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Envisioning Healthcare in 2025

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Abstract

Today, there is a greater demand for information and the use of new and emerging technologies. Healthcare especially can benefit from more information and cutting edge technologies, and, although there are systems in place, there are also opportunities to support the current electronic medical records' (EMR) capabilities and the way health care is performed today. Existing issues include duplication of information, security concerns, misaligned systems, and uninformed patients.

With today's evolving technology there is an opportunity to implement initiatives to improve the recording and communication of patient information, and the healthcare experience overall. These current issues as well as our rapidly evolving technology needs, can be improved for medical professionals and for patients by empowering the patient and bridging the gap that some of these current healthcare issues create with the help of innovative thinking and research.

The data that makes up this report was gathered utilizing techniques such as vision seminars, interviews, job shadowing, and literature resources to gather useful information on the issues and technologies impacting modern health care. To exhibit our research and findings we utilize three different scenarios based on current health issues, to showcase how this research can be used in 2025 to improve the healthcare process with the patient in focus. Our findings encompass artificial intelligence, augmented reality, virtual reality, 3D visualization, data collection, speech recognition, tablets, video recording, drones, smart home technologies, and more.

Our findings and research have the potential to improve today's healthcare system. Doctors and nurses will benefit from working with a higher quality of patient care, and with a patient who is more informed and educated about their own health as well as the processes involved with their care. Patients will have a much greater understanding of their situation and will be able to interact with medical professionals on a much more personal level and with greater self-awareness.

Sammanfattning

Det existerar idag en allt större efterfrågan på information, och vi innehar den teknologi som krävs för att den tillhandahålla. Sjukvården i synnerhet kan dra nytta av en större spridning av information och trots att det finns system på plats så förekommer även möjligheter att stödja den förmåga som nuvarande elektroniska journalsystemen besitter. Befintliga problem inkulderar duplicering av information, säkerhetsfrågor, felinriktade system samt patienter med felaktig eller icke tillräcklig information. Med dagens ständiga teknikutveckling finns möjligheten att ta initiativet mot en förbättrad process av registrering och överföring av patientinformation, samt den totala upplevelsen inom hälsovården. Detta skulle förbättra situationen för såväl vårdpersonal som för patienterna själva genom ett ökat inflytande.

Denna rapport grundas på insamling av information genom användandet av metoder såsom seminarier, intervjuer, besök hos vårdgivare samt litteratursökningar. Tre olika scenarion har använts för att presentera de fynd som gjorts under studien och hur dessa kan implementeras till år 2025 för att förbättra vårdprocessen med patienten i fokus. Dessa fynd omfattar områden som artificiell intelligens, virtuell verklighet, 3D-visualisering, insamling av data, taligenkänning, surfplattor, bildinspelning, drönare, teknologier för ett smartare hem samt mer.

Vår studie och dess fynd har potentialen att förbättra de sjukvårdssystem som finns idag. Vårdgivare kommer att begagnas av arbete med en vård av högre kvalitet samt med en patient som är välinformerad och besitter mer kunskap. Patienter kommer därmed ha en betydligt bättre förståelse för deras situation vilket kan leda till ett samarbete med vårdgivare på en djupare nivå än vad idag är möjligt.

Contents

1 Introduction

The use of technology in the world and how we use it is constantly growing and changing [90] to improve everyday life. Consequently, the healthcare industry is being influenced with the influx of new technologies and ambitions to create more efficient systems. Two parts of healthcare that can be impacted are the Electronic Medical Record (EMR) and Information Technology (IT) systems.

The Uppsala region/county is currently exploring new technological solutions for their EMR and IT systems. Akademiska wants a system that improves patient care by removing redundancies, increasing transparency, and exploring new technologies to expand preventative care.

This project is the result of a collaboration between the Region Uppsala and IT and engineering students at Gannon University and Rose Hulman Institute of Technology in the United States and Uppsala University in Sweden. The students researched how the IT systems surrounding the EMR could be improved for the Year 2025. It was clear from interviews with several healthcare professionals that they were not satisfied with the IT systems in use today. An example is that one nurse said "I did not start working as a nurse to just sit at the computer all the time, using the IT systems" [Interview5]. This report discusses possible technical solutions that could be implemented by 2025.

This project has been developed with a focus on patient care at home and in the hospital. The focus areas are primarily patient empowerment, monitoring, and experiences. To cover all these areas from a patient's perspective, three different medical scenarios will be used as examples throughout this report. The chosen scenarios are: cancer, diabetes, and head trauma. This report shows how these situations occur for a patient today and how technological changes could influence them in 2025. Based on knowledge gathered through research, these scenarios aim to build a foundation for a framework that puts forward possible solutions that might be of interest to implement in future systems.

1.1 Background

The Region Uppsala requested university students to propose new ideas and envision what a healthcare system in 2025 could look like. The group of student researchers come from three universities, Gannon University, Rose-Hulman Institute of Technology, and Uppsala University focused on solving complex and multifaceted problems and report writing. The main goal of a healthcare system is to not only provide patient care, but to also investigate sources for sicknesses and prevent them from happening in the first place [92]. To reach these goals, it is essential to focus on the patient when developing healthcare systems.

The Uppsala County Council Electronic Medical Record (EMR) system currently serves over 10,000 users with constant access. The annual budget to run this system is 120 MSEK. The county's EMR consists of several systems working together, including Cosmic, Orbit, MetaVision, and KoVIS. These systems manage a variety of operational aspects of the hospital, such as the operations theater (Orbit) or intensive care and anesthesia (MetaVision). The EMR serves as an electronic platform with the goal of seamless interaction between different hospital divisions as well as outside organizations such as National Patient Overview (NPO).

Despite these aspects of the current EMR system, there are still many issues. The system needs to be more usable. Healthcare professionals often become frustrated by the large number of steps they must perform for specific tasks. They become discouraged by the considerable amount of text on screen, and would prefer a more user friendly visual appeal [Interview1]. A crucial problem with the system is the amount of repeated work each user must perform [Interview1]. If the user enters data in one subsystem of EMR, they often must enter the same data into one or more other subsystems as well. This wastes a significant amount of the medical professional's time that could be spent on something more productive, such as patients.

Healthcare professionals strive to provide patients with the best possible care. This means that the patient's needs must be a priority in every situation. Unfortunately, the medical staff at Akademiska has been pushed to the limit [53]. This increases the workload for the current staff and it becomes more difficult for the personnel to perform the same quality of care. The EMR system needs to work with the healthcare professionals work flow to help them provide the highest quality of care.

To be afflicted with a disease or injury can be a negative experience. When something like this happens, it is important to feel support from health care professionals. The patient should trust that they are given the best care and all the information that they need to recover from their condition. This can be hard to achieve by the medical staff and it is not uncommon that the patient will feel insecure.

When Akademiska and other hospitals all over the world face dilemmas of this nature, can technology be an aid to help ease these problems in the health sector? Can it be a way to help healthcare professionals carry out their work tasks more effectively and therefore have more time to tend to the patients' needs? Can technology be a tool for allowing the patient to feel more involved in the process and be less insecure?

1.2 Scope and Goal

The main of the project is to explore the future healthcare systems with the patient in focus. By exploring current technology in both healthcare and other industries, this report strives to present and discuss technologies and solutions that could benefit healthcare in 2025. The ambition is that the work presented in this report will serve as inspiration and guideline for Region Uppsala when investigating how to improve healthcare in the future through technology.

1.3 Limitations

There were some limitations throughout the project that surfaced. The first of these is that some ideas were drawn from international sources such as China and India. The issue is that not all solutions can be implemented in Sweden due to differences in government. Next, there were no focus on current rules and privacy concerns for this project. The project instead focused on breadth and perspective rather than limiting future solutions.

The majority of people working on this project do not have a background in healthcare. This project was conducted by IT and engineering students. Though there are advantages in regards to reforming the EMR system, there are also disadvantages such as limited knowledge on the workflow in hospitals. To remedy the issue, extensive research was done to gain perspective on healthcare professionals use of IT systems.

1.4 Outline of the Report

The report is organized into seven main sections. The first section will discuss the research methods used to gather information on the project. The next session discusses the findings from the research done over the past few months organized into smaller subsections pertaining to each technology. The next three sections after the findings depicts three different scenarios that compares current day process and what the process could look in 2025 with technologies discussed in the findings. The last sections wrap up the paper and mentions additional work for the future and concludes the report with a summary of the findings and scenarios.

2 Research Methods

The research presented in this report was conducted to look into the future of systems used in healthcare, and the proliferation of data gathered and contained in the systems. Research was handled utilizing professional journals, articles, websites, and publications detailing emerging technologies, including this the review of the literature (section 2.4). Interviews and job shadows (section 2.2) with healthcare professionals, healthcare students, patients, and information technology professionals were conducted to gain a deeper understanding on user requirements when interacting with the data. All research was handled with a focus on interactions between healthcare professionals and patients.

2.1 Project Structure

The students of the three different universities who participated on this project were requested to research how Region Uppsala's healthcare system would look in 2025. To approach this task the students were divided into two main groups. One group focused on the patient at home and the other on how the patient and healthcare professionals interacted with the IT-systems at the hospital. The group tasked with patients at home were divided into three sub-groups:

- Healthcare Interaction
- Patient Data
- Patient Empowerment

These three sub-groups researched how patients interact with IT systems from home today and how that interaction might be expressed in the future. The other main group that focused on the patient experience at the hospital were also divided into three subgroups:

- Doctors
- Nurses
- Patients

Each of the sub-groups examined a specific role on how the interactions with the IT systems look like today within the hospital. The doctors and nurses must be able to efficiently interact with the systems to be able to provide the treatment and care the patients need.

All of these sub-groups divisions were conducted by the project members' preferences.

After doing the research and having some results of it, the students were then combined again and splited into three different groups to present their findings as scenarios. These scenario groups were formed by randomly mixing at least one of all different sub-groups members into each scenario. In this way, all the scenarios have a complete insight coming from all six sub-groups, in other words, from all the sources. These scenarios were focused on specific ailments to see how they are prevented, diagnosed, and treated today, but also on how healthcare would look like in 2025. The three scenarios are as follows:

- Cancer (Lymphoma)
- Diabetes
- Head Trauma

The groups has been divided into head trauma, diabetes and cancer in order to have one injury (head trauma), one severe disease (diabetes), and one severe temporary disease (cancer) so team members could see the technology in different fields and how that would effect the different situations. Then, these members in the groups were divided into the three scenarios so it would be at least one from each subgroup that it had for research so it could get competences from different search backgrounds.

2.2 Interviews and Job Shadows

A method that was used extensively to gain a greater understanding of the current process was interviews. Numerous interviews were carried out with a variety of different stakeholders. Patients, doctors, nurses, IT specialists, and hospital administrators were interviewed to gain an insight into data interaction. It was important to look at multiple perspectives to get a well-rounded viewpoint of the apparent strengths, weaknesses, and opportunities. These interviews took place both in Sweden and the United States spread out on a total of 14 weeks. This provided a greater context by collecting data on two different healthcare industries. A combination of informal, general, standardized, open-ended, and fixed-response interviews was used to collect a large variety of responses and opinions. During the time period for the project there was 72 medical professionals, 24 patients, 13 medical students, four politicians, and eight IT-professionals had been interviewed. 26 visits to the hospital or other health care establishments has been done to carry out the majority of the interviews with medical professionals.

Interviews were conducted either via telecommunications or in-person. In-person sessions consisted of a planned meeting between a healthcare professional and a researcher, most of there included some sort of job shadowing. A job shadow was an in-person session where the researcher had the opportunity

to visit a professional and observe their day-to-day tasks while asking questions. The questions were generally prepared beforehand with some improvisation dependent on new topics and angles that emerged. Questions were designed to be open-ended as opposed to multiple-choice to give the interviewees space to share their opinions. Interviewees would discuss about the present and future, identifying current issues as well as potential solutions. The information gained from these sessions was invaluable in terms of shaping the vision of the project. Eleven job shadowing sessions of various length and depth were performed to get information about the work at the hospital.

Once the interviews were completed, information was shared among the various groups. Comparison of the data allowed for reoccurring themes to be identified. Often different interviewees brought up the same points which highlighted their importance. The key pieces were selected and used to build the foundations of the project.

A list of the interviews and job shadows conducted is attached in appendix.

2.3 Vision Seminars

Vision seminars [92] were used to develop a vision of what the information technology system in healthcare could look like in 2025. Vision Seminars consist of a series of well-guided discussions. Vision Seminars are conducted by the researchers with the users of the system. The goal of a vision seminar is to develop an understanding of how a system could work.

Vision seminars adapt to the situation and the participants at each individual seminar [92]. Vision seminars were adapted based on this research's context for use as a research method. Traditional vision seminar practitioners suggest at least four discussion seminars, each lasting about half a day with a two to three weeks gap between each seminar [52]. Due to time constraints, Vision Seminars for this project were conducted with a single session per group of participants, with each session lasting one to two hours. Uppsala University conducted two vision seminars, one with patients and one with healthcare professionals, such as doctors and nurses. Gannon University also conducted one vision seminar with students currently studying to be future healthcare professionals.

Despite time constrains, the key characteristics of the vision seminar were preserved. The seminars focused on describing and analyzing the current healthcare process, viewing multiple perspectives, achieving a common consensus, and letting the participants brainstorm together. The brainstorming was mainly focused on how the participants thought that the future of healthcare will look like with IT inventions. This primarily from their perspective and what would benefit them in their different fields, for example

in the surgery room or when contacting patients.

Outlines of the vision seminar format is attached in appendix A and appendix B.

Note that the vision seminars in Sweden and the US differ in setup due to that various people moderated the seminars and had been taught different methods of how to do a vision seminar.

2.4 Research/Literary Resources

A large portion of the research was conducted with literary resources such as scientific journals, articles, and publications gathered through online resources. This gave background on existing, emerging, and evolving technologies, that could allow for data interaction inside and outside the hospital. Literary review focused on Sweden as well as inspiration and ideas from other countries around the world. After gathering the information generally, it was analyzed and structured based on scenarios. The scenarios include cancer patients, diabetic patients, and head trauma patients. The results found using these resources can be seen in the Findings section (section 3).

3 Findings

Technology never ceases to enlighten and amaze. With new advancements being made every day it is hard to keep track of all the new innovations and breakthroughs. This is especially true in the healthcare space. Through research and interviews we have pulled together many great ideas for integrating new and upcoming technology into healthcare, envisioning what the future may hold for healthcare.

3.1 Artificial Intelligence

An important idea for a better operation room is the increasing innovations of the Artificial Intelligence (AI) [9]. AI is being improved at an exponential rate and can be adapted for nearly all jobs out there. The improvements in AI have already begun in the medical field as well. IBM has an AI named Watson, which analyzes vast amounts of unstructured data, and finds exactly what is being looked for. To quote the engineers who made it: "IBM Watson can just go into a medical record system, pull out all the relevant data, and do it much more quickly. A response from patients to me has been absolutely overwhelming." IBM Watson is much more than a search engine [25]. This AI has the potential to be just as good, if not better, than any other colleague worked with. Watson has been proven to be useful in many situations [26], and this is just one example.

Robots are able to work with medicine much more efficiently than humans ever could. The Watson's engineers also stated that "understanding every drug and every drug's interaction with every other drug is beyond the scope of human know ability, especially when there research bots whose whole job it is to test thousands of new drugs at a time" [31]. Integrating what already is successful into the operating room is a great solution. NYU Langone's Robotic Surgery Center is already doing this, having thousands of robotic assisted surgeries completed. These robots filter out hand shakiness and allow maneuvers that are not possible for surgeons [73]. Giving these robots the ability to connect to the databases and systems allow them to communicate with the EMR's and the operating room will be much more communicative and allows the staff to better treat the patients.

3.2 Automated Transportation

Most people are probably aware that smart or self-driving vehicles are rapidly becoming more and more popular. There are many applications for self-driving vehicles and one of which could be the transportation of patients who may not have the ability to drive themselves. Many times this task falls on the patient's

relatives or friends and can become a cumbersome endeavor. Smart vehicles could relieve some of this burden and allow patients to be more independent where normally they would be incapable of transporting themselves.

3.3 Blockchain

Blockchain technology [11] has many applications but one of the most interesting is that of healthcare. In its most primitive form, a blockchain is an electronic ledger that promotes decentralized data, data integrity, network wide consensus on data, and high data availability. These important features of blockchain point directly to the current problems in healthcare which include data interoperability, the integrity and completeness of data, as well as the privacy of health records.

The exchanging and making use of data is especially important in healthcare today. There are many "walls" that block the exchanging of information between healthcare systems and facilities. Not only could the implementation of this technology tear down some of these walls currently stopping data interoperability, but also help identify when and where data is being manipulated.

Security of healthcare records is an obvious necessity. With this technology, the data cannot be hacked because the data is not there. To explain further, the data that is put onto the blockchain is similar to a receipt. It has a timestamp and hash value that verifies when and where the information was introduced or manipulated, but is only a pointer to where the actual records are. Only people with access to certain information will have the ability to see the actual records. An added benefit to this is being able to have separate access rights for different healthcare professionals.

3.4 Data Collection

New technology for data collection is constantly being developed. It has the potential to discover illnesses from monitoring a patient's values and to effortlessly communicate the results to the medical professionals.

3.4.1 *Drawable Biosensor*

A drawable biosensor [10] is a gadget which looks like a normal pen and is used for self-monitoring blood glucose. One problem an original biosensor faces is the high cost of the glucose stripes that are required to use the device. A drawable biosensor, on the other hand, can be used to draw 500 high-fidelity renewable sensor strips on the skin that measures blood glucose. The results from this sensor can easily be stored

on any bluetooth device. The gathered data can be sent to the doctor for analysis and the healthcare professionals can get easy access to the gathered data when the patient meets up for a physical meeting.

3.4.2 *Patient Status Engine*

The Patient Status Engine system (PSE) [35] makes use of wireless sensors that can be attached to the body for monitoring a patient's vital signs such as blood pressure, heart rate, respiration rate, oxygen saturation and on-demand electrocardiography (ECG).

The information from each sensor is then sent via Bluetooth [12] to a tablet-like device called the Patient Gateway [50], ideally located by the patient's bedside. The Patient Gateway displays the patient's vital signs in the form of real-time graphs, analyzes the data and finally transmits the information to a central database called a Lifeguard Server [38]. From here, the information can be displayed on any computer or mobile device that healthcare professionals have access to. By collecting data this way, a nurse can access a patient's status at all times and from anywhere. The PSE may also be directly connected to the hospital's own EMR for record keeping.

Using this system, a patient can receive a sensor upon arrival at the hospital before an operation to collect data about the patient during the day. When entering the operation room, nurses no longer need to hook up new devices for measuring and monitoring vitals, since the sensors are already attached to the patient. This will save time and reduce the need of equipment and cables, which hopefully results in a better working environment. A system like this would also be beneficial for the patient. After the procedure, when the patient is still in the ward for further monitoring, the same wireless sensor from the operating room can still be in use. This reduces the need for other monitoring devices that often demands physical connection between patient and device via cables (just as in the operating room), allowing more flexibility as the patient can move more freely while still being monitored.

3.4.3 *Skin-like Biostamp*

Most cars these days are equipped with sensors to detect problems such as low fuel or tire pressure. Before a problem arises, a warning alerts the driver. The same can be done for the human body, and biostamps could be the way to achieve this. Its design resembles a tattoo and is referred to as a "skin-like biostamp" [2]. It has the ability to constantly measure data, which can be easily accessed by a healthcare professional. Up until now, there are three different types of biostamps. One monitors the ultraviolet rays of the sun, another one uses the sensitive dyes to detect chemicals in sweat and the last one uses

electronic circuitry to measure blood pressure. During a normal visit to the doctor, the blood pressure, temperature and pulse will be checked and the patient may be sent to do further tests. All of these things can be done by the biostamps and the patient can directly do further tests without the initial checkup. The patient just need to show the doctor the measured data, which can be stored on a smart device.

3.5 Drone

A drone is an unmanned aerial vehicle, in other words it is an aircraft without a human pilot on board [75]. The steering of the drone can either be done remotely by a human operator, by computers that are located on board, or a combination of them. A larger drone can know where it is by using an inertial measurement unit which incorporates three-axis accelerometers and gyroscopes, together with a global positioning system (GPS). This is unfortunately not precise enough for a small drone that flies closer to the ground. A smaller drone therefore needs additional sensors that can calculate the distances to surrounding obstacles, e.g. vision cameras [94]. The Dji Phantom 4 drone can move up to 20 m/s [19], which equals to 72 km/h. Since a drone does not depend on things like traffic and roads, it means that they often can travel faster than cars for the same distance.

Drones are today used to give police a first view of a car accident. In Portugal, by using high definition cameras, the police can see the accident before arriving [88]. Drones could be used the same way in healthcare, by giving the ambulance a preview of the scene of the accident. This would be beneficial for example if an accident happens in a crowded area where it might be hard for an ambulance to find a way or if it is an accident if a forest for example, where it might be hard to find the person who needs help.

In emergency healthcare drones can be used to quickly get to people who are wounded or in any way need medical care. Several prototypes have been built and tested with this purpose. An example of this is the defibrillator drone developed by an engineering student in the Netherlands [5]. The drones are able to reach heart attack victims within the crucial first minutes after the attack and can bring a defibrillator to the site. To know where the patient is located, the drone uses GPS and tracks emergency mobile calls. Once the drone arrives at the scene, a paramedic can watch, talk, and instruct people that are trying to help the patient by watching the footage that is being transferred to the hospital through live stream webcam. Another similar application is using drones to find and help hurt and distressed swimmers [70]. The drone can carry a floating device such as a life preserver which can be dropped down to the person in need of help. Lifeguards will then see where the person is, and be able to come to the rescue.

3.6 Iris Scanner

Many technologies are utilizing devices that we already have access to. A company that is taking advantage of smart phones and other smart devices with cameras is Brightlamp LLC [78], a startup company started by a student at Purdue University. They are developing an app called Collide [60] that can utilize a smart device's camera to scan a person's iris and detect whether or not they have a concussion. Technology like this only grazes the surface of the possibilities of what we can accomplish in healthcare.

3.7 Speech Recognition

Speech recognition is when a computer identifies words and phrases in a person's speech and converts it to a machine-readable format. By using speech recognition during surgery reporting sessions, the process of documenting information would be severely cut down on time and stress. Instead of doctors and nurses manually typing and logging everything multiple times, the simple act of speaking into the microphone about what is currently happening will reduce time substantially both during and after surgeries. According to the Dragon Speech Recognition website [20], using speech recognition can be up to three hundred percent faster than typing, and with 99% accuracy. In the next ten to twelve years, there is a good chance these numbers could even be increased.

The technology in its current state does however have flaws that need to be considered. For one, the system can not distinguish accents. Every accent can not possibly be accounted for, so one that may not be speaking a native language has a hard time with the software distinguishing the exact words they said. Another issue along these lines is the problem with the way humans talk, we do not talk the way we write. Humans take pauses with sound effects or "fillers" to think or to further a conversation, for example: "uhh". We also speak in a colloquial manner, using simplified terms. For example: when saying "What are you doing?" we tend to break it down to say it faster, as in "whacha doin'?". The system has a hard time translating informal phrases and it takes time for the user to fix these issues in the report they are recording. Another problem with voice software is not with the system, but with the users handling it. Many people do not care for learning new equipment to work with, as they are content with what they have. They often refuse to use new technologies because they trust human eyes more than a program.

3.8 Smart Home

A Smart Home is a home that is equipped with sensors, cameras, and Internet of Things (IoT) devices that make the occumenpts lives easier. The ultimate goal of a Smart home is to control, automate and optimize functions such as temperature, lighting, security safety or entertainment [13].

3.8.1 *Today*

Today Smart Homes use sensors, cameras and IoT to make homes smart and interactive. For example Smart Homes of today use cameras and sensors to keep an eye on pets and loved ones remotely from another location via smartphones [62]. Instead of using a key, Chipster, a chip implant in your hand can be used to unlock your door [63].

There are also many new devices which can help you with your everyday tasks around the house today. For example a talking fridge from Samsung [55] could help purchase and keep groceries fresh. Another example, are smart thermostats that can control the temperature and adjust itself automatically to reduce utility bills when no one is home [72].

3.8.2 *Future*

Development of smart home technology is moving forward quickly and many advance features will be added between now and 2025. One of the features that was recently introduced is a virtual assistant called the Amazon Echo [4]. The Amazon Echo allows integration of voice control with all kinds of smart devices and IoT devices in a house. For example voice command can be used to turn off a lamp, start brewing coffee and even order prescriptions [1].

As more developers get involved with Amazon Echo's API many more devices will be available with voice control. AI could be integrated with Amazon Echo to provide patients with quick and accurate responses regarding their health questions. This part is interesting for the healthcare sector because this possibility could provide patients with better distant care or self-care. Instead of calling the hospital the patient could ask the AI what they can use to treat themselves.

Today there is research about the possibility that the smart home can monitor the patient's health [84]. Allowing homes to monitor patients is very interesting because it can provide critical data to healthcare professionals without intrusive wearables and chips on patients. A Smart Home could empower patients, help healthcare professionals make better diagnoses and reduce recovery times.

3.9 Radio Frequency Identification

Radio Frequency Identification (RFID) is a technology that uses radio waves to transmit electronically stored data. The technology works by using radio waves to send an interrogating signal and reading the response from the tag. The technology has been widely adopted for tracking inventory in a variety of industries. Passive RFID tags have been extensively used to track anything from livestock to clothing in stores. In healthcare, it is important to keep track of patients in the hospital setting. Not only could this keep track of patients, but could hold detailed information about the patient that can be scanned by healthcare professionals to gather data on the patient like vitals, previous and scheduled tests, and basic demographics for patient verification.

3.10 Tablets

During 2015, 77% of the Swedish population had access to smartphones [58] and 59% to tablets. The usage is declining with older generations but overall increasing [80]. The knowledge of how to use a smart device could therefore be assumed to be very good. By introducing tablets into the hospital environment for the patients to have access to, could solve a lot of the problems. Research has shown that 67% of the patients using smart devices to search for information on their own feel more confident in their care [86]. Compared to more non-technical sources of information, such as the doctor orally providing the patient with information, smart devices seem to be more efficient on providing the information with technical resources [91]. By using tablets provided by the hospital that include applications with accurate information, the patient could feel more secure before an up-coming surgery. The applications could include their medical record, a database to search for reliable information about your condition, and find FAQs.

The tablet can also be used for the animations and visualizations [42]. When the doctor is not present, the patient can scroll through the procedure at their own pace. The “patient tablet” can also make it possible to contact medical staff assigned to the patient and see their schedule. All paper work can be provided and signed through the tablet, which could be linked to their medical record. Introducing the “patient tablet” the patients could feel more empowered and be less anxious before entering the operation room.

3.11 Video Checkups

A way to close the gap between patients and medical professionals is to utilize applications like Skype [57] for in-home checkups that do not require the patient to be in a healthcare facility. This can also help with patients who may not easily be able to transport themselves or get transportation to simple checkups. Solutions like this are already in place, but have yet to be widely adapted. American Well [6] is a company that offers this service with an average waiting time of under two minutes [68].

3.12 Video Recording

One of the most consistent themes that were discovered from the interviews was that patients felt disconnected from their experience at the hospital, leaving them feeling without control. This could partially be because the patients are not provided with enough information. The usage of video recordings in the hospital environment could aid in well-informed patients, increasing patient empowerment.

3.12.1 *Wearable Cameras*

In order to allow patients to feel more connected and have more informed post procedure conversations with their doctors, the doctors can be required to wear cameras to capture the procedure from their perspective. The footage from these cameras would then be uploaded into the patient's medical files so they can review the procedure at their leisure. Patients and doctors would also be able to have more effective conversations because they are both starting the conversation with the same basic knowledge of what happened. The cameras being considered for implementation would be similar to body cameras that are starting to be used within police departments in the United States, according to a Los Angeles Times article [89]. There are articles from journals such as Medpage Today [79] that describe the potential benefits of using body cameras within operation rooms based upon correlations between doctors and police. The connections the articles make are based upon lawsuits and training for future doctors. While these are two very valuable and viable applications of the video, they are not the main point of this article.

The cameras could be used to record from either the doctor's face or head. In an article by American Journal of Ortopedics [87], it is suggested that there are two current technologies that could fit this application very well, Google Glass [27] and GoPro [29]. However Google has stopped development of Google Glass, thus it appears that GoPro would be the only option that could be viable. The video

camera could be worn by everyone within the operation room to ensure that every possible angle is captured. The audio and video files that were produced from all of the cameras would then be uploaded into the patient's medical files so they could review them. A benefit of this is that during the procedure the commentary between the doctors and nurses would help the patient understand exactly what they were looking at.

3.12.2 *Monitoring Cameras*

Cameras can not only record during operation, they can also keep track of patients in their rooms and efficiently collect data and vital signs from them. Oxehealth is developing a software [49] that analyzes data from video cameras to produce estimates of vital signs and other parameters, basically turning an ordinary camera into a health monitor.

The software checks for pixel changes in each video frame as a patient's chest rises and falls when breathing. It also tries to track small changes in the color of their skin, using this information to determine their pulse. The software also works in the dark, using invisible infrared lights in order to not distract the patient. The data is processed on a computer that is connected locally or over internet to the camera, with the vital signs then being transmitted to the electronic medical records.

By using something like Oxehealth, there is no need for all the equipment used today for monitoring vitals in the operation room, giving nurses more time for interacting with the patient. The question with a system like this that measures vital signs from afar without direct contact with the patient is its reliability. In a recent trial carried out by Oxehealth at Broadmoor Psychiatric Hospital in England [77], seven patients were monitored overnight in order to observe the software's monitoring accuracy. The software managed to correctly measure the patient's breathing rate to within two breaths per minute 94% of the time, while also correctly measuring the patient's heart rate to within three beats per minute with the same percentage. The trial also showed that being covered by blankets did not affect the accuracy of the measured data. This means that patients can be monitored at night while sleeping without having a nurse constantly doing visual observations by being present in the room, which in turn can reduce the risk of disturbance.

Except for Oxehealth, Philips is also developing a contactless system [93] for monitoring patient data using cameras, similar to Oxehealth's system. The main difference is that Philips camera based monitoring technology is first in the world to actually measure a patient's absolute oxygen saturation of arterial blood from across the room. This is done by measuring the amount of light reflected from patients' skin.

3.13 Visual Resources

Various visualization technologies have the potential to be used in healthcare by medical professionals and patients alike. It can help doctors prepare for surgery, medical students gain valuable experience through virtual practice, or empower patients by involving them further in their own treatment.

3.13.1 *3D-Visualization*

Helping to understand the preparation, rehabilitation, and how an operation is performed will not only give the patient more involvement in his or her healthcare decisions but also reduce stress and worry for the patient and their families. This can partly be done with 3D-vizualisation. Communicating healthcare information with the help of 3D-visualization is worth doing because it makes it easier to understand large amounts of information at once. Images can be processed much faster than text and 50 percent of the human brain is dedicated to visual functions. By having 3D-animation it is easier to concentrate on the meaningful details so that blood, for example, does not have to be shown and the patients do not have to look at authentic film material [42]. It would also be possible to highlight specific areas in the body that needs more attention. Since it is animated the need of a camera would also be reduced.

According to Sparksworks [59], 3D animations and visualizations have revolutionized the healthcare marketing industry since it makes it easier to communicate highly complex ideas or processes. Patient safety is also increased since it reduces the risk of incorrect preparation. The doctors and other healthcare professionals workload will be reduced and will therefore increase the productivity and profitability.

3.13.2 *Augmented Reality*

Augmented reality is the idea of displaying a computer generated image that changes a person's environment. An example of how this is currently used in the real world is with the HoloLens [44]. With the HoloLens, users are able to visualize 3D models overlaid onto the world.

Medical schools have even been adopting similar technologies to help train their students. Students are able to operate on people without having the risks of performing on a real person [56]. Since some medical schools have been adopting this technology, it would be good if the doctors are familiar with it to benefit the patient.

This technology would tremendously help the patient as the interviews found that patients would have liked more detailed information about what was going to be done to them during an operation. While

patients are able to look things up on the internet or ask their doctors detailed questions, they still identified this as an area where they would like to see an improvement. A remedy for this situation that was identified was having the doctor and the patient both wear glasses that are able to project images like in the augmented reality glasses described above. In this interaction, the doctor would be able to go through each step of the procedure so the patients can know exactly what is going to happen to them. This would require the doctor and patient to wear augmented reality (AR) glasses that are linked together so the image the doctor is seeing is exactly the same image that the patient is seeing, even though they are looking from two different locations.

With this technology, patients would be able to interact in a much more informed manner with their doctors. This applies to how patients interact with their medical records because within the current system the doctors merely write down procedures and talk through them with their patients. Patients are able to ask questions to their doctors but then once they leave the doctor's office, the only option they have is the internet. With augmented reality, the film from the patients and doctors interactions with the glasses could be saved and then uploaded into the patient's medical records. This would allow the patient to look back and review everything in case they are getting nervous, scared, or forget something the doctor is going to do.

3.13.3 *Virtual Reality*

Virtual reality (VR) is an environment created by a computer that lets you experience a different reality [67]. It may be a powerful tool for healthcare. It has been tested in several different fields and has proven to be successful in many of them. Since the cost of VR devices is going down [71] due to an increasing amount of companies creating new devices, it could help hospitals to save money in their acquisition.

VR is a good technology for teaching future doctors and nurses procedurs, for example it gives the student an interactive 360 degrees view of the operating room. According to The Guardian [82], doctor Shafi Ahmed has tested VR in the operating room to share his experience with whoever is watching. Dr. Ahmed had earlier tried augmented reality (section 3.13.2) with Google Glass [27], but said that the 360 degrees with VR gives students the opportunity to see what other people in the operating room are doing, for instance nurses. VR also gives students the opportunity to hear the types of sounds that occur in the operating room.

Using VR is a way to teach medical staff procedures that is not often used. According to Dr. Narendra

Kini, CEO at Miami Children's Health System, the retention level a year after a VR training session can be as much as 80%, compared to 20% retention after a week with traditional training [83]. Using VR as a teaching device actually creates memories for the viewers. It is also economically beneficial to use VR for training procedures that before could only be trained on live people [83].

VR could also be used to educate patients. By using VR to let patient see the results of taking care of themselves, it can give them the motivation needed to make the change [76].

Furthermore, VR has been proven successful as a pain reliever in healthcare. According to BloomberTechnology [85], MRI-scans [39] showed that when using VR, the brain registered less pain. By swamping the brain with sensory input, the ability to process pain lowers. This has been used for both children and adults, and the result has been so good that several patients with chronic pain bought their own VR-device.

Virtual reality can also help patients who have to stay in the hospital for a long period of time. One example is someone waiting for a heart-transplant: using VR was something that made the patient relaxed and made the hospital stay for the patient more enjoyable [39] [71].

4 The Cancer Scenario

Cancer is a disease that comes in many different forms and it affects not only the person who is sick, but also the patient's family and friends. This scenario will present a patient with lymphoma and their journey through the current healthcare system and what it could look like in 2025. The goal of the cancer scenario is to highlight the procedure surrounding a disease with a lengthy period of diagnosis, treatment and recovery.It is important to note that surgery is not generally the chosen remedy for lymohoma but we have selected it for it's illustrative purposes.

4.1 Today

4.1.1 *Before Hospital Visit*

Before discovering the presence of cancer, the patient lives a normal life. While performing daily activities, the patient may discover symptoms that cause concern in regard to their health, including swelling of the lymph nodes, persistent fatigue, fever, or weight loss which are symptoms of lymphoma. The patient decides to call 1177 [18], a medical care guidance organization that gives advice over the phone. Should their symptoms be of enough concern, the 1177 operator may suggest making an appointment with the patient's primary care physician.

4.1.2 *During Hospital Visit*

If 1177 recommends they visit a doctor, the patient will contact their primary care physician, where the staff makes an assessment of the patient's symptoms, enters provided information into the patient's journal, and decides to make an appointment with a doctor. The maximum waiting time for a visit in primary care is seven days in Sweden according to the "health care guarantee" [69].

This appointment starts with the nurse collecting information from the patient verbally and through questionnaires. From here the nurse can take time during the appointment to enter the data into the system or wait until afterwards and enter it from notes or from memory. If the examination shows signs of cancer then the doctor sets up an appointment with a specialist. The doctor at the primary care provides the referral, and is also responsible for deciding the urgency of the upcoming appointment. The waiting time to see a specialist can vary depending on the doctor's assessment, but can not exceed 90 days according to the "health care guarantee".

The specialist conducts MRI or CT scans at the hospital to locate the unhealthy cells. The waiting time for the results vary from patient to patient [15]. The results may be delivered to the patient during the same visit if the specialist considers the situation to be severe enough, but they may also be delivered within a few days. After getting the results, the patient has to wait for a new appointment where a PET scan or biopsy will be performed to determine what the appropriate treatment is. A specialist uses the information to decide the appropriate treatment. For the purpose of this scenario the appropriate treatment is surgery. The prognosis is shared with the patient who now has to wait for the next appointment.

After the patient has arrived at the hospital for surgery, the patient must wait until the nurses have cleaned the surgery room, prepared all the tools needed for the operation and the dosage of medications and injections for the patient. During the operation, one nurse takes notes on the doctor during surgery. The notes are taken by hand and copied or written directly to the system, so that every step of the operation is documented. The doctor performs a voice recording which will be transcribed by the nurses after the operation. The vitals of the patient will be checked by a post operation check up, and the doctor has to sign the notes which were taken during the operation, to ensure they are correct.

4.1.3 *After Hospital Visit*

Afterwards, the follow up care for the patient begins. The patient attends checkups every three to six months, to make sure the cancer did not come back. At these checkups, the patient has physical exams, blood work checked, imaging by CT, and possibly several other tests [23]. The medical professionals set up future appointments and decide which medications the patient needs and schedules when the medications should be taken.

4.2 2025

4.2.1 *Before Hospital Visit*

The patient discovers symptoms that cause them to question their own health and they call 1177 [18] to receive a professional opinion. Upon hearing the symptoms, the medical professional concludes that they could be symptoms of a more serious condition. The patient is advised to use an online application where their medical records and other healthcare information such as price of healthcare services or prescribed medicines are found. The application provides a tool for setting up virtual appointments through a video

call with a medical professional from the comfort of the patient's home. The patient enters information about the reason for his appointment. This provides background information for the doctor to help with diagnosis, without having a nurse being held up with gathering the information through questionnaires. When the doctor is ready, the virtual appointment begins. The waiting time for these appointments are often as low as a few minutes, and the travel time is a non-factor since it doesn't take more than an internet connection to get access.

When the doctor considers cancer as a possible diagnosis, a referral is provided for the patient to see a specialist at the hospital for a more thorough examination.

4.2.2 *During Hospital Visit*

A MRI or CT scan is used at the hospital to locate the cancer cells. These results are delivered within a few days and occasionally during the visit. Following the results, a biopsy or PET scan is performed to determine the state of the cancer cells. The option to communicate with healthcare professionals online is often of great benefit, however it may not always be optimal. Receiving results for a serious condition, such as cancer, is one of those cases. These tools are designed as a supplement to be used in cases where it improves healthcare, such as decreased waiting time or for people who have difficulty leaving their home. Being able to see a doctor for any reason should always be a possibility.

Being diagnosed with cancer is scary and confusing. It is hard to know what to think and what questions to ask while receiving the diagnosis. The time between hearing the results and having the surgery is an opportunity for reflection and time to cope with the news of a possibly life-threatening disease. A lot of questions arise during this time and the patient needs a reliable source of information. The same application that was used for the virtual doctor's appointment also offers a function in which the patient can chat with a doctor and receive answers to any of their questions. Since the chat feature is always available, there is no need to write down a long list of questions to bring to the hospital at the next visit. Whatever questions the patient may have can be answered quickly, resulting in a patient that is more aware of the their own health and have a more satisfying experience.

Educating the patient and their family on the preparation process, operation, and rehabilitation program will result in an empowered patient who is more confident. Communicating health care information with the help of 3D visualization [42]. is a way to understand large amounts of information at once. Images can be processed much faster than text and half of the human brain is dedicated to visual functions [42]. By having 3D visualization, it is easier to concentrate on the meaningful details. The blood for example

would not have to be visualised and the patient does not have to see actual footage from a operation; which could be terrifying [42]. The visualisation could also highlight specific areas in the body that needs more attention.

When planning a surgery, doctors peruse over documents and test results to discover any problems that may impact the operation. Providing better tools and information to the doctors during the planning phase would increase the doctor's confidence when operating on the patient. Augmented Reality (AR) (section 3.13.2) will play a large role in this area. Doctors will be able to wear headsets, such as the Microsoft HoloLens glasses, that can overlay information and potentially highlight certain areas of the patient's body. During the planning phase, doctors can walk around patients and see results from tests such as a PET scan or CT scan highlighted on the patient themselves.

Surgery demands extensive documentation during the procedure. A speech recognition system is used in the operating room to gather information from the medical professionals as they perform the surgery (section 3.7). Having a computerized system that handles this frees up nurses to perform other work that requires a nurse attending, instead of taking notes during a potentially long operation. With this technology, the surgeon simply speaks and notes are automatically taken and entered into the EMR system. This technology is considered relatively reliable, however considering the importance of the notes being correct, the doctor should review them after the surgery to make sure they are accurate (section 3.7).

Moreover, the surgery is monitored by cameras in order to view everything that is happening. This footage could be used later for viewing how the surgery went for example, it could also be used for educational purposes. The cameras in the room monitor the patient and look for changes in his vitals and record the staff's work (section 3.12). Doctors in the surgery will also wear cameras so the film can be viewed by the patient, or put up on pages like Medfilm [42], where patients that are going to have a similar surgery can research prior to their operation.

4.2.3 *After Hospital Visit*

After the patient's surgery is complete, he is delivered to a postoperative recovery room. Here, the patient can use tablets to review their operation and ask questions as necessary (section 3.10). The cameras mentioned in the operation room will also check the patient's vitals so nothing dangerous or fatal happens while doctors and nurses are out of the room (section 3.12.2).

Checkups are needed every three to sixth months after the surgery to make sure the patient is recovering well. As the absence of cancer cells is not enough to be declared healthy, the checkups are needed even

if the cells look healthy. The patient needs physical exams, blood work, imaging from CT scans, and several other tests if needed. Some of these require a hospital visit, but others are simple enough for the patient to do at home.

There will be a possibility to see some results from check ups online where the patients and medical professionals can discuss the results. It is important for the online results to have descriptive information so the patients understand the results. If the values show there is low risk for cancer or if the values show that further analysis is needed, the online source should say what might be the cause [Interview4]. A patient should not need to worry unless he or she has to, because sometimes if the online results show that further analysis is needed, the cause may not be the cancer returning.

Further on, having reliable information is crucial since there are numerous things to keep in mind for the patient during rehabilitation. During and after treatment a patient needs to know what the next steps are in their recovery. Is it possible to meet with a counselor, why is it important to do the exercises that has been instructed, if there are problems getting back to work how can the patient get help? These questions can be answered by providing the opportunity to send questions to an expert team at the hospital that can answer possible questions or by having a website where patients can post their questions to be answered by professionals. Some patients have a harder time than others asking for help so it should be possible to be anonymous [Interview4].

5 The Diabetes Scenario

Diabetes is a disease that comes in two forms, type 1 and type 2 [37]. Type 1 is hereditary and type 2 you develop due to bad habits. Diabetes is characterized by high blood sugar caused by reduced production of insulin within the body, inability to release insulin when the blood sugar is high, worsening insulin effect on target organs, or a combination of these causes. This scenario will present a patient with type 2 diabetes. It is understood that type 1 and type 2 diabetes differ in how they are diagnosed, but this scenario proceeds with type 2 diabetes because most of the identified solutions apply to that scenario. This scenario will be a way to show how we in the future can be able to detect, cure and live with a disease such as diabetes.

5.1 Today

5.1.1 *Before Hospital Visit*

Type 2 diabetes typically presents itself with symptoms of excessive thirst, urination, or constant exhaustion. This type of diabetes is the most common, approximately 85% of all people suffering from diabetes have type 2 diabetes. Usually, middle aged people suffer from diabetes, but it can also affect younger people [54]. Obesity is a common cause of type 2 diabetes, which can be attributed to an unhealthy lifestyle [37]. Today diabetes often remains undiagnosed, which can be hazardous to the patient's health [81].

5.1.2 *During Hospital Visit*

If a patient has the symptoms mentioned above the nurse or doctor might suspect that they have diabetes. There are different methods to test for diabetes and all of them involve checking the level of blood sugar during a period of time. Either blood and urine from the patient are needed to do these tests [18].

If a patient is diagnosed with type 2 diabetes, the patient will often be scheduled with a diabetes nurse at a local clinic. In this meeting the patient gets overall information about diabetes,and what to do in order to improve the patient's health. During this meeting the patient has the opportunity to ask questions and get advice about community groups for people with diabetes. It is also common that the patient borrows a blood measure device so that the patient can check their blood values at home and see how the glucose level is affected by different diet and exercises [Interview3]. During this meeting the the patient is

often introduced to the possibility of sick leave for during 1-2 weeks in order to learn about blood sugar measuring and adapting to a new lifestyle.

5.1.3 *After Hospital Visit*

By understanding the needs of the human body and how to keep the blood glucose levels stable, diabetes can be managed properly [24], yielding a treatment that often can be customized to fit a person's habits and routines. Therefore, many patients can continue living a normal and active life even after their diagnosis [24].

For type 2 diabetes, the main focus is instead directed towards the patient's lifestyle [18], and what oneself can do to manage the disease. By exercising, eating healthy and quitting smoking one can often prevent and, to some extent, lower the body's blood glucose levels. Daily exercise is namely one of the most effective ways to increase cell sensitivity to insulin [18]. By increasing this sensitivity, the cells will extract the sugar found in the blood after eating much faster, and keeping healthy blood sugar glucose levels becomes easier. This improved effect on insulin sensitivity after a workout, such as cycling for half an hour, can last up to two days. Healthy eating habits can also have a huge impact on type 2 diabetes. With a diet that avoids unnecessary sugar, one can stabilize blood glucose levels, improve cholesterol levels, blood fat amounts, lose weight, and reduce the risk of other diseases. It may feel like a big step to change one's eating habits entirely, however, one only needs to focus on excluding or including a select amount of foods. The traditional plate model is often a good guideline [32].

Even though patients diagnosed with type 2 diabetes have greater control over the disease, it is not always the case that exercising and healthy eating is enough for maintaining stable blood glucose levels [40]. Drugs for controlling blood glucose levels may be a necessary part of the treatment early on, but it may also take years before they are needed. As the body's ability to convert glucose into energy becomes less effective with time [40], these drugs are often replaced with insulin dosages eventually for many with the type 2 diagnosis.

Due to the different needs of the patients, a key part in today's treatment process is the constant interaction and communication with healthcare professionals in order to find a treatment plan that fits each individual. In addition to annual visits at the hospital, where the patient meets their doctor responsible for treatment for discussing the situation of the disease and taking blood and urine tests, each patient has direct contact to a diabetes nurse who can answer any questions about the treatment process [Interview3]. This interaction with healthcare professionals is crucial for helping the patient understand the disease

and how a patient can affect their own situation, but they also provide support, encouragement, and advice on how to handle different everyday life situations.

Today, different applications are used for communication between patients and nurses. For example, Akademiska uses an application that can manage this contact online, called Diabetes Dialog [17]. The application is primarily intended to be used by younger patients with the type 1 diagnosis as a tool for establishing a better contact with the health care in ways that suits their needs and schedules. Patients can use a mobile or web application to book online meetings with a nurse and directly use the application to either chat or make a video call. A nurse can suggest open times for the online meetings, and also take notes in the application during the actual video call. After the meeting, the notes and a summary about the meeting will be saved for the patient and the nurse to access later. These virtual conversations can be seen as complements to the annual hospital visits, and allows for medication to be quickly adjusted if necessary. With flexible solutions, the patient can get help faster if needed. This solution has been implemented based on patient's and healthcare professional's needs and highlights the importance of flexible communication.

There exists different types of applications and technologies for assisting people with diabetes today. As mentioned before, there are, for example, pumps for drawing out insulin automatically [34]. There are also applications that can help with diabetes management. Some can help the patient keep track of their medication while others help the patient keep track of the food they are eating. An example of an application that helps people with diabetes is called Triabetes [66]. It helps you keep track of your food, exercise, and insulin levels. These applications for tracking food and lifestyle behaviors are important for patients living with type 2 diabetes.

5.2 2025

5.2.1 *Before Hospital Visit*

In the vision for 2025 all patients leave a DNA sample at the hospital. Experts would be able to look at the patient's DNA and the patient's family history regarding diseases. This method helps the patient and the hospital in monitoring possible diseases the patient might develop. Patients with a hereditary gene containing diabetes would find this type of monitoring useful. Both the patient and the healthcare professionals have information regarding which diseases the patient can be prone to develop.

A smart home (section 3.8) can help the patient monitor their own lifestyle and thereby decrease the risk of

diabetes. As an example the kitchen in the house can control the food and order groceries automatically. In order to motivate and help the patient develop and maintain healthy habits, the smart home can provide the opportunity to join different groups within the community. For example, it can be a group of people with the goal of losing weight or with the goal to quit smoking cigarettes. If the patient is already in the early stages of diabetes, the home can also help the patient to find a group in the same situation. These people can help the patient with questions and calm their his or her worries.

To monitor the patient's health status, a small device, the size of a computer chip, can be implanted in the arm of the patient [65]. This device constantly analyzes the blood, hormones, and other relevant things and sends the information wirelessly to a storage device. This chip scans for, among other things, the diseases that the patient might be prone to get. The illnesses that the device scans for is decided by both a doctor and the patient in collaboration.

In the future homes can be equipped with smart home technology which will monitor bodies with advanced technology for preventing illnesses and other body related issues. The small device mentioned previously is connected to the smart home belonging to the patient. If there are any vital changes in the patient's body the device notifies the patient via the house or another device. There could be an urgent message in a mirror the patient is standing in front of for example.

The device suggested could be particularly useful for a patient that does not realize their own risk of diabetes. An algorithm that can tell whether or not you might be in the early stages of diabetes can be used on the data the device wirelessly sends. If there is a risk that the patient might be in the early stages of diabetes then a hologram can appear in the patient's smart home. The hologram is going to inform the patient about the disease, the consequences of diabetes, and how the patient can further prevent diabetes. The hologram system would have similar functions as Apple's system Siri provides. The patient can ask questions to the system and get an answer. If the hologram does not have an answer to a question the patient will have the opportunity to call the hospital or schedule a meeting at the hospital.

5.2.2 *During Hospital Visit*

Diagnosing Diabetes

In the future there will be devices that prevents a patient from ending up in an emergency room due to symptoms caused by diabetes. smart homes can be used in order to detect early stages of diabetes. For example, each time a patient visits the restroom, the smart toilet can take a urine sample and test for irregularities. The smart toilet would only take samples from people living in the household, and it is

optional each time the patient visit the restroom to take a test or not. In other words, the toilet needs to be able to identify the person. This is connected to your medical record and gives the patient and the patient's doctor a notification if there is any indication that you might have diabetes. The smart home is also able to capture the entire clinical assessment of the person. The clinical assessment are factors that contribute to diagnosing diabetes, such as age, weight, and other diseases.

A smart home could detect whether or not you might have diabetes, but deciding which type of diabetes it is can be difficult even for the doctors to determine. Self testing could in this case be used as a way of determining which type of diabetes you have. In the future the patient would be able to buy these self tests at their local pharmacy.

Information both from the smart home and the self test could be added to the patient's medical record. Then the doctor or the nurse together with the patient can book an appointment to discuss the next steps. Depending on age and the severity of symptoms the patient might need to stay at the hospital to be evaluated.

Explain Illness

When a patient arrives to the hospital before a treatment of their illness, there are a lot of insecurity and questions that need to be answered in order for the patient to feel more secure. Our research has shown that technology could help solve this matter. Throughout the interviews, patients expressed anxiety or curiosity for knowing what is going to happen with them during their stay. Except for a few interviewees, all the patients wanted to receive as detailed information as possible about their current state. Another issue found during the interviews were that the doctors are often using medical terms that could be hard to understand and some of the interviewees were scared to ask clarifying questions [Interview6] [Interview7] This problem seems to depend on how much you already know about your own body since some of the interviewees did not express the same anxiety [Interview8] [Interview9] Some other patients did their own research on Google to see if there were some things they still needed to have clarified [Interview8]. While waiting for their scheduled surgery some of the interviewees thought it could be a good opportunity to read about the approaching procedure and found answers to their questions by themselves [Interview10]. Even though most of the patients needed more clarification on information, they all felt that they could trust their doctor, both in giving them correct information and that they are introducing correct notes into their medical record. The anxiety and curiosity seems to depend on not being able to comprehend the information and not having the courage to ask the doctors. The people interviewed in this case did believe that technology could help them solve these matters and were not foreign to use it.

5.2.3 *After Hospital Visit*

Self Monitoring

One important element of the diabetes management in 2025 will be the self-monitoring; which is already part of today's treatment. In the future a patient centered care and technology can ensure that measuring health related data can be simpler and less intrusive. Patients would have the opportunity to see their blood sugar values, or these values could be checked automatically. There could also be technology which helps the patient to automatically regulate their insulin level. The current solution to this is very expensive and is visible on your body [48], although in the future this technology could be simpler and more affordable. In order to prevent careless behaviour by the patient when using the device which will regulate insulin automatically, it is important that the blood sugar level and the injected doses of insulin are collected and reported to the patient's nurse.

In the future sensor technology will radically influence the way patients measures themselves. Today tattoos [45] and contact lenses [28] are able to monitor someone's blood glucose level. Based on this trend, we can assume that self-monitoring will be done by even smaller and less visible devices in the future that do not require the user to interact with them at all. This new technology can also result in special wearables such as clothes or jewelry that will be able to measure blood sugar levels for example. There solutions could make self-monitoring not only less visible but also more personalized.

Data Communication and Connection

Automatic measuring of data needs to be simple and not visible in order to make diabetes management more patient centered. The data that is collected needs to be analyzed and communicated. Measured results can directly be added to the patient record in order to have relevant data. When collecting data it is also relevant to know what caused for example a spike in the insulin levels, for example the data could tell you that the spike in the insulin levels was caused by something the patient ate.

If all the data a patient generates is sent to healthcare professionals there would be an overload of irrelevant information. There are also ethical issues connected to the data a patient generates. Filters needs to be added between the collected data and the healthcare system in order to solve these problems. Artificial Intelligence (AI) (section 3.1) can be used in order to evaluate the collected data.

An AI would work as a layer between the patient and the healthcare system. The AI would be able to both access information from the patient's medical journal as well as personal data from the patient, such

as meetings in the calendar and information the smart home (section 3.8) has collected. This would help the AI create a full assessment of the patient's life without making the information visible to anyone. This would ensure that a patient's private information stays private, and thus ensuring a more ethical healthcare.

Healthcare professionals would only be informed about, via the AI, the relevant parts of the patient's data. Data that could help doctors diagnose a disease could be an example of data the AI would inform about. If the AI would detects an emergency, such as the patient has too low blood sugar, it could immediately alert the hospital so that help can arrive. The information the AI will display needs to be easy for the healthcare professionals to understand. This could be done by for example providing an overview of the important changes in medication or changes in the patient's behavior that might influence their health.

Communication

Having information about the patient's health status collected and filtered allows a more informed interaction between the patient and medical professional the nurse or doctor. This also allows for different, more flexible and easier to personalize ways of communication by using different channels and services.

Scheduling meetings can happen automatically based on the patient's situation or can happen based on a demand from the patient, doctor or nurse. In some cases the patient need to have different tools that provides direct access to healthcare professional. This could be done by using communication channels such as chat systems. A patient could also have the opportunity to talk to an AI via a communication channel. This could be done by using for example chatbots [22]. Since the AI will have access to all stored data it can either answer the patient's questions directly or connect to the responsible nurse, doctor or emergency. Predefined answers can be used for frequently asked questions, with the possibility of answers being personalized based on the patient's data.

Education and Avoiding Stigmatisation and Education

Both young and old people can get diabetes, but the goal is that they will still be able to live a healthy and normal life. In order to live a normal life the diabetes should only be a very small part of their lives. It is also important to avoid the stigmatization surrounding the disease. Not being stigmatised can help with coping and managing the diseases as well as preventing it by allowing an open communication about it.

In the section (section 5.2.3) there are examples of technology which would enable discrete automatic monitoring and medication. This would help reduce the stigmatization of diabetes since people would not be able to see whether or not you have diabetes. This technology would also allow patients to have a life without constantly checking their blood sugar and planning their diet.

Making education regarding diabetes easy and accessible for school and work would help improve the everyday life of a diabetic. Videos could for example be shown in class in order to let the patient's classmates get a better idea of what diabetes is and what to do if anything happens. People close to the patient with diabetes also need education regarding what it means to live with someone who has diabetes. Virtual reality training sessions [47] could be used in order to educate family and friends. By using virtual reality they could for example learn what to do in the case of an emergency, the player could go through different scenarios and practice different situations.

Improving the Patient's Life Style

People with type 2 diabetes might not even need to take any medication if they can maintain a healthy lifestyle where they eat healthy and exercise. Food and exercise trackers can be used in order to help the patient maintain a healthy lifestyle. Since it is tiresome to write everything you eat and do to exercise a future solution could be to have devices that could gather this data for the patients. These devices could also give suggestions as to what the patient could improve and in that way further help the patient maintain a healthy lifestyle.

The introduction of the smart homes (section 3.8) could also help the patient with living a healthy life. Smart homes can help gather data about the patient, resulting in more detailed information which can be used to motivate the patient and give better suggestions for improving the patient's lifestyle. For example a dog owner could get the suggestion that longer walks would improve their health or someone who loves watching soccer could get a suggestion of local soccer teams they could join. A patient's eating habits could also be improved with the help from the smart home. The fridge could for example help you by giving you ideas of healthy food you can make with the groceries in your fridge.

Augmented reality (AR) (section 3.13.2) could also be used to help a patient with diabetes. With AR the patient could get more detailed information about what they are eating and how this affects their blood glucose level. Using AR in for example glasses or even in kitchen devices could be a good way to integrate this information more seamless into their lives.

6 The Head Trauma Scenario

Head trauma is a serious injury often inflicted by an accident. Several different issues can occur after head trauma, which affects and changes not only the daily life of the injured person, but also their family and friends. This scenario will highlight the improvements that technology can bring to the emergency care and the patient's daily life after the injury.

6.1 Today

6.1.1 *Before Hospital Visit*

When an accident occurs today, like someone falling and hitting their head, not much can be done except calling for emergency help. Once the injury occurs, the person remains on the ground while waiting for the ambulance. For bystanders, it can be difficult for them to know what to do to help the patient. It can be tempting to try to help the person by moving them, but the patient should not be moved because that can exacerbate any associated neck injuries and cause a chronic disability [30].

The ambulance arrives and emergency personnel perform first aid on the patient. They monitor vital signs and stabilize the patient's neck, if the patient is unconscious the paramedics check for signs of brain damage.

6.1.2 *During Hospital Visit*

The ambulance staff will rush the patient to the hospital as quickly as possible. Once at the hospital, the patient will be taken to the emergency ward and since they were taken to the hospital by ambulance they will get an examination room immediately. Here the patient will wait for the examination to be carried out by the medical staff. In this scenario the patient is still unconscious and the medical staff will exercise more caution in checking pulse, breathing, and measuring blood pressure to make sure the patient is stable.

Since the patient was hit in the head it is important to make sure that there is no intracranial bleeding. The patient will therefore get transferred to the radiology department where a CT scan can be performed. In the CT scan the medical staff can investigate if there are signs of bleeding in the head. If this is the case the blood has to be removed to ensure that the damage doesn't get worse. If the blood is not removed there is a risk that the patient will never wake up again. The blood can be removed in the operation

room by a neurosurgeon. The surgeon will drill holes or remove a small part of the cranium to dispose the blood and decrease the pressure in the skull [61].

After the operation is complete the patient might be hospitalized for a substantial amount of time. The patient will receive information about their condition mainly from the medical staff. If the patient would like to get more information about what happen while they were unconscious, it is possible to use the internet to access their medical record. It is also possible to search for more information about their condition through the internet. Once the patient has recovered from the operation he will be able to go home.

6.1.3 *After Hospital Visit*

When the patient comes home from the hospital the work of adjusting to everyday life begins. Head trauma affects the whole family. But for the individual who has suffered the brain injury, it is important for them to regain their independence.

When someone has suffered head trauma, changes have to be made in the patient's everyday life. This could, for example, include adapting the patiet's house; they may need to remove the doorsteps in order to prevent the patient from falling. After head trauma, a patient could show several symptoms such as loss of mobility, difficulty to communicate due to damage to the brain, memory loss, fatigue and problems with taking in new information [Interview2].

Rehabilitating working memory [8] takes a lot of therapy and may not always be achievable. To get through their daily lives, patients often compensate by using other people around them for help or finding new ways to manage their daily tasks. This is often achieved by working at a slower pace and acquire information in new ways.

Patients who suffer from head trauma often have a lot of contact with different authorities and the hospital. It's sometimes hard for people with head trauma to schedule appointments, to understand the rules, and to contact people that can help them [Interview2]. There are several different tools that can be used today to help someone who suffers from head trauma. Some tools include:

Apps To help with scheduling

Several apps exist today to help someone who suffers from head trauma to schedule their time. However, these apps are often too complex for someone with head trauma to use. The apps often have too many steps, and are hard to use [Interview2].

Assistance

People who, after head trauma, suffer from a disability so severe that they have a hard time moving, often get help in the form of personal assistance.

6.2 2025

6.2.1 *Before Hospital Visit*

When an accident occurs, it is important to help the victim quickly. Sometimes there are no people around to help someone in need, and because of this it is important to find other ways that don't depend on someone to call for help. If there are people around, it is important to utilize these people until the ambulance can arrive.

A wearable makes it easy to know when someone falls and needs help. First, it can vibrate to check if the person is fine, if so, it can be disabled. When the wearable doesn't receive a response it will produce a loud sound to either alert the person wearing it, or if unconscious, the people around the person. It will also send an alert to the emergency number with the location.

A wearable could also notify the family in case of an emergency, instead of forcing the hospital to identify the patient and to notify the family, the wearable could notify the family about the accident and let them know that the emergency number has been notified. One example where an application alerts relatives during an emergency is Not Alone [46]. The app sends out a text message with a map and coordinates to emergency contacts when the earplugs are pulled out from the AUX connection in the phone. Similar technology could be used to alert relatives or emergency contacts through a wearable.

Wearables could also gather information about the patient before they arrive at the hospital. Information like identification, blood type, and heart rate could be provided before the patient arrives. Several devices today can measure heart rate, like Microsoft Band [43] and Apple Watch 2 [7], but they are not used by healthcare. A pulse is critical information in regards to first aid and understanding the correct action to take.

Since the first minutes after an accident can be very important, they have to be utilized as effectively as possible. It is impossible for the ambulance to arrive faster than it already does without connecting it directly to the city's traffic systems to clear a path before the ambulance actually gets there.

Quick responses are essential, drones will therefore be dispatched immediately to the accident site in order to get an overview of the situation. This is especially important in cities where, due to traffic, it

might take much longer for an ambulance to reach a location than a flying drone. It's also important in situations where an ambulance might have trouble getting close to the patient, like in a forest.

The drone can carry important first aid equipment, and fly to emergency situations before the ambulance gets there. Through the drone, a person trained in medical procedures could help nearby people and guide them in giving first aid to the patient. This is a way to utilize people around an accident before the ambulance arrives.

As a complement to drones, victims of accidents could alert people trained in first aid or medical fields who are nearby. This already happens, for example, in the Netherlands when quick reanimation is needed [21]. People who are trained in reanimation or first aid can get a message on their smartphone when someone in their area requires reanimation, this message also tells the respondents where they can find an automated external defibrillator if they need it. The people who signed up for the service are then notified automatically by the call center for the emergency telephone number.

6.2.2 *During Hospital Visit*

Once the patient arrives at the hospital it is important to inform close relatives or friends about what has happened. In the vision for 2025 each patient will already have submitted a list of people they would like the medical staff to contact if something would happen to them. This could be a partner, parent, close friend, or other relative. When the patient in this scenario arrives at the hospital, a message can be sent to the people on the list saying that there has been in an accident and the patient is currently at the emergency ward. During the patient's entire stay at the hospital, relatives can be updated through these messages. The message could be about where the patient is in the hospital and how they are doing.

Another way to help in making the process run more smoothly is to use wireless sensors that keep track of vital signs from the patient. The sensors are connected to the Patient Status Engine system [51], mentioned in the findings, where the medical staff can monitor information such as blood pressure, heart rate, respiration rate, oxygen saturation, and on-demand ECG. This monitoring ensures that the doctors and nurses will be informed all the time of how the patient is doing. If the patient starts to get worse the nurses and the doctors will know immediately and be able to give the patient more assistance [16]. These sensors can also be implanted into the human body with help of new biotechnology devices. This can be useful if the patient would have to spend a long period of time in the hospital. One of the strong advantages of having wireless body sensors is that these can also be used in the operation room. This will save time and reduce the need for equipment and cables in the operating area, resulting in a better

working environment.

Another objective for the 2025 vision is to make it easier for medical staff to keep track of where the patients are. To solve this, the patient will have a barcode or RFID tag incorporated in the wristband they get when they arrive at the hospital. When a patient arrives at a new ward the nurse will scan the wristband to give the system information, for example that the patient has arrived to this specific ward. It will then be possible for another nurse, e.g. an operation nurse, to see where a patient is located if they need to find them. Only the nurses that are related to the care of this patient will be able to use the location system. This is to make sure that this system is not abused.

Once the patient wakes up, it is essential to make them feel as comfortable as possible. It would be ideal if they could feel at home even if they are at the hospital. This can be done by, for example, letting the patient listen to his favorite music in his room at the hospital or to use different fragrances to make the surroundings feel more peaceful.

6.2.3 *After Hospital Visit*

As mentioned before, the focus of this section is on recovery after head trauma. In the future,complications of head injury will most likely not change. What would/could be subject to change however is the rehabilitation process, hopefully improved. The future of the recovering patient has been divided into two different parts. The first section is how the home will become the patient's assistance, and the second, how the patient will handle obstacles in daily life.

Indoors - At Home

As explored in the challenges of recovery from head trauma today, the patient would want to contact the hospital for various questions. In 2025 the direct interaction with doctors within the healthcare is going to be less frequent than it is today. Instead of receiving most of the help from the hospital, the patient's house is going to assist the patient. The focus is going to improve the self care treatment and decrease the daily interaction with the hospital. The smart house is going to be voice-controlled [84] and the patient should be able to get feedback from the smart house at any time. In the case of the head trauma resulting in a speech impairment, similar technology that is being developed for ALS patients [64] could be implemented. The main point is that we want to reduce the screens and text in the patient's life. Think of the house as an assistant for the patient as well as a handy tool. The system would have similar functions as Apple's system Siri has. The patient will ask questions to the system and get the

answer. If the system can not answer the system the patient can chose between to either call the hospital or schedule a meeting there.

In the case that the patient has been in an accident and has suffered head injuries resulting in difficulties in movability and communication. The main focus is to facilitate the daily life for the patient. The smart house is going to be vital tool for the patient.

To make it easier for patients with mobility issues, the smart house is going to handle the kitchen and order food ingredients automatically. The fridge keeps a record of what food ingredients it contains and can order more when necessary. The food ingredients are home delivered by food companies [41].

This smart house should adapt to the patient. It could give a lot of assistance in the beginning of the patient's recovery process. The patient mandates the level of interaction with the house and the patient should also have the ability to completely turn off the system.

Outdoors

To help transport patients to the hospital, they can offer ride services. The car would be an electric self-driving vehicle that could look similar to the Kenguru Electric Car [36]. To hail a car, the patient would contact the hospital and the car would drive itself to the patient. The positive aspects of this car is that it doesn't require a driver and runs completely on electricity. The car could be used for daily tasks, such as visits to the hospital or going shopping. Providing the means of free travel to the patient who might have lost their ability to drive could make all the difference in the patient's life. Having easy access to the outdoors will improve the patient's outlook and quality of life.

Conclusion

Through the use of the three scenarios, cancer, diabetes, and head trauma, the findings of this report should be viewed in terms of applicability within the hospital. There are many solutions that are discussed within the scenarios; it was deemed necessary to create a findings section to provide a narrative for the presented solutions in more detail.

7 Technology and Patient Empowerment

Patient empowerment is a process in which patients are able to take control over decisions affecting their health [74]. An empowered patient is aware of their health condition and its effects to their body. Empowerment allows patients to make decisions regarding their health with confidence [3]. Results of empowerment include engagement, confidence, health literacy and self awareness. Health literacy, being an effect of empowerment, can reduce long term costs of healthcare at a system level [14] and increase efficiency of the whole healthcare process. Five important examples of technology that can empower patients are presented below.

7.1 Artificial Intelligence

Artificial intelligence (AI) (section 3.1) is growing at a rapid pace. Just this year IBM Watson, a question answering AI, had a major breakthrough at analyzing and diagnosing cancer patients. The University of North Carolina School of Medicine tested IBM Watson on the treat of 1,000 cancer patients [33]. IBM Watson recommended treatments for these patients and 99 percent of them were the same as proposed by actual oncologist. However, in 30 percent of the cases, Watson found a treatment option the oncologists missed. Treatments were largely based on research papers that the doctors could not possibly have read due to the sheer numbers; more than 160,000 cancer research papers are published a year. Utilizing AI technologies, such as IBM Watson, could thus empower patients by giving them a greater selection of solutions. They can choose the most effective option for them from a massive stream of research.

7.2 Augmented Reality

Another solution that was brought up is the cutting edge technology of augmented reality (section 3.13.2). As a medical patient one of the most worrying aspects is fear of the unknown. Augmented reality allows the doctor to visually illustrate to the patient the steps of a given procedure. The benefits of this solution are very apparent. The patient will be far more informed and will be experiencing the uncertainty to a lesser extent than they have had in the past. For instance, using augmented reality to guide the patient on how to treat a burn, increasing the chance of proper treatment.

7.3 Tablets

Tablets (section 3.10) at hospitals can be used to empower patients. Before a patient goes into surgery they can use a tablet to read official electronic documents to inform themselves on what is about to take place. These electronic documents can contain visual animations which will help clear questions and concerns. As a result patients will be more self aware and confident.

7.4 Smartphones

Video recordings let patients review their doctor's visits and conversations from home. Smartphones provides an accessible tool for patients to record these visits. Even though some doctors would prefer not to be on record like this it brings benefits for both the patient and the doctors. Having access to these recordings, patient's can for instance clear concerns and look up key information without having to call their doctors. Resulting in doctors having to spend less time on the phone clarifying or repeating conversations from the visit.

7.5 Virtual Reality

Virtual reality (VR) (section 3.13.3) is an up and coming technological field that could prove itself to be a useful and a powerful tool in healthcare. MRI-Scans have shown that VR can reduce pain in both adults and children. VR thus has potential to be used during the entire treatment process. Before treatment VR could reduce anxiety, during it could reduce fear and after to reduce pain. Implementation of VR in healthcare could therefore lead to an improved patient experience.

8 Conclusion

This project, and the resulting report, was undertaken to present possible solutions that could be implemented into the Swedish healthcare system with a focus on how that system could be improved with technology that would be available by the year 2025. To narrow the research focus, interviews and vision seminars were conducted to understand the patients' and doctors' thoughts on what the future healthcare system could do better. The interviews (Section 2.2) revealed that most systems contained vital information, but were difficult to use. Further, most patients and healthcare professionals stated they are open to virtual technologies that are not currently being utilized. The vision seminars (Section 2.3) further supported the information already obtained in interviews. The process for getting medical care in Sweden is lengthy, and the possibility of utilizing remote healthcare, home monitoring, and virtual communication was something patients would consider to get faster care per interviews and vision seminars. Healthcare professionals do not have as much time as they would like to address patient concerns, and the hope is that a new system would allow those professionals to utilize their time more efficiently when dealing with the healthcare system.

One of the primary challenges doctors and nurses face now is the necessity for professionals to enter identical patient information into multiple systems, which causes a large amount of time to be focused solely on recording data. Speech recognition, when implemented into a system used to record patient information, can be used to help reduce the amount of time spent storing data (Section 3.7). A doctor can simply have a conversation with a patient while the system records relevant information and stores it in the necessary location(s). The issue with speech recognition is a doctor or nurse must ensure the correct information was recorded into the system, which forces the healthcare professional to still spend their time on recorded data. Until speech recognition can be 100% accurate, it is unable to be used by a healthcare professional without someone reviewing the notes to ensure the correct data was entered.

Further research was conducted regarding the possibility of implementing Artificial Intelligence (AI) into the healthcare system (Section 3.1). Robots utilizing AI technology can work with medicine much more efficiently than humans. The primary use of robots with AI technology would be during surgery, which could help to reduce human error during the procedure, but AI technology could also be utilized in other parts of the healthcare system.

Patient empowerment in healthcare was a major focus during research for this project. Currently, patients often do not have enough information about their medical condition, the procedure they are scheduled to undergo or have already undergone, or the medication they are taking. Research revealed possible

solutions that could help to improve these concerns. First, tablets could be introduced into the hospital, possibly in each room by the patients' beds before and after their procedure to use for research and to view their medical record (Section 3.10). Augmented reality could present another possible solution (Section 3.13.2), patients and doctors could both wear glasses that would allow the doctor to step through visual representations of procedures or other relevant information. Finally, to allow a patient to have a more informed discussion with their doctors and nurses, it is proposed that medical professionals wear cameras on their heads throughout operation and would make the videos available to the patients after the procedure (Section 3.12.1). The video would provide the patient with a first-person view of the operation that he or she underwent, and would allow the patient to feel more involved in their healthcare experience.

Also, being able to consistently collect patient data, analyze that data, and make it available to medical professionals with the consent of the patient would allow those professionals to provide better healthcare and to extend that care beyond a patient's visit to the hospital. During the hospital stay, the Patient Status Engine system (Section 6), a system that utilizes wireless sensors to measure a patient's vitals, would allow doctors and nurses to wirelessly monitor a patient and provide the best care based on those readings. After a hospital visit, a patient could utilize home monitoring cameras (Section 3.12.2) and smart homes (Section 3.8), to allow for passive monitoring while the patient is away from the hospital. The cameras and other sensors in the home would allow for early detection of disease and recurring problems while the patient is not at the hospital.

Virtual reality is a tool that can be used as an education tool as well as to provide relaxation (Section 3.13.3) to the patient. When patients must remain in the hospital for a long time, they may become nervous about the procedure or procedures they must undergo. Virtual reality could provide entertainment to take the patient's mind off their procedure, or could educate him or her about the procedure to reduce anxiety caused by the unknown elements of an operation.

To complete this project, the project team discussed technologies that would help to increase patient involvement, improve patient and doctor communication, and expand the patient's empowerment in their healthcare. Increasing the time doctors can spend with patients is a high priority, and can improve the doctor-patient relationship. By implementing the solutions above, the Swedish healthcare system will take a leap toward the future and help both the healthcare professionals and patients become happier with the healthcare system.

9 Future Work

Utilizing existing and future technology is crucial for progression in healthcare. This report used the scenario sections to showcase the potential technologies and their positive implication in healthcare. Even though this report takes an extensive look at potential technologies for healthcare, further research is suggested due to limitations.

Suggestions for further research:

- How will biotechnology improve healthcare in the future?
- How to make collected data useful for patients?
- How to integrate all the data with the Electronic Medical Record(EMR)?

Questions to be considered by someone with a business background:

- What is the cost of implementing the findings?
- How long will it take to see the financial benefits from utilizing the technologies in the findings?

Questions to be considered by someone with a legal background:

- Do potential patient have to be monitored 24/7?
- What ethical issues should healthcare providers take into consideration?
- How to keep patient's data secure and private?
- What cyber laws should be considered?
- What is the process of getting a device certified for medical use?

Issues to be considered during further research:

- Spend more time interviewing and analyzing patients and users of the new EMR system.
- Conduct a longer and more spread out vision seminar with a wider variety of participants to validate the findings.
- The findings in this report was put together from students with a technology background. Having a more diverse group would have allowed for a broader perspective.

- Developing in-depth use cases for new technology.

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Interviewer: Everyone
Format: Presentation
Location: Uppsala, Akademiska
Date: 2016-09-12.

[Interview2] "Information from birgitta,"
Interviewer: Various
Format: E-mail
Location: Uppsala
Date: 2016-11-29.

[Interview3] "Interview of diabetes nurse,"
Interviewer: Joel Åstrand
Format: Over the phone
Location: Uppsala
Date: 2016-11-05.

[Interview4] "Interview with Åsa andén abrahamsson, head of pain center department,"
Interviewer: Rebecka Nyström, Anders Hamfeldt
Format: In person
Location Akademiska hospital
Date: 2016-11-14.

[Interview5] "Job shadow with anaesthetist nurses,"
Interviewer: Rebecka Nyström, Anna Normark, Douglas Fröling
Format: In person
Location: Orthopedic, Akademiska hospital
Date: 2016-10-07.

[Interview6] "Patient interview 1,"
Interviewer: Lisa Bergström
Format: In person

Location: Phone

Date: 2016-09-26.

[Interview7] "Patient interview 3,"

Interviewer: Andrew

Format: In person

Location: Phone

Date: 2016-09-26.

[Interview8] "Patient interview 4,"

Interviewer: Andrers Hamfeldt

Format: In person

Location: Phone

Date: 2016-09-26.

[Interview9] "Patient interview 5,"

Interviewer: Andrers Hamfeldt

Format: In person

Location: Phone

Date: 2016-09-26.

[Interview10] "Patient interview 6,"

Interviewer: Elin Johansson

Format: In person

Location: Phone

Date: 2016-09-26.

Appendices

A Gannon Vision Seminar Summary

This vision seminar was conducted with two different groups of people, future nurses and patients or healthcare professionals. The vision seminar was moderated and was used to formulate what healthcare 2025 might look like. The vision seminar at Gannon University was conducted by Rushi Ranjan, Kevin Kauffman, Glenn Sweithelm, Doug Margosian, Brian Rubino. At the end of the vision seminar everyone came to these general consensus.

Topics Covered

- Artificial Intelligence
- Patient Empowerment
- Data Monitoring
- Identity Monitoring
- Blockchain Technology
- Technology that can help healthcare interaction

General Consensus

- Data monitoring is import, however AI takes priority, because it will have a greater impact.
- A single person can not remember thousands of research paper. AI should assist and help validate a diagnosis.
- Deep learning is key to AI's success. Security and privacy of patients records should be taken seriously.
- "FitBit" is not a medical device. Data monitoring device must be approved by the
- Federal Food and Drug Administration(FDA). Medical devices should follow standards and must be certified by the government.

- IoT is not secures. Government should force technologies companies to guarantee security patches.
- Is 24/7 monitoring without a goal necessary? Data overflow will waste resources.
- Possibly a data monitoring prescription? Prescribe data monitoring if you don't trust patients and/or if they are unable to monitor themselves.
- Currently there is no method of making doctor's/nurse's notes useful. Incomprehensible notes will increase doctor's/nurse's workload.

B Uppsala Vision Seminar Outline

"What is their vision for the healthcare system in the future?"

The vision seminar will be a moderated discussion with healthcare professionals to get their visions and ideas for how healthcare could look like in the future.

Structure

Preparation

- Have people sit in a circle (not around tables)
- Involve everbody all the time
- Have post-its for the names
- Bring post-its, pens, cookies, coffee

Have clear expectation settings in the beginning

- Very short introduction, what do we study and what is the course
- Introduce who is there (moderator(s), note taker(s))
- Why are your here?
  - Exchange ideas about the current system of the healthcare system
  - Help us with their expert knowledge on the current system
  - Explore ideas for the future together
  - We want to get your input
- What do we want from them?
  - Open discussion
  - Tell us your experiences
- Structure for the seminar
  - 1 hour about the current system - what is good and bad

- break
- 1 hour about the future - what can a system look like in 2025

Part 1: Talk about different situations and scenarios - current system

Start in an introduction round (What is your name, what are you working on?)

1. What is your experience with the current healthcare system? What does the patient experience look like at the moment?
2. Let them talk about different scenarios or situations from their working life
3. How is your interaction with patients?
4. How are patients involved the current healthcare system?

Part 2: Good and bad things about the current system

1. Write down three things that are good with the current healthcare system?
   - Discuss these things in the group, let everybody explain that
   - Rank your notes from very good to least important
2. Now write down three negative things
   - Discuss them
   - Rank them - What needs to be solved first?

If you get stuck, just have a look at the questions :)

Part 3: Building the vision

1. What technology and tools can you imagine using in the future?
   - Write down three things you can image for 2025
     - How would you like to talk to your patient in the future?
     - Would you like to share information with your patient?
     - What role do you think does eHealth and telemedicine play?

2. Based on the positive and negative points and the tools for the future - let's build a vision!

How would you like to have the system in 2025

Virtual Care Patient self-monitoring

What are the three things that you want to get out of this vision seminars?

Patient - Healthcare Interaction

1. How do you think access to virtual care (video call, hologram "call", chat, etc.) will affect the interaction with the patients?
2. Consider a patient that today would go to the hospital to get examined for some symptoms, but instead uses the virtual tools in the future to get the exam - Would you feel confident diagnosing a patient virtually?
3. What tools/systems/functions would you wish to see in the future to make the communication with colleagues (same/different departments) easier?
4. What is your biggest concern about virtual care?

Patient - Data Collection

1. Which data is useful to be collected?
2. How should the data be presented/shown to the healthcare professionals?
3. Which legal and ethical issues will be faced?

Patient - Empowerment

1. How would they define patient empowerment? What is patient empowerment for them?
2. What is the ideal interaction with a patient? What role does the patient have?
3. Informed patients reduce cost for the healthcare system: What kind of education do patients need in order to improve their own health and to make better decisions?

Operation - Doctors

1. What can the operation room look like in 2025?
2. What could doctors do to lessen work on reports and focus on patient care?
3. What could be done with the health care system to improve doctor care?

Operation - Nurses

1. Would be stressed out if you knew that you were filmed performing an operation, and that the patient you're doing the operation on might see the film after?
2. Would your work be easier if you could track where patient, personnel and equipment currently are?
3. How much in the operation room would you like to have automated? Blood bags, Blood loss
4. Would your work become easier if you had more wireless equipment? Like wireless sensors for the patients vitals and more

Operation - Patients

1. What do you feel you could do to help the patient feel more comfortable leaving the hospital?
2. What useful information, programs, apps etc. could be stuffed into a tablet that is handed out to the patient prior to, and post, the operation?
3. What possible problems/potential risks could exist with a person videotaping operations?

C Uppsala Vision Seminar Summary

About: The vision seminar was a moderated discussion with patients to get their visions and ideas for how healthcare could look like in the future. The participant in the group consisted of five people. Four of these participants were students in the age of 21 - 28. The fifth participant was a teacher in the age of 50. Their nationalities were Chinese, Venezuelan, Swedish and Iraqis. The moderator for this vision seminar is Linnea Dahl. The topic of the vision seminar was "What is their vision for the healthcare system in the future?".

Part 1: Talk about different situations / scenarios - current system

Part 2: Building the vision

Part 3: The future

Summary of the discussion in part 1

- **The emergency takes a very long time in Sweden**

  The emergency takes a very long time in Sweden compare with China, Venezuela and Iraq. In the other countries they got the treatment in the emergency room immediately. In Sweden they can be waiting for hours. The participants had difficulty to understand why the emergency takes so long time in Sweden compare with the others countries. The participant from Venezuela does not think it is a matter of stuff issue, he experiencing that the amount of personal is the same in Sweden as it is in Venezuela. Two of the participants described that even if the emergency is full of patients in theirs home countries the treatment is always fast and you got help within a half hour. They described situations there the emergency has no available rooms for patients but they get treated fast anyway because the treatment can be down in the corner of the waiting room. One participant described that in a Swedish emergency they quite quickly get into a nice private room but he hated that because he know that he is going to be stuck there for hours waiting for the doctor.

- **Everything is digitized in Sweden**

  The difference between how countries deal with the documentation of a patient is very high. In Sweden everything is digitized and connected to each other which participants thought in many cases was good. Some of the participants thought that the disadvantages with these was that is was hard to see your test result from the hospital. Also if the patient moved to other countries it was hard to bring their medical history in order to show it to other doctors. In China, Venezuela and Iraq the patients have theirs medical history in a personal book which the patient brings to the

hospital, the doctor then writes the examination in the book, and after the examination the patient takes the book home.

- **Communication between pharmacy and the hospital**

  Some of the participants thought it is very good communication between pharmacy and the hospital. This because everything is digitized in Sweden so the patient does not need to bring a prescription in paper to the pharmacy. In Iraq you need to bring the prescription in paper to the pharmacy the consequences of this is that it is harder to have control over the medicine market.

- **Trust for doctors and the healthcare**

  In overall all of the participants feel trust for the healt care and for the doctor. Some of the participants described that the doctor in Sweden had more time for the patient and the patient could ask more questions. In other countries the visit with the doctor is very short and the patient has not the same possibility to ask questions.