC has the smallest range) Bluetooth and Wi-Fi are also capable of faster data transfer than NFC (McHugh, S. and Yarmey, K., 2014, p.14). Although, NFC does not require manual configuration like Bluetooth and Wi-Fi, resulting in one of the key properties of NFC being device pairing (Ibid.). The time saving this entails is significant in many situations, mainly used in peer-to-peer mode (Coskun et al., 2012, p.115). For instance, pairing two NFC enabled mobile devices can be done by simply bringing the mobiles close together, making it highly human centric as well (Ibid., p.71).

Regardless of the mode, NFC information exchange always follows standardized protocol (McHugh, S. and Yarmey, K., 2014, p.6). Furthermore, the communication is altogether local, meaning it doesn’t require external network or Internet access. NFC has significantly slower rate of data exchange than other wireless options, ranging from 106-848 kbs. However, another main property of NFC is that the exchanges require only minimal amount of power and therefore is very useful in circumstances where there is little or no power available (Ibid.).

Finally, the implicit security and privacy (Coskun et al., 2012, p.71) that follows from the short-range capability of NFC is essential.

### 2.2.5 Encrypted NFC

Normally records are only protected by “write lock” configured when the data is first written to tag and a device reading an NFC tag is unable to detect whether the message read is authentic or not. For example, if smartphone users are tapping NFC tags containing URLs, without some level of integrity protection, a tag containing a
malicious URL could launch a phishing attack. By signing the record, the integrity of the content is protected, and the user is able to identify the signer if desired. In April 2015 the NFC forum released the signature record type definition 2.0 that defines how a digital signature should be added to an NDEF record therefore (NFC Forum, 2015). Although such a signature prevents malicious hackers from tampering with trusted messages, it does not prevent the message to be copied to other NFC tags or keep the content confidential (HID, 2019).

Copying the data of a normal NFC tag is very easily done, for example there exists NFC applications that do this, available and free from the app-stores (HID, 2019). This is not problematic for promotional uses of NFC tags, but when the NFC tag is meant to store confidential data or to be used for security purposes this is a significant issue (Ibid.). To combat this problem, HID Global was one of the first companies to come up with encrypted NFC tags (Ibid.). In broad terms, this means that each tag is encoded with a special hidden key that is used to generate a unique code at each scan. Storing it as standard NDEF data, that code can be checked on the server using the same key. This allows the authenticity of the tag to be confirmed and since the code changes each time, the data cannot be copied (Ibid.).

2.2.6 Actors and adoption

The future of NFC is much dependent on the relationship between actors (McHugh, S. and Yarmey, K., 2014, p.15). To give a brief overview of the NFC ecosystem the primary actors will be presented in this section.

Since NFC was established by Sony and Philips in the early 2000, they have remained as big actors in the NFC ecosystem (McHugh, S. and Yarmey, K., 2014, p.15). Sony plays a great role in producing NFC enabled devices while Philips (through NXP Semiconductors, founded by them) is responsible for a large amount of NFC chip production (Ibid.). In 2007 NXP and Sony created a joint venture, Moversa, tasked to develop NFC technologies and drive the adoption (Sony, 2007). Three years earlier they also founded NFC Forum together with Nokia. The forum is a non-profit organization focused on sharing development, application, and marketing ideas, as well as standards, in order to benefit the implementation of NFC (NFC Forum, 2018). To label certified NFC devices the forum also developed a logo, seen in Figure 4 below.

![NFC logo](image)

*Figure 4. NFC logo (NFC Forum, 2018).*
NFC forum has, since established, admitted around 200 members representing a wide range of areas. McHugh and Yarmey (2014) lift the main categories and list the few key actors at the time (when NCF Forum had around 130 members):

- **Device manufacturers** - including Sony, Nokia, Samsung, BlackBerry, Canon, Hewlett Packard, LG Electronics, Texas Instruments, and Lenovo.
- **Chip and card manufacturers** - including NXP Semiconductors, Broadcom, Qualcomm, Intel, and Inside Secure.
- **Tag manufacturers** - including Identive-Group and RapidNFC.
- **Financial services** - including MasterCard, Visa, American Express, and Discover.
- **Mobile network operators** - including Verizon Wireless, AT&T, and Sprint.
- **Internet/software providers** - including Google and Microsoft.
- **Research institutions** - including VTT Technical Research Centre in Finland.

Since then, many other actors have joined the ecosystem of NFC. The largest of them being Apple, making it possible to use NFC on iPhone 7 and later released Apple mobile devices (NFC Forum 2017). In 2018 they launched the **background tag reading** feature in efforts to make user experience even better and continues to drive the NFC technology adoption forward (Apple, 2018a). Even though the NFC Forum is the hub of the NFC ecosystem, there are many stakeholders that are not members of the forum as well (McHugh, S. and Yarmey, K, 2014, p.16).

The global NFC market is estimated to reach 47.3 billion $US in 2024, which is a significant growth compared to the 3.1 billion $US market share NFC had in 2014 (Statista, 2019). The progress can be seen in Figure 5.

![Figure 5. Size of the NFC market worldwide from 2014 to 2024 (Statista, 2019).](image-url)
The history of NFC adoption shows primary effects in Asia and Western Europe (McHugh, S. and Yarmey, K, 2014, p.17), and have since been accompanied by many other countries. As a basis for this, a map visualising which countries utilize at least one of the most established mobile payments methods (Cnet, 2018) is shown in Figure 6. The use of mobile payments, in fact, means that NFC is used and is therefore a good representation of the market spread of NFC worldwide (Apple, 2018a, Samsung, 2019, Google, 2019).

![Figure 6. Countries that support NFC payment methods (Apple pay, Google pay, Samsung pay).]

2.3 Digitisation in healthcare

According to Mesko et.al. (2017), digitisation of healthcare was inevitable by 2010. Caregivers deal with the burden of the rapid growth of medical knowledge and responsibility and patients become frustrated with the mess of information while stakeholders at the same time are hesitant to changes of the system (Mesko et al., 2017). The authors continue to argue that technology usage only results in better health outcomes as long as needs of patients and cultural challenges are met and acknowledged.

E-health emerged in the 1990s as a result of personal computers becoming widely available, later on leading to mobile e-health alongside the penetration of smartphones (Mesko et al., 2017). The challenge of keeping up with the fast pace of innovations is faced globally and the process of digitisation in healthcare is disrupted by patients’ and caregivers’ being hesitant of change (Ibid.).
One of the main gains coming from digitisation of healthcare in Sweden is lowered costs and higher effectivity according to Blix and Levay (2018, p.13). They continue to describe the process as very broad since it consists of many different parts. Roughly, the authors divide it into development of software and development of hardware, giving examples of applications and programs using artificial intelligence (AI) and the use of robotics in different areas (Ibid., p.14). In the report, the authors state that expectations of being able to communicate with healthcare in the same way as in other areas – with a smartphone or computer, 24 hours a day, in a simple, user-friendly interface – will increase to a great extent.

The Swedish government announced a common vision for digitisation in healthcare 2016 (Regeringskansliet, 2016). It is stated that the goal is to make Swedish e-health the best in the world to “take advantage of digitisation opportunities to promote equity in health and welfare” by 2025. Even though Sweden is considered to be one of the most digitised countries in the world already, the country lags in digitisation in the healthcare sector (Regeringskansliet, 2016). Forslund (2018), Deputy Regional Council, argues relatedly that digitisation of healthcare in Sweden, despite being time-consuming, is ineluctable. Furthermore, he asserts that the digital e-health services need to be developed so that they are easy to use and that they should be a natural part of the healthcare offering, regardless the level of technology-experience or disability.

2.3.1 NFC in healthcare

NFC is already used in several areas in healthcare today (McHugh, S. and Yarmey, K, 2014, p.39). One area is pharmaceutical and patient tracking. By using NFC-enabled packaging and mobile devices, medication inventory, information distribution and medication tracking can be simplified. For example, one way for visually impaired users to hear the name of the medication and instructions on use is to simply tap the medication with an NFC-enabled mobile device. A demo app called HearMe was developed for this purpose by VTT Technology in Finland (HearMe, 2018). In the same sense, NFC can be used in hospitals to accurately match a patient with the correct dosage or read relevant health information about a patient (McHugh, S. and Yarmey, K, 2014, p.39). Most of these cases use NFC attached to medications, patient wristbands and caregivers’ identification badges. By using NFC-enabled mobile devices staff members can read and record data (Ibid.). The authors point out other ways of using NFC as well. Amongst them are using NFC for at-home caregivers to monitor a patient’s status, for patients to self-report their status from home or using NFC-enabled bracelets that contain medical information in case of emergencies.

Furthermore, another area where NFC is very anticipated is health monitoring devices. For example, transferring data from blood pressure monitors, glucose meters or scales to preferred NFC-enabled device (McHugh, S. and Yarmey, K, 2014, p.41). Also mentioned by McHugh and Yarmey is the idea of using NFC in subdermal implantable health devices (e.g. heart monitors or biometric sensors) for tracking during clinical trials. However, the authors point out that these ideas can seem futuristic but reason that
NFC-enabled health monitoring has been an active area of development and have potential for mainstream adoption in the very near future.

Lastly, the authors highlight two more areas: fitness and nutrition and assistive technology. Similar to health monitoring, fitness and nutrition can benefit from NFC-enabled devices for data transfer. Adding to this, the area can use “smart-food” (NFC-enabled food packaging) to access nutrition information and automatically add calorie-counts to mobile applications (McHugh, S. and Yarmey, K, 2014, p.42). Apart from weight managing, this feature has potential application in treatment of eating disorders according to Menschner et.al. (2012).

2.4 Cybercom

As this thesis was executed in collaboration with Cybercom Group AB (henceforth referred to as Cybercom) an introduction to the company appropriate. Cybercom’s areas of expertise are IT and communication technology and their largest business is development (Cybercom, 2019a). Devoting itself to strategic consulting, innovation, system development, testing, quality assurance and operation, the company realise their goals. The company’s main market area is telecom, industry and the public sector in the Nordic region (Ibid.). Whilst Cybercom mainly cater to the private sector such as Ericsson, Husqvarna, IKEA and Volvo Cars, about 35% of Cybercom’s sales is accounted for by the public sector (Ibid.). Examples of products that Cybercom has been involved in are BankID, Verisure and SignPort (Cybercom, 2019b).

Cyberom’s mission is to make companies and organizations thrive in a connected world. Consisting of four specialist fields: digitalisaton, Internet of Things, secure connectivity and cloud services, Cybercom strives for digital sustainability (Cybercom, 2019a). They focus on the UN global sustainable development goals and assignments are selected so that they contribute to one or more global goals (Cybercom, 2019c). One of these goals is Good Health and Well-Being and aims to ensure healthy lives and promote well-being for everyone of all ages (UN, 2018). In 2018, Cybercom won about thirty new contracts that contribute to the Good Health and Well-Being goal (Cybercom, 2019c). Several assignments focused on improving healthcare and increasing patient safety and security (Ibid.). The same goal of Good Health and Well-Being stands as basis for this thesis.
3. Method

This chapter describes the method used to address the research question. Since the aim of the thesis is to understand experience and problems, as well as identify a possible solution, the use of a literature and exploratory study was chosen. In order to make sure to thoroughly assess the possibilities of using encrypted NFC in Swedish healthcare, a prototype was designed and evaluated.

3.1 Literature study

A literature study was done for several reasons. Firstly, to form a thorough understanding of NFC-technology, both in terms of technical evolution and the part it plays in today’s society. The second reason was to gather information about the Swedish healthcare system, focusing on areas of improvement. To answer the second research question, if NFC is a possible solution to problems in Swedish healthcare, the information from these two sections of the literature study was necessary. Thirdly, though interface design is not of primary focus for this thesis, a basic understanding of how to model a good mobile application is required to fulfil the defined purpose. To acquire this knowledge a brief literature study of interface design for hand-held devices was conducted.

The material selected to stand as basis for this study has undergone peer-review or the process of publishing and is therefore considered to be reliable. By only using the latest published material found on the subject, the notion on NFC and Swedish healthcare system was formed to be as up-to-date as possible.

3.2 Exploratory study

The choice to conduct an exploratory study enabled further understanding of the Swedish healthcare system and its issues as well as the possibility of using encrypted NFC in favour of a possible solution.

The study consisted of qualitative interviews and observations based on the methodology of Holme and Solvang (1997). They point out flexibility and simplicity as strengths of qualitative interviews (1997, p.99) as they allow the subject to steer the conversation to what they find important. However, Holme and Solvang emphasize the importance of an interview guide to ensure the purpose of the interview is fulfilled (1997, p. 100-101). Henceforth, they define two types of subjects as informants and respondents (1997, p. 104-105). The first one being people that have knowledge or competent opinions about what’s being studied but are not direct partakers (informants) and the other one is people that are in any way involved in the event that is being studied (respondents).
3.2.1 Interviews with informants

Initially, the heads of security of four of the largest hospitals in Sweden were contacted. Only two responded and agreed to interviews, Akademiska Sjukhuset and Skånes Universitetssjukhus. These were performed over the telephone in a semi-structured manner, based on questions that can be found in Appendix A. The aim was to get another perspective of the current problems facing Swedish healthcare, supplementing the results of the literature study.

3.2.2 Interviews with respondents and observations

The literature study led to several ideas of solutions with encrypted NFC and one was chosen to proceed with for this study: using encrypted NFC as identification for hospital visitors. In this case the ones suffering from the current system are the subject types; patients, caregivers and relatives. To get a deeper understanding visits were paid to Södersjukhuset, Danderyd Sjukhus and Södertälje Sjukhus where interviews were conducted with the three subject-types first-hand. The aim of the interviews was to understand the needs of the subjects as well as how and at what level the current system meets these needs. Focus points and a few questions were prepared, but due to the various circumstances, the interviews were either semi-structured or unstructured. Since the aim was to get as genuine and unbiased responses as possible the interviews were chosen to be performed at the hospital, even though this at times came to strained conditions. By the same token, either note taking or recording and transcribing was used to document the interviews.

The three hospitals were chosen primarily on the basis of location to facilitate the exploratory study. With regards to the time limitations of the project, the number of patients and visitors was also accounted for in order to maximize the number of possible respondents. A total of 35 interviews were conducted at the hospitals, ranging from 5-20 minutes. This was considered sufficient for the purpose of the study based on the conformity of the answers and the dissemination of respondents. Concurrently, observations of the hospital security systems, information distribution to visitors and work procedure of caregivers were made. According to Holme and Solvang (1997) observations are longer or shorter time spent together with (or in direct connection to) the members of the group that are of interest. As the interviews for this study were conducted first-hand, they therefore enabled easy observations. The observations were open, meaning the participants were aware of the observations (Holme and Solvang, 1997, p.113), and notes were made with pen and paper.

The selection of examination units is a crucial part of the survey according to the Holme and Solvang (1997, p. 113) and should be done based off of consciously formulated requirements. For the purpose of this study, the respondents were categorized as patients, visitors and caregivers and requirements were defined respectively. The patients’ used in the study were required to be admitted to a ward in a Swedish hospital that allows visitors. This was to ensure the respondents had some experience with...
Visitors. Visitors were defined as anyone coming to visit a patient currently admitted to a ward in a Swedish hospital. In order to get as large content as possible, there was a strive for maximum spread on age, gender and family situation. Aside from that, the subjects were chosen at random.

3.3 App design

The method of app-design was based on the double-diamond of design as described by Preece et.al. (2019) and illustrated in Figure 7 below.

![Figure 7. Double-diamond of design (Design Council, 2019).](image)

The model consists of four phases that are iterated: Discover, Define, Develop and Deliver. Due to time constraints of this study the last phase was only covered partially but this did not hinder the purpose of the study being met.

The first phase of app design involved the combination of literature and exploratory study as it consists of gathering insights about the problem (Preece et al., 2019, p.38). The second phase entails defining the design problem (Ibid.) and this was done by analysing results from the exploratory study and defining requirements. To understand the problem better and define what needs to be done in order to find solution an impact map utilized. The impact map was elaborated in collaboration with Cybercom that provided defined guidelines. It consists of five question formulations: Why, Who, What and How. From this, the requirements were defined and listed in order to ease the process of the third phase: Develop. Concept creation, prototyping and testing was covered in this phase and iterated as suggested by Preece et al. (2019, p.49). For the purpose of this study, the focus was directed towards functional requirements, i.e. what the system should be able to do (Benyon, 2010, p.51) and necessarily how it should perform. By making use cases, sketching and finally prototyping the idea users were
able to evaluate the app effectively. A wireframe-prototype was made using Adobe XD, a tool created and published by Adobe Inc for designing and prototyping web and mobile applications (Adobe, 2019). The wireframe was based on an iOS standard since a majority of Swedish population uses iPhones (Dagens Analys, 2018; Macworld, 2018). A great benefit of using Adobe XD is the feature to preview the prototype on a mobile device making the testing of the app more realistic.

3.3.1 Evaluation

Evaluation involves collecting and analysing data about users’ or potential users’ experiences when interacting with a design artefact (Preece et al., 2019, p. 496). Preece et al. (2019, p.499) suggests, that for new concepts, evaluation should occur after requirements have been established and a prototype has been developed. This enables the designer to check if their design is appropriate and satisfactory for the target user population. The results of the evaluation also allow the designer to see if the interpretation of requirements have been done correctly.

Evaluation can be done in several ways depending on the setting, user involvement and level of control (Preece, et al., 2019, p.500). In order to provide different perspectives of the study, the evaluation covered both the category defined as “natural settings involving users” as well as “any settings not directly involving users” (Ibid., 2019, p. 500). The former category entailed observing intended users with the prototype while the latter entailed a demo and feedback-session with consultants at Cybercom AB. On both occasions’ notes were made on any ambiguities or lack of wanted features.

For “natural settings involving users” Södersjukhuset and Danderyds Sjukhus were visited in the same manner as in the exploratory study. Södertälje Sjukhus was not visited due to time limitations of the study. The two visits were made on weekday afternoons as this is when most wards are open for visits. The evaluation was made with a total of 30 users, 10 patients and 20 visitors. Going by the method of Preece et al. (2019, p. 505) the users were first presented to the idea of the study and then invited to give a general opinion of the app. Following this the users were given a few tasks (listed below) without instruction in order to observe the clarity and intuitivity of the app design.

- View upcoming visits
- Add new visit
- Edit contact
- Cancel sent request

The tasks were selected with regards to the extensivity of the prototype. For instance, the feature of the physical NFC-scan was not tested since the actual functionality was not implemented. This was not considered inhibiting of the evaluation since the purpose was to identify opportunities for new technology, not test the technical functionality of
NFC-chips. However, the subjects were still able to explore all the tabs and could therefore comment on the usability of the app as a whole.

Parallel to the user testing, a demo-session was organized at Cybercom for consultants to critique the interface design and identify the most obvious usability problems. About 10 experts participated. This signified as the “any settings not directly involving users” category and was opened by a video briefing showing the features of the app, followed by questions and feedback.

When both parts were finished the notes were considered and analysed, and finally the prototype was updated.
4. Results

In this section, the results of the interviews and observations as well as the app design are presented. The former is arranged by key aspects of the matter and the latter by the different parts of the process in chronological order.

4.1 Interviews and observations

A total of 37 interviews were conducted for the exploratory purpose of this thesis. These were 2 interviews with heads of security for hospitals, 11 interviews with caregivers, 16 interviews with relatives and 10 interviews with patients, visualised in Figure 8.

![Figure 8. Distribution of subject types for the exploratory interviews.](image)

For the purpose of evaluating the app another 30 subjects were observed. These consisted of 10 patients and 20 relatives, displayed in Figure 9 below.

![Figure 9. Distribution of subject types for the evaluation of the app.](image)
4.1.1 Digitisation of healthcare

The interviews with the hospital security heads showed inconsistent results. Tedenlind (2019), head of security at Akademiska Sjukhuset, appeared to be more reluctant to digitisation of the healthcare sector as he mentioned more risks than benefits linked to IT in hospitals. However, Jensen (2019) expressed a more positive outlook on digitisation of healthcare and gave examples of how IT had eased the workload for many caregivers. On the other hand, she emphasised the fact that this is still an area of improvement. Another essential point made by Jensen was that NFC already is implemented as a solution in home care services in some areas of Sweden, and thus indicated that NFC has potential in Swedish hospital care as well.

With regards to digitisation of healthcare patients and relatives were of the notion that digitisation is necessary and near inevitable in today’s society. “Everything has an app today; it almost feels a little strange if something doesn’t …. You wonder ‘why are they not keeping up with the technical evolution’”, a relative said at an interview in Södertälje Sjukhus (Participant 1, 2019, translated by the author). Several patients and relatives also showed a trust in the system as they argued that only safe and secure IT-solutions would be implemented in Swedish healthcare. “I would never be worried to use [an IT-solution in Swedish healthcare] but I know some people would. I guess it’s because they aren’t familiar with how it works”, a relative said when asked about IT-solutions in healthcare (Participant 2, 2019, translated by the author).

4.1.2 Security

With regards to security, the interviewees’ opinions were somewhat contrasting. While Jensen (2019) identified security as an issue and addressed it with a serious focus, Tedenlind (2019) argued that all reasonable actions regarding security had been taken. He continued to say that even though hospital threats and violence is graver nowadays, the frequency of incidents statistically have not increased. Nevertheless, he mentioned that this has had significant impact on caregivers work environment as well as patients’ and visitors’ hospital experience and that locked hospital wards are considerably more common today in order to have better control over who enters. Tedenlind (2019) affirmed that he advocates all hospital wards should be locked but that this faces resistance from employees: “[the employees don’t] think that it works particularly well with logistics and so on, there will be food carts and visitors coming, resulting in a lot of running back and forth to open [the door] all the time.” (Tedenlind, 2019, translated by the author). Similarly, Jensen (2019) stated that it is important to have control over the number of people visiting the ward in case of emergency and evacuation and thus there is often limitations to the number of visitors, and relatives are given precedence. On the same topic, Jensen informed that there is limited to no identification of visitors: “we simply have to trust what they say and sometimes there are quite a few who present themselves as ‘brother’” (Jensen, 2019, translated by the author). At times caregivers
have to deny visitors of entering and these situations are often experienced as uncomfortable for everyone involved, Jensen concludes (2019).

Complementary to results mentioned above, patients and visitors seem to prefer locked wards whenever possible. The majority of the wards visited were locked most of the time but open during a couple of hours in midday for convenience. A caregiver said “the doors are supposed to be locked after 16:00 but usually we keep them open until later because there are so many people going in and out [of the ward]” (Participant 3, 2019). Only three visitors and two patients had no preference on whether they preferred locked wards, the remaining 19 said they preferred it locked at all times or at least the majority of the time. Likewise, all caregivers said they would prefer locked wards in regards of security for themselves, patients as well as visitors. Three of the patients interviewed stated that they often or sometimes worry about people they do not recognize visiting the ward: “You never know who decides it’s a good idea to enter the ward” (Participant 4, 2019, translated by the author).

4.1.3 Workload

All subject types have shown a desire to not affect the workload negatively. Naturally, there is a general view amongst caregivers that the workload should be relieved or at least not increased due to visits from patients’ family or friends. In addition to this, the results of this study showed that the impact they have on caregivers’ workload is of great importance for patients and relatives as well. Several patients of this study claimed that they sometimes avoid planning visits when they feel it might be disruptive of the caregivers’ work. One patient also described a situation when he stepped outside to get some air in the evening and when he came back, he had to wait for a while to be let in since only one caregiver was working at that time. “It feels a little weird that you don’t even have access to the ward you’re admitted to”, the patient said at an interview at Södersjukhuset (Participant 1, 2019, translated by the author).

Similarly, some relatives described that they feel uncomfortable disturbing the caregivers when they ring the doorbell and therefore try to minimize visits: “Every time you have to ring the doorbell it feels like you are interrupting their work” (Participant 5, 2019, translated by the author).

4.1.4 Importance of visits

Despite the desire to not disturb the caregivers, both patients and relatives highlighted the importance of visits. All patients argued that visits are an important part of their stay at the hospital and some expressed a longing for more visits. Patients that had spent a longer time at the hospital put special emphasis on visits as the most important factor of their recovery. “My girlfriend visits me every day after her work, it’s the highlight of my day. It’s the only thing that motivates me”, said one patient during interviews at Södersjukhuset (Participant 6, 2019, translated by the author).
The results of the interviews also showed a general idea amongst caregivers that visits give energy and joy to the patients. “It is (...) good for them since, usually, visits mean that they get up and walk around for a bit or go down to the cafeteria, anyhow it gets them moving which is especially good for those who are reluctant to physiotherapy”, a caregiver said at Danderyd Sjukhus when asked about the impact visits have on patients (Participant 7, 2019, translated by the author).

Finally, the interviews showed that relatives value visits equally as much for themselves as for the patients. One relative expressed: “I can’t imagine not visiting my relative in the hospital, not only for their sake but for mine as well, I need to see that they are doing OK to feel calm myself” (Participant 8, 2019, translated by the author).

4.2 App design

There are two aspects to design; the conceptual and the concrete aspect (Preece et. al, 2019, p.421-422). The first one focuses on the idea of the product, what the product will do and how it will behave, while the second one focuses on the details of design; menu types, haptic feedback, physical widgets, graphics etc. (Ibid.). Since the purpose of this thesis isn’t focused on the design (but requires prototyping for evaluation) the main attention will be on the conceptual aspect. Although, Preece et. al. (2019, p. 422) acknowledges that the two aspects are intertwined as concrete design issues will require some consideration in order to prototype ideas, and prototyping ideas will lead to an evolution of the concept.

4.2.1 Impact map and requirements

To define the requirements of the system an impact map was made based on the literature and explorative study (Figure 10).

The “why”-section consists of two parts: vision and prioritized effects. Vision amounts to what the aspired change is and is based on both the literature and exploratory study. Further on, the effects that will be achieved in order to meet the challenge are defined, as well as ordered according to priority.

The next section, “who”, identifies actors and presents them in prioritised order. Actors that are marked as light red (7, 8, 9, 10) are considered to have the least impact on the system designed in this thesis, but in theory allowing them to use the system in their work could contribute to the effects. Caregivers (6) are marked as dark red as they are not necessarily users of the system but are used in the exploratory study since they can give valuable information about the situation. Categories 1-5 are marked as black to indicate that they are the intended users and will contribute to the effects greatly. The “what”-section describes what the actors need in order to contribute to the effects. These are in turn linked by connecting lines with the actors they are related to. Finally, “how” defines what needs to be delivered in order to meet these needs.
The last two categories of the impact map together resulted in a collection of requirements listed below, in Table 2, along with a short description of their meaning. According to Preece et. al. (2019, p. 387) the requirements state what the intended product or system is expected to do or how it should perform.

**Table 2. System requirements.**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calendar view</td>
<td>In order to easily see coming visits a calendar view should be implemented. This should be easily accessible.</td>
</tr>
<tr>
<td>Identification</td>
<td>To ensure security visitors should always be identified. In order to decrease the caregivers’ workload this should be done via NFC and Mobile BankID on the user’s device.</td>
</tr>
<tr>
<td>Encrypted NFC</td>
<td>The user should be able to unlock the ward-entrance by scanning their mobile phone 10 min before until 10 min after a booked visit or if the user is registered as a patient.</td>
</tr>
<tr>
<td>Phone number</td>
<td>The account should be linked to the users’ mobile phone number and should be able to be changed. The user should not be forced to re-register in case of number-change.</td>
</tr>
<tr>
<td>Booking system</td>
<td>There should be a system for patients to request or get requests of visits. The visits should be able to be viewed in the calendar view and the user should be able to edit and remove visits.</td>
</tr>
</tbody>
</table>
Users should not be able to request visits at times when the patient has another visit planned.

**Message**  
When adding a booking request the user should be able to add a message visible for the participants.

**Navigation**  
The user should easily be able to navigate to a visit.

**Emergency contacts**  
The user should be able to register emergency contacts. As an emergency contact the user will be able have access to the ward during all visiting hours meaning they do not have to book a visit.

**Interface**  
Clean and simple interface design. Colour scheme should be chosen to represent trust and security. The interface should be intuitive, easy to use and appeal to all ages.

**Register as a patient**  
The user should be able to register as a patient by scanning an NFC-chip that only caregivers can provide. This patient-status should be retracted automatically when the patient is dismissed. Information about the respective ward should be imported via the scanning.

**Language option**  
The user should be able to choose between English or Swedish language. Since the majority of users will be Swedish speaking the default language should be Swedish.

**Platform**  
The app should be run on iOS and Android platforms.

**Notifications**  
The user should be able to receive notifications and edit notification-settings (what kind, how often etc.). An example is getting a notification when a request is accepted by all participants.

**Foreigners**  
European patients and visitors should be able to use the app with Foreign eID.\(^1\) Non-European users will be forced to use the analogue system.

**First time page**  
Upon downloading the app, the user will be met with a page where it’s possible to sign in or register as a user. This page should only be presented for first-time users.

**Door bell**  
An analogue doorbell should be existing in case of unplanned visits, non-European visitors or if the user forgets their device.

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\(^1\) September 29\(^{th}\), 2018, a legal requirement was introduced which means that the public sector must be able to offer European users to login with their national identities (Svensk e-identitet, 2019).
4.2.2 Wireframe

In order to manifest the system idea a wireframe prototype was created. An iOS standard was chosen since the majority of mobile devices in Sweden are iPhones (Dagens Analys, 2018; Macworld, 2018), but as stated in the requirements the system should be able to run on an Android platform as well. This is not a problem for the design since it can be adapted to Android design standards fairly easily. Adobe XD provides templates for both platforms.

The app is divided into four tabs, representing calendar, profile, contacts and NFC-scan. In order for the tools to always be at hand the tab bar was opted for instead of the equally as common hamburger menu and was positioned at the bottom to be close to the user’s thumb (The Kinetic UI, 2018).

The home tab is set to be the calendar view (Figure 11), meaning it will be the tab presented when the user opens the application. The current day is shown as default with related events featured in the lower section. In this case, for the 15th of May, there are three events presented. The first one is a booked visit, indicated by the navigation feature directly visible. The second one is a request sent by the user, indicated by the cancel feature to the right of it. When the request is accepted it will automatically turn into a booked visit and other visits will not be able to be requested at that time. The third one is a received request that is waiting to be accepted or declined. By pressing an event, information about it can be seen and changed (see Figure 12). If changes are made all participants will be notified.
Figure 11. Calendar view.

Figure 12. View and edit visit.
There is also a feature that allows the user to search visits by name. If a name is entered in the search bar, all planned visits with this name as a participant will appear, as seen in Figure 13 below.

*Figure 13. Search visit.*
The second tab is the Profile-tab. Here the user is able to view and edit profile information. This is the view that differs the most between patient-users and visitor-users. In Figure 14 below, the patient-view is displayed to the left and the visitor-view to the right. If a user is registered as a patient, it will be able to see information about the ward on this page. This includes ward name, address, visiting hours and rules.

Figure 14. Profile view. Patient profile to the left, visitor profile to the right.
The third out of the four main tab is the Contact-tab. Here the user can view, edit, delete and add contacts, as well as view received and sent contact requests. The blue cross indicates that a contact is an admitted patient, as seen in Figure 15. In the following, Figure 16, the views of a regular contact and a patient contact is shown.

*Figure 15. Contact view.*
Figure 16. Edit and view contact. Patient to the left, visitor to the right.

When adding a new contact, the view (Figure 17) is very similar to the one shown in Figure 16. The contact will be added via telephone number and the email is only asked for because of confirmation purposes. The name is chosen by the user and denotes only how the contact will be displayed to the user. By selecting ‘emergency contact’ the user allows the contact to book visits without having to accept them every time.
The last view of the Contacts category (Figure 18) demonstrates what a received contact request looks like. The requesting user’s registered name, email and telephone number will be displayed. As mentioned earlier, the user can later change the name if they want to, but this will only change the name displayed locally.

*Figure 17. Add contact.*
Figure 18. Search visit.

The final of the four tabs is the Scan-tab and is where the user activated NFC to scan their phone when desired (Figure 19). As this is one of the main features of the app it is positioned closest to the thumb (of right-handed users) and has only one feature in order to minimize the number of clicks. If the scan successfully finds a registered visit the user will be asked to identify themselves with mobile bank-id or foreign e-Id to finally unlock the door. If not, an error message will be shown as in Figure 20 and lastly there is a link to more information and contact details to the administrator if the scan isn’t working correctly.
Figure 19. NFC scan.

Figure 20. Identification.
4.2.3 Evaluation

During the evaluation a total of 30 interviews were made in addition to a demo session with IT-experts. In general, the evaluation showed a very positive picture as the majority of the subjects stated that they would use this or a similar app if implemented. Only two of the 30 subjects said that they wouldn’t use the app, equalling to 93% that would use the solution.

However, the evaluation led to several changes that are listed below (Table 3) along with the source. Some were proposed directly by the subject while others were defined by the author in conjunction with the evaluations. The final views can be seen in Appendix C.

Table 3. System changes.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text under icons</td>
<td>In order to clarify what the main tabs are a patient requested titles under the icons.</td>
<td>Patient</td>
</tr>
<tr>
<td>Explanation on emergency contacts</td>
<td>When adding a contact several subjects noted that the meaning of emergency contact was unclear. By adding a tooltip and further information in the information bar this problem is solved.</td>
<td>Patients, relatives and demo session</td>
</tr>
<tr>
<td>Message when declining visit</td>
<td>The desire to be able to send a message when declining a visit was expressed.</td>
<td>Demo session</td>
</tr>
<tr>
<td>‘Stop’ scanning</td>
<td>If a user accidentally starts scanning or for some other reason wants to stop, the option should be present.</td>
<td>Author</td>
</tr>
<tr>
<td>Info about GDPR^2</td>
<td>It should be stated clearly how the data is used and should ask user for permission when registering.</td>
<td>Demo session</td>
</tr>
<tr>
<td>Room number</td>
<td>To further aid caregivers work load, the feature of seeing which room the patient is situated in is preferred. This would minimize the guidance needed to find the right room.</td>
<td>Relatives and demo session</td>
</tr>
</tbody>
</table>

^2 General Data Protection Regulation (GDPR) regulates the processing of personal data relating to individuals in the EU (European Comission, n.d.)
5. Discussion

This section interprets and discusses the results from the exploratory study and the evaluation of the app design. The discussion is based on the aim of the study and assesses the methodology of the study as well as the reliability of the results. Finally, recommendations for further research is presented.

5.1 Security

As is clear from the exploratory study, security is one of the most crucial factors of Swedish healthcare. While digitisation of healthcare seems as inevitable for the majority of the subjects, the attitude towards the effects of it was somewhat divided. Considering the fact that the duty of a head of security is to avoid all security breaches, it is expected that they would be extremely focused on potential risks of digitisation of healthcare. This is significant because of the way it might influence their view on what risks are worth taking for the sake of organisational improvement. It can be argued that since their main focus is on security and not caregivers’ workload and patients’ rate of recovery, it is natural to assume it would be easier to neglect a solution that (in their eyes) involves risks. However, it is interesting that Tedenlind, who gave the impression that security on wards is unproblematic and had a more reluctant view on digitisation of healthcare, mentioned that out of a security point of view it would be ideal to have all wards locked. This proves that in fact, implementing a solution as the one presented in this study would improve the security of hospital wards. The only way this statement would be false is if the solution handled data in an unsecure way.

As explained in the background, the transferring of data with encrypted NFC would be incredibly secure. Combining the two key factors, encryption and the short read range, provides a great degree of security. Of course, the way data is stored in the app is crucial as well but based on the already existing e-health apps and websites, one can conclude that there are definitely ways of doing this securely.

During the exploratory study the patients and relatives showed a positive view on digitisation of healthcare, leading to the assumption that there is a kind of trust in the system that regulates security of data storage in healthcare. This might be surprising to some but nevertheless it is an important result for this study. The fact that this trust exists further speaks for the possibilities of this kind of solution. This is further discussed in section 6.2. Another interesting find was the fact that many of the patients expressed their sense of security as an issue, contrasting with the beliefs of Tedenlind. This again highlights the importance of a solution of the type presented in this thesis.
5.2 Implementation and usability

One of the facts benefiting the implementation of this study is the number of wards that are already provided with electrical locks. Together with the low cost of NFC and the utilisation of the users’ own devices the total cost of implementing a solution of this kind would be considerably low. Of course, it would entail a certain cost. The question one has to ask is how much the effects of it are worth.

A drawback of this solution is the fact that it requires users to have and be able to use their own smartphone. A common view may be that a vast number of patients aren’t of this category but based on the findings of this study it can be argued that this isn’t the case. Almost all of the subjects interviewed owned a smartphone and the evaluation showed a strong positive result on the use of such a solution. For the purpose of this study a wireframe was produced but in order to officially launch the app the design needs to be considered more profoundly and developed by UI/UX experts for the intended users. Another concern is that some patients are not physically or mentally capable of operating such a solution themselves. The answer to this is that firstly, the number of such users is very few, as mentioned in the result, so the majority of users are positive and willing to use such a solution. Secondly, there is the possibility to partially accredit the use through emergency contacts. In this way, what is required by the original user is minimized.

Hypothetically, if only 50% of patients and relatives used the app, the effects it would have on caregivers’ workload would still be significant. Not to mention the security aspect, if the wards were all locked. In the light of this study the effects outweigh the potential costs.

Another aspect of implementation is the administration and the technical development behind the app. Since this isn’t included in the purpose of this study, this isn’t discussed greatly. Worth mentioning is the fact that this solution does require administration and maintenance but isn’t considered problematic based on the governmental vision of Swedish healthcare mentioned in section 2.3.

5.3 Method and limitations

With basing a study on a qualitative method comes a couple of drawbacks. Firstly, the dataset is limited as interviews require more time than gathering data from a database or surveys. The benefits of interviews, such as the deepened understanding and flexibility, came to the decision that a qualitative research method is best suited for the purpose of this study. However, qualitative studies can often be advanced through more observations on a broader range. For example, observations at more hospitals of different locations and sizes would be advantageous for the results. Furthermore, the length of the interviews could be longer to provide an even deeper understanding of the subjects’ views. These factors are unfortunately limited by the timeframe of the study and the fact the subjects were not seldom in a hurry.
The use of Adobe XD for the prototyping proved to be satisfactory. Since there was limited experience in prototyping, it was important that the tool is easy and efficient to use. One of the features that proved to be very useful was the possibility to view the prototype on a mobile device. This led to a very realistic experience for the subjects of the evaluation. There are most likely similar tools existing that provide the appropriate features and results.

The method for the design of the app was based on the iterative Double-diamond of design. Some might argue that this method is outdated for modern-day software development, but it is entirely sufficient for the purpose of this study. For further development of such an IT-solution other, for example agile, methods might be preferred. The time limit of the project also affected the number of iterations made; it would undoubtedly be advantageous to perform additional iterations if possible. This is further discussed in section 5.4.

5.4 Further research

During the course of this study, several areas for further research have been discovered. As mentioned in section 5.3 further research and development of the idea presented in this study is possible and would be beneficial. However, implementation of encrypted NFC in Swedish e-health solutions overall seems to be a rather unexplored area.

One of the biggest issues apart from security in hospitals was found to be navigation. The number of patients and relatives as well as caregivers that complained about how many visitors don’t find the right place was astonishing. This could easily be solved by implementing NFC stations where visitors can scan their mobile device and get instructions on how to get to where they’re going. If they get lost again, they just scan the nearest NFC station again to get further instructions. An idea would be to link this to a solution similar to the one presented in this thesis. That would mean the location of the visit would be registered (i.e. the ward) and the only task required for visitor to do is to scan their phone.

Another area of further research regarding encrypted NFC in Swedish healthcare is elderly care or home care. It is already looked into using NFC-applications for employees that visit patients at home but there is no such solution for friends or relatives. Older people may experience difficulties opening doors for physical reasons, but there may also be a fear of opening the door due to the fact that they are frequently a target group for burglars and the like. With an application similar to the one presented in this study, this risk-taking is eliminated for the elderly and could mean a safer everyday life.

In addition to these areas, there are undoubtedly other possible areas for implementation of encrypted NFC in healthcare that are unexplored.
6. Conclusion

This study is set to investigate the possibilities of using encrypted Near Field Communication (NFC) in Swedish healthcare. In doing so a prototype of a possible solution was presented, more specifically, a system for booking visits and for using encrypted NFC as a method of entering and exiting the ward in a way that increases security. By prototyping and evaluating this solution it has been shown that there is at least one favourable use of the technology: the use of encrypted NFC for improved process of visits. The exploratory study showed a high level of trust among potential users which in turn benefits the possibilities of a potential encrypted NFC implementation. The evaluation of the specific solution formulated in this study showed a result as high as 93% for possible users amongst patients and relatives. Furthermore, the study showed that the area of encrypted NFC in Swedish healthcare is rather unexplored but has potential to be used in several ways. In conclusion, with the prevailing critical situation among employees and the drastically increasing pressure on available beds at hospitals as well as patient security, the possibilities for encrypted NFC within Swedish healthcare has proven to be significant as the solution requires minimal infrastructural and organizational efforts.
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Appendix A

Intervjufrågor
Patienter

- På vilket sätt påverkar besök dig?
- Finns det något man kan göra för att öka antalet besökare?
- Hur tydlig upplever du att information om regler för besökare är?
  - Vad tycker du om de regler som finns?
  - Saknas några regler?
- Vad är din upplevda trygghet på vårdavdelningen?
- Vad tycker du om att avdelningen är låst/olåst?
- Har du hört om någon som blivit av med en ägodel eller liknande på avdelningen?
- Hur upplever du att besöken påverkar personalen?
- Vad skulle kunna bli bättre?
- Använder du en smartphone?

Anhöriga/närstående/patientbesökare

- Hur tydlig upplever du att information om regler för besökare är?
  - Vad tycker du om de regler som finns?
  - Saknas några regler?
- Hur gick du till väga vid ditt första besök? (hitta rätt osv)
- Hur påverkar besöken dig? (Hur viktiga är besöken för din egen del?)
- Finns det något man kan göra för att öka antalet besökare?
- Vad tycker du om att avdelningen är låst/olåst?
  - Hur upplever du bemötandet från personal?
- Vad skulle kunna bli bättre?
- Använder du en smartphone?

Sjuksköterskor

- På vilket sätt upplever du att besökare påverkar patientens välmående? (positiv/negativ)
- Finns det något man kan göra för att öka antalet besökare (med förutsättningen att det inte påverkar ert arbete?)
- Är besöksstiderna fastställda eller varierar de efter patient? Vad beror det på?
- Hur hanteras mängden av besökare? (total och per patient)
- Hur mycket av ditt arbete är ägnat åt att hantera/informera besökare/anhöriga?
- Vad tycker du om att avdelningen är låst/olåst?
- Vad skulle kunna bli bättre?
Appendix B

Prototype views of the first iteration
This message can be viewed by patient and all visitors.

Max amount of visitors is 3 at this ward.
Your ward allows visitors Mon-Sun. Choose what days you would like to admit visits.

ERROR
Something went wrong. Please try again later.
Appendix C

Prototype views of second iteration
Scan not working correctly?

STATUS
Visitor

PHONE
07X - 000 00 00

To change status talk to a care giver.

Save