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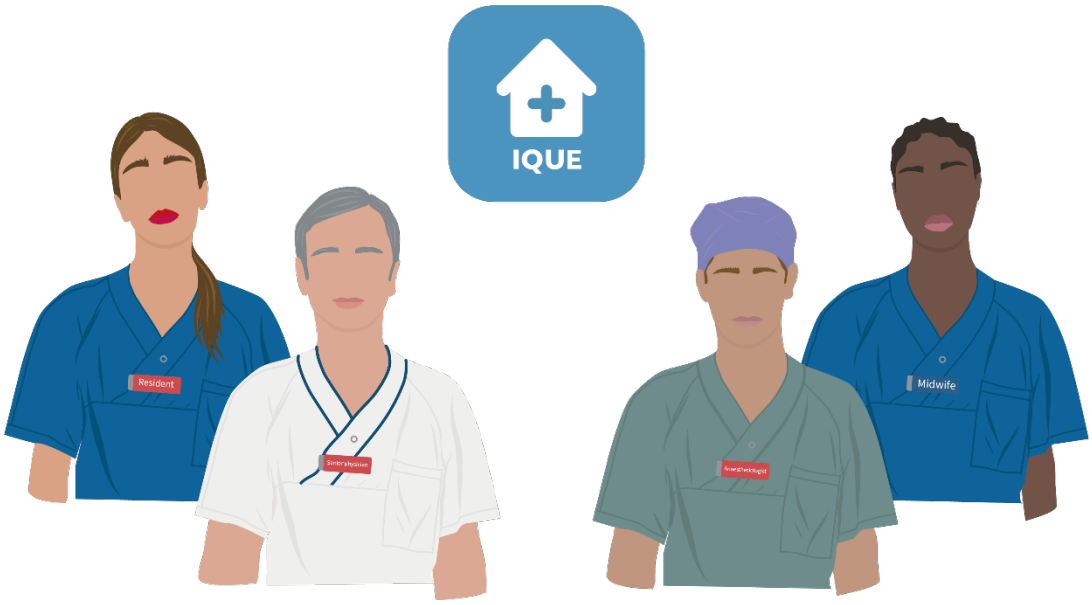

IQUE - A queuing application for healthcare personnel

For a more efficient workflow at the Emergency ward & Obstetrics and Gynaecology department of Östra Hospital

Malin Forssberg & Malin Svensson

Master's Thesis in Industrial Design Engineering

DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE
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Master of Science Thesis (IMSX30)

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Malin Forssberg

Malin Svensson

Abstract

As the need for healthcare increases, the pressure on the healthcare organization is constantly growing. Today, Swedish healthcare lacks resources, and the implementation of digital health information services is considered slow compared to other industries. Currently, analogue ways of working are still used, and digitalization within several areas could facilitate the healthcare personnel in their work.

This Master's Thesis aims to investigate if the workflow at the Emergency ward, and the Obstetrics and Gynaecology department of Östra Hospital, can be improved with digitalization of the current systems. Specifically, looking at the internal queueing systems related to consultation at the Emergency ward, and the orders of anaesthesia at the Obstetrics and Gynaecology department. The user groups focused on are the doctors and consultants at the Emergency ward, as well as the midwives and anaesthesiologists at the Obstetrics and Gynaecology department. Further, the goal is to improve efficiency, cooperation and communication as well as free up resources.

In order to investigate the aim, four main phases have been carried out. In the first phase, the current systems and problem areas have been examined, by performing user studies at Östra Hospital, as well as sending out surveys to additional hospitals. The studies contributed to an understanding of the user needs and resulted in a requirement specification. The second phase included concept development, where ideation, brainstorming and iteration resulted in four concepts for each department. The concepts were tweaked and prototyped in the software Figma. The third phase included evaluation with the users, using the prototypes, together with a theoretical evaluation. The insights were analysed, and the final concept was developed, in the fourth phase.

From the user studies, it could be seen that the majority of the participants were pleased with the current systems of today. However, several of the participants in the Emergency ward were positive about trying something new. At the Obstetrics and Gynaecology ward, the midwives believed the phone communication with the anaesthesiologists was crucial. Due to this, they did not believe digitalization of the system was necessary. However, the majority of the anaesthesiologists believed a digitalized system would make the process more efficient as well as patient safe.

The final outcome of the project is a queueing application called IQUE. It provides support and an overview of the queue for the consultants and anaesthesiologists, enabling the doctors to keep working while still being positioned in the queue, and provides transparency for the midwives of the Maternity wards. To conclude, IQUE is a digital tool that might help healthcare personnel to perform their work more efficiently. However, the solution needs to be further tested by the users in the real user environment.

Keywords: healthcare, digitalization, user experience, digital design, the design process, user studies, prototyping.

Table of content

1. Introduction

In this chapter, an introduction to the Master's Thesis is presented. This includes the background of the project, the user groups, the aim, the goal and the demarcations.

1.1 Background

Healthcare in Sweden is under constant pressure, and the lack of resources is one of the many reasons (Sjöberg, 2019). Furthermore, many tasks within the healthcare system are today performed manually and analogously, which in some situations slows down the process (M. Strandberg, November 3, 2022). Some of these tasks can be carried out more efficiently, with the help of technology. Currently, the use of digital solutions is not utilized to its full potential, which is an area in need of development.

Due to these challenges, two doctors working with innovation and technology, Maria Strandberg and Helena Andreasson, have initiated this project of improving the current workflows at the Emergency ward and the Obstetrics and Gynaecology department at Östra Hospital. This is achieved by developing a digital application intended for the different queueing systems at the two departments.

1.1.1 Innovation & Technology Program

Sahlgrenska University Hospital has a two-year educational program in technology innovation (Sahlgrenska Universitetssjukhus, 2021e). The goal of the program is to contribute with practical and useful knowledge regarding innovation work and technology. Further, the participants are also given tools to be used to lead and develop innovation projects of their own at the hospital. The program is an opportunity for residents to be a part of the changes within the healthcare organization, including patients, in the future. Facing future challenges with innovative and technical solutions is something that Sahlgrenska University Hospital is actively working towards: "Together we shall work smarter, more efficient and more patient safe" (Sahlgrenska Universitetssjukhus, 2021e).

The program is a strategic effort initiated by the hospital chief executive officer Ann-Marie Wennberg, together with the hospital management (Sahlgrenska Universitetssjukhus, 2021e). With support from the Innovationsplattformen, the program is part of the operation of the Speciality training chancellery. The education is available for all residents at Sahlgrenska University Hospital and is carried out for two years, consisting of 20 per cent of the working time.

Queuing application project

This Master's thesis is performed in collaboration with Sahlgrenska University Hospital, with the initiators of the project Helena Andreasson and Maria Strandberg.

Helena works as a specialist in anaesthesia at AnOpIVA at Östra Hospital, which is the department of anaesthesia, surgery and the intensive care unit. Maria works as an emergency medicine resident at the Emergency ward of Östra Hospital.

In December 2021 they both graduated from the Innovation and Technology Speciality training program. During their studies, they identified two similar problem areas at their departments: The need for increased efficiency of the current workflows. In the Emergency ward, there is a need to reduce the passive time spent physically queuing by doctors for advice from a specialist in emergency medicine. In the Obstetrics and Gynaecology department of Östra Hospital, there is a need for anaesthesiologists and midwives to be able to plan and clarify the order of epidural administration.

Helena and Maria initiated the project in 2019, due to the similarity of their problem areas identified. In 2021, the project was approved for financial support from the innovation fund, which enabled collaboration with the company Evolve, today part of the consultant agency AFRY.

Together with the team at AFRY, a proof of concept was developed and programmed during the early spring of 2022. This concept included the problem areas identified by Helena and Maria and has been used as a base during this Master's Thesis. The application developed by AFRY and the initiators of the project included several set requirements, which have been used for this Master's Thesis as well. Presented below are the set requirements:

- The solution should be digital
- The solution should be used on a computer or a smartphone
- The solution should not include any personal patient data
- The solution should enable personal login

Emergency ward

As stated by M. Strandberg (personal communication, January 21, 2022), several doctors with less experience, such as junior doctors and interns, are working at the Emergency ward of Östra Hospital. For the patients to be handled with as good expertise and experience as possible, a specialist in emergency medicine is available to supervise the doctors of the department. This specialist is working as a consultant for the remaining doctors in the ward. When referring to a consultant further in this report, this specialist is intended.

Currently, the consultant is seated at an office where the remaining doctors of the ward can come and ask questions (M. Strandberg, personal communication, January 21, 2022). The queueing system of today consists of a physical queue, disabling the doctors from working with other tasks, in order not to lose their position in the queue. Furthermore, the

doctors often handle several patients at a time and therefore have several questions for the specialist.

Further, the consultant also has other responsibilities, such as responding to incoming high emergency cases, according to Strandberg (personal communication, January 21, 2022). If an incoming high emergency case is received, the consultant has to leave the office to attend the emergency. Due to this, the consultant is unavailable for an unknown period of time. This further delays the process, since the queue remains even though the consultant leaves the office.

The current queuing system disables resources, due to the need for physical presence while queuing (M. Strandberg, personal communication, January 21, 2022). Therefore, the need for a more efficient queuing system is needed, in order for the doctors to be able to continue working whilst queueing.

Obstetrics and Gynaecology department

At the Maternity wards of Östra Hospital, a mother can be provided epidural anaesthesia if she is in need of pain relief. In this situation, the responsible midwife of the woman giving birth calls the anaesthesiologist to book epidural anaesthesia (EDA).

When an order is placed, the anaesthesiologist writes the information down on a piece of paper, and then puts it in his or her pocket (H. Andreasson, personal communication, January 21, 2022). This means that the anaesthesiologist is the only person aware of the queue of orders of anaesthesia, including how many mothers are waiting. As a result, the mothers sometimes are not prepared for the EDA when the anaesthesiologist arrives. For example, they might be on the toilet or similar, which makes the work inefficient as the anaesthesiologist needs to wait for the patient.

Furthermore, Andreasson (personal communication, January 21, 2022) stated that the anaesthesiologist has other responsibilities in addition to applying anaesthesia, such as being present in emergency caesarean sections, or when women have heavy bleedings after childbirth. If there is an incoming high emergency case regarding such a situation, this is prioritized over an EDA since an EDA is not vital for the woman giving birth, but relieves the pain. However, the midwife ordering the EDA is not notified of the incoming high emergency cases but is waiting for the anaesthesiologist to arrive. Therefore, the midwife may call the anaesthesiologist asking about the delay while the anaesthesiologist is attending to the incoming high emergency case.

These situations contribute to inefficient work both for the anaesthesiologist and the midwife (H. Andreasson, personal communication, January 21, 2022). To begin with, the anaesthesiologist might have to wait on the woman giving birth, since she is not prepared when the doctor arrives. On the other hand, the current situation contributes to an uncertainty for the midwife, including the mother giving birth, of when the EDA can be provided. Due to this uncertainty, other activities, such as bathing, are not carried out to facilitate the mother. It also results in that the anaesthesiologist needs to answer calls from

the midwives while being occupied with other tasks. Finally, there is also a risk of orders disappearing, since they are only written down on a piece of paper. Therefore, the need for a more efficient, clearer and transparent queuing system is needed.

1.2 User groups

In this Master's Thesis, the user groups in focus are the healthcare personnel of the two departments mentioned, the Emergency ward and the Obstetrics and Gynaecology department of Östra Hospital. The primary users include the consultant at the Emergency ward, together with residents and less experienced doctors, such as interns and junior doctors, and the anaesthesiologists and midwives at the Obstetrics and Gynaecology department, see figure 1. The secondary user groups are the other staff in the departments, as well as the patients.

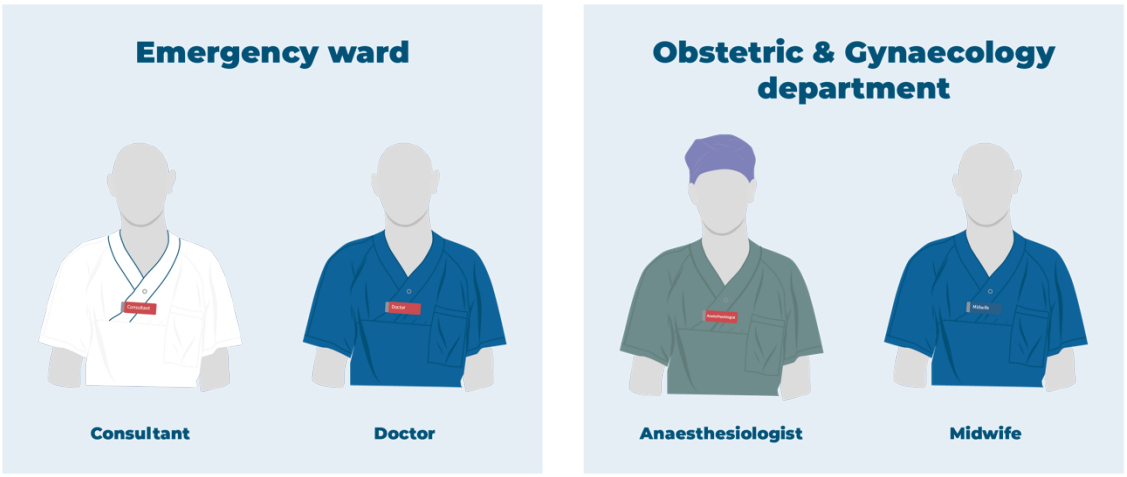

Figure 1. The user groups

1.3 Aim

The aim of this Master's Thesis is to improve the workflow and increase efficiency, within the Emergency ward and the Obstetrics and Gynaecology department at Östra Hospital as well as to free up resources and improve cooperation and communication between the healthcare personnel.

1.3.1 Research question

The project also aims at answering the following research question:

Can a digitalization of the current queueing systems facilitate the workflow in order to increase efficiency?

1.4 Goal & objectives

The goal of this Master's Thesis is to apply design methodology to develop a digital application, intended to facilitate the healthcare personnel at the Emergency ward and the Obstetrics and Gynaecology department.

The main objectives include:

- Gain an understanding of the users and the current workflow
- Identify the main problem areas
- Develop and prototype concepts
- Evaluate concepts
- Develop and prototype a final concept

1.5 Demarcations

The project is delimited to two departments within the healthcare organization at Östra Hospital in Gothenburg; the Emergency ward and the Obstetrics and Gynaecology department.

The problem analysis is focused on the current workflow regarding the queueing systems of each department. In the Emergency ward, the analysis is delimited to the queuing system of when doctors are in need of advice from a consultant. In the Obstetrics and Gynaecology department, the analysis is delimited to the workflow between the midwives and the anaesthesiologists, during the order of anaesthesia.

Furthermore, the research is conducted from the healthcare personnel's' point of view, and the solution developed will only be used internally by the healthcare personnel in question. Therefore, the project will not include investigating the patients' point of view.

1.6 Process

In figure 2, the full design process of the project is presented. The process will be further explained in Chapter 4.

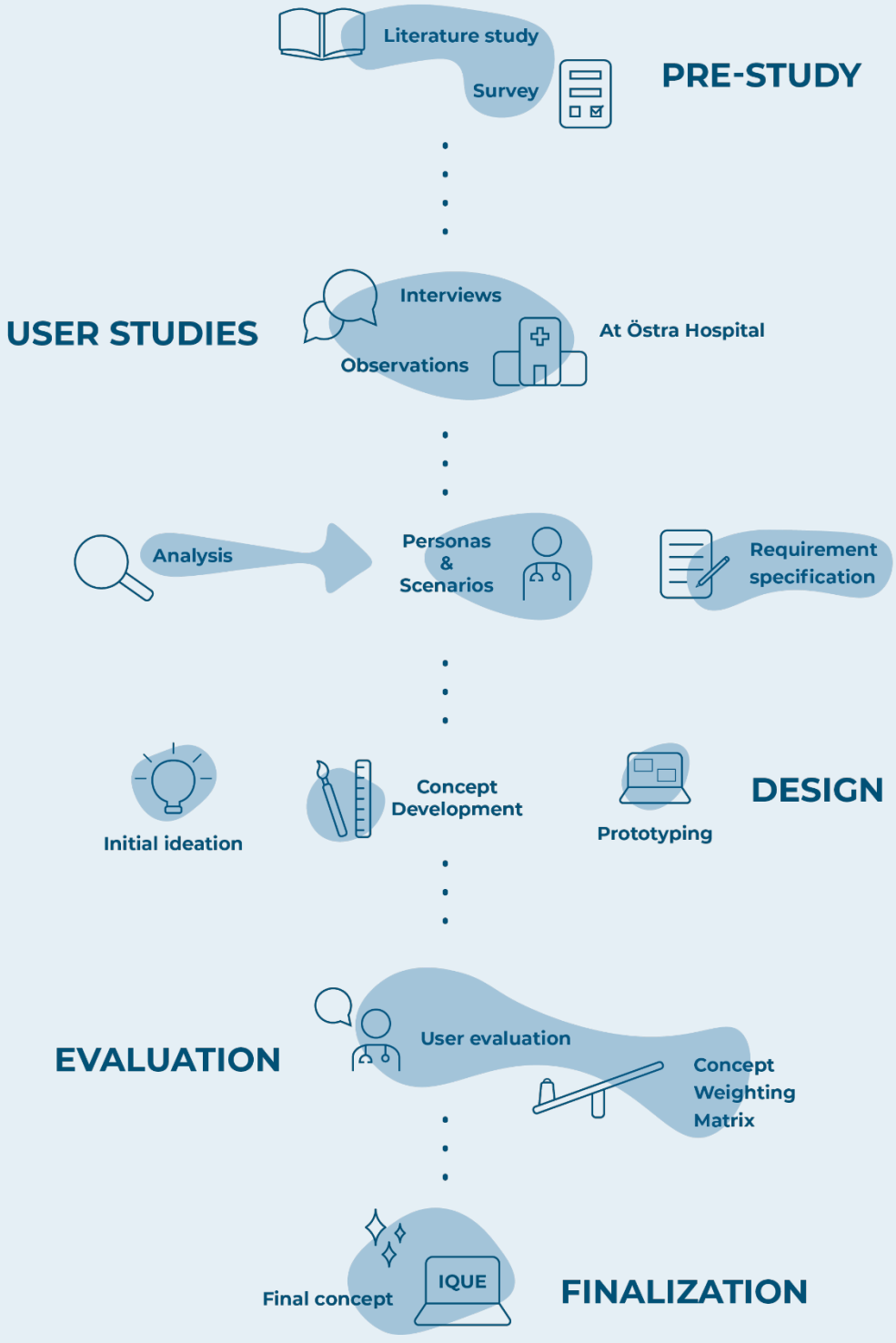

Figure 2. The process

2. Östra Hospital

Östra Hospital is located in Gothenburg, Sweden, and is part of Sahlgrenska University Hospital (Sahlgrenska Universitetssjukhus, 2021a). In the sections below, the Emergency ward, as well as the Obstetrics and Gynaecological department of Östra Hospital are presented.

2.1 Emergency ward

The Emergency ward of Östra Hospital is intended for individuals over the age of 16 (Sahlgrenska Universitetssjukhus, 2022a). Individuals under the age of 16 are referred to the Emergency ward for children at Queen Silvia Children's Hospital, located at Östra Hospital.

At the Emergency ward, individuals who have been in a serious accident, or have symptoms such as chest pain, severe abdominal pain or headache can seek healthcare (Sahlgrenska Universitetssjukhus, 2022a). This also applies to individuals with severe conditions such as having difficulties in breathing or symptoms that indicate a stroke, among others. However, individuals with orthopaedic injuries, such as an injury to a joint or a fracture are directed to Mölndal Hospital.

Both doctors, nurses as well as assistant nurses are working at the ward (Sahlgrenska Universitetssjukhus, 2022a). The first step when a patient is arriving at the Emergency ward is to meet a nurse. The nurse will make a first assessment of the condition of the patient. During this examination, a prioritization of the patient will also be conducted. At the emergency ward of Östra Hospital, a triage model called GÖTT is used (Lukic, 2020). GÖTT stands for Göteborg Triage Test in Swedish, meaning Gothenburg Triage Test in English.

After assessment by a nurse, the patient can be directed to an on-call centre or a health centre (Sahlgrenska Universitetssjukhus, 2022a). However, if further examination is needed, the patient will meet a doctor, who decides if any further investigations are needed. This can for example be blood samples or X-ray. When the test results are delivered, a doctor will decide if the patient needs further care at any of the wards of the hospital, or if the patient can go home again.

During certain hours of the day, a specialist is available as a consultant at the Emergency ward of Östra Hospital (Carlsson, 2021). This doctor has the overall medical responsibility of the ward when on duty. If other doctors at the ward, or nurses, need help, the consultant is the person to ask primarily. The consultant is also the doctor who answers questions from the ambulance or health centre. Furthermore, together with the section leader, the consultant is responsible for the flow of patients as well as the workload at the ward. If needed, they relocate both employees and patients. In addition to the consultant, doctors with different experiences are working in teams at the Emergency ward. These are presented below.

Junior Doctor

After finalization of term 9 of the medical program in Sweden, medical students can start work as junior doctors (Sveriges läkarförbund, n.d.a). A junior doctor is not yet licensed as

a doctor, and is not fully trained. Therefore, a junior doctor is in need of supervision of more experienced colleagues.

Intern

In order to get a medical license, an approved medical practice as an intern is needed (Sveriges läkarförbund, n.d.b). This applies to individuals studying the medical program for five and a half years in Sweden. The medical practice complements the medical program with experiences from, and introduction to, the real work environment. It is performed over 18 months, including practice within different areas of healthcare. Within each area, the possibility for consultation with more experienced doctors should be available. Furthermore, the intern should be provided with a supervisor. The 18 months end with a test called the intern test. An approved medical practice, and test, results in a medical license, working as an intern. It also authorizes the possibility to start residency training, to become a resident.

Resident

If a doctor wants to get specialized within an area, they have to perform residency training (Svenska läkarförbundet, n.d.c). This is conducted during five to five and a half years, depending on the area. The residency training should include supervision with a supervisor with high competences within the area. When their training is finalized, a doctor becomes a resident.

Emergency medicine residency

There are many different areas to get specialized in within healthcare (Redaktionen SU, 2021). Since 2015, residency training within emergency medicine is possible in Sweden (Sahlgrenska Universitetssjukhuset, 2018c). In other words, the speciality is quite new in Sweden. However, it has existed longer in countries such as England and the United States.

The emergency medicine residency training is one of the most fast-growing specialties in Sweden (Carlson, 2018). It includes handling patients in acute condition and patients involved in accidents. At an emergency ward, the time is limited and many patients are in need of care at the same time. The healthcare personnel at an emergency ward, should therefore have generalistic competence.

Basic training

In 2021, a new medical program was introduced in Sweden (Hegner, 2020). The program is six years, instead of five and a half. It includes a medical license, meaning that a medical practice as an intern is no longer necessary. Instead, a basic training is added, as an introduction duty included in the speciality training. This also means that the medical practice as an intern will gradually be phased out.

The basic training is performed for one year in most cases (Hegner, 2020). However, a six-month program is also possible. The aim with the training is to increase clinical competence, among others. The basic training is also intended for doctors studying the medical program abroad with practices equivalent to an intern in Sweden to get an introduction to Swedish healthcare.

2.2 Obstetrics and Gynaecology department

Östra Hospital is the only hospital in Gothenburg where women are giving birth (Sahlgrenska Universitetssjukhus, 2018a). There are three Maternity wards at the hospital. Two of the departments, 308 and 312, are for normal childbirth, where healthy women giving birth from week 34 deliver (Sahlgrenska Universitetssjukhuset, 2021b; Sahlgrenska Universitetssjukhuset 2021c). The third department, 314, is for special deliveries (Sahlgrenska Universitetssjukhus, 2021d). This department is available for women in need of special care due to for example illness or other special conditions. At all the departments, midwives are working together with obstetricians, assistant nurses and maternity nurses. When an anaesthesia is ordered, an anaesthesiologist, mainly located at the Surgical ward 2, moves to the department concerned.

At the Surgical ward 2, gynaecological operations as well as operations related to childbirth, such as caesarean sections, are performed (Sahlgrenska Universitetssjukhus, 2022b). In total, six operating theatres are available at Surgery ward 2. Furthermore, a postoperative and a preoperative section is also located at the ward. Both planned and emergency surgeries are performed at the ward.

Different types of healthcare professionals work at the Surgical ward, including doctors such as anaesthesiologists, gynaecologists and obstetricians, and nurses such as anaesthesia nurses, operating room nurses and assistant nurses (Sahlgrenska Universitetssjukhus, 2022b).

Together with the Maternity wards, the Surgical ward 2 belongs to the Obstetrics and Gynaecology department of Östra Hospital. They are all located in the same house, but on different floors. In table 1, all the wards of the Obstetrics and Gynaecology department are presented.

Table 1. The Obstetrics and Gynaecology department at Östra Hospital

Floor 6
Management Neonatal
Floor 5
Department 317 Surgical ward 2
Intensive care unit Neonatal 316
Floor 4
Department 315 Special BB[1]
Department 314 Special delivery
Caesarean section registration
Floor 3
Department 313 Gynecology
Department 312 Delivery
Floor 2
Department 311 BB[2]
Department 310 BB[3]
Caesarean section sur
Floor 1
Department 308 Delivery
Department 309 Neonatal
Perinatallab

[1, 2, 3] BB refers to the department to which mothers and newborn babies are transferred after birth (Sahlgrenska, 2022c; Sahlgrenska 2022d; Sahlgrenska, 2022e)

Anaesthesia

A healthy mother can be provided epidural anaesthesia when she is opened four to eight centimetres (Olausson, 2021). In this situation, the responsible midwife of the woman giving birth calls the anaesthesiologist to book an EDA. If the mother is opened less than four centimetres or more than eight centimetres, the midwife needs to contact the obstetrician before calling the anaesthesiologist for an EDA. This also applies to the situations where the mother is not healthy.

In order to prioritize the women in need of EDA in the right way, the following information is needed (Olausson, 2021):

- Possible anaesthesia consultant
- Information about diseases, including obesity
- Information about the course of event of the childbirth
- Information about the degree of opening of the mother
- Information about if the mother is primigravida[4] or multigravida[5]
- Information about if there are any communication difficulties

During a day shift, the goal is for an EDA to be applied within half an hour, and during on-call hours, within an hour (Olausson, 2021).

Emergency caesarean section

There are four different degrees of caesarean sections (Burchert, 2021). High emergency caesarean section is the highest degree where there is an immediate threat to the mother's or the baby's life. Urgent emergency caesarean section is the second highest degree where the mother's or the baby's life is threatened. The guideline for the caesarean section is that the baby should be out within 20-30 minutes. Not urgent emergency caesarean section is the third degree where there is no immediate threat to the mother's or baby's life. The last degree is the elective caesarean section which is a planned caesarean section.

On-call duty

The on-call duty of anaesthesiologists at AnOpIVA, the department of anaesthesia, surgery and the intensive care unit, is distributed to four different employees, having different work tasks depending on their work position (Olausson, 2022). The different positions are named on-call 1, on-call 2, on-call 3 and standby duty. On-call 1,2 and 3 are based at the hospital, while the standby duty is in readiness.

[4] The definition of primigravida is "a women pregnant for the first time" (Miller-Keane Encyclopedia, 2003)

[5] The definition of multigravida is "a pregnant woman who has had one or more previous pregnancies" (American Heritage Dictionary, 2011)

On-call 1

The on-call 1 is responsible for the intensive care unit as well as surgery ward 1, including post surgeries (Olausson, 2022). The work includes taking care of cardiac emergencies and pregnancy emergencies among others.

On-call 2

The on-call 2 is responsible for surgery ward 2, including post surgeries (Olausson, 2022). Furthermore, the anaesthesiologist on-call 2 is responsible for the gynaecology ward and the maternity wards, including the delivery wards as well as the post-delivery wards. This also includes the surgery room at the maternity ward for special deliveries. Furthermore, the work includes taking care of pregnancy emergencies among others.

On-call 3

The anaesthesiologist on-call 3 is, in collaboration with the standby duty, a resource to support the on-call 2 primarily, but also on-call 1 (Olausson, 2022).

Standby duty

The standby duty has the overall medical management responsibility and is in readiness for the remaining on-call duties (Olausson, 2022).

Professions

As mentioned in the section above, the professions involved when anaesthesia is ordered are mainly midwives and anaesthesiologists. These two professions are presented below.

Midwife

In order to become a midwife, nurses can further educate themselves for one and a half years (Sveriges akademikers centralorganisation, 2021). A midwife works with childbirths, including both the period before, during as well as after the delivery. The work includes giving the woman giving birth support during delivery, as well as performing examinations and providing pain relief. Working as a midwife can also include gynaecological examinations of women, abortion care and giving contraceptive advice, to name a few.

Anaesthesiologist

An anaesthesiologist is a doctor specialized within anaesthesiology and intensive care (Nellgård, 2022). As mentioned, the anaesthesiologist is applying spinal or epidural anaesthesia as pain relief during childbirths (SFOAI, 2018). However, an anaesthesiologist also has other work tasks.

During anaesthesia of patients at surgery, the anaesthesiologist is the expert of monitoring and maintaining the function of the vital organs (Nellgård, 2022). This also applies to post surgery. Furthermore, the speciality includes diagnosing and treating patients in critical conditions with multiple organ failure at the intensive care unit.

3. Theory

In this chapter, the theory related to the project is presented. This includes information related to the lack of resources within the healthcare organization, innovation and digitalization, as well as information of the design aspects used for this project.

3.1 Swedish healthcare today

The situation at the Swedish hospitals has been critical several times during the last years (Sveriges Riksdag, 2017). When understaffing and overcrowding occur, the hospitals need to implement a state of readiness, where tuff prioritizations need to be done regarding the usage of resources. Due to these prioritizations, patients might have to be referred to other hospitals, and surgeries might need to be cancelled. The Parliamentary Committee on Defence is concerned that hospitals need to enter the state of readiness during these relatively normal circumstances. The possibilities of providing adequate medical care, if an extraordinary event would occur, are most likely to be low.

3.1.1 Challenges within healthcare

The medical profession focused journal Framtidens Karriär - Läkare, performed a study including a random selection of physicians (Wihlborg, 2017). Different aspects were investigated considering the main challenges within the healthcare organization. The participants considered the following three areas as the main challenges; the working situation of the healthcare personnel, the lack of resources, and how the organization shall be organized and produced. 79 percent of the participants considered the working situation as a challenging area, 61 percent believed the lack of resources was a challenge and 51 percent found how the organization shall be organized and produced to be challenging.

Johan Rosenqvist, a specialist in urology and the Healthcare Director at Kalmar County Council, believed that the challenges highlighted by the participants in the study are very much relevant (Wihlborg, 2017). All healthcare providers need to constantly, and actively, work with the challenge of the work situation. Further, Rosenqvist believed there is a need for reviewing the individual workload of physicians, as well as ensuring that they devote their working time for the proper things.

Lena Lundgren, Healthcare Director in the Östergötland Region, understood the fact that the working situation was considered to be the largest challenge according to the study (Wihlborg, 2017). The working environment of the physicians is not up to date, or as digitized, as other parts of today's society. Further, she believed that the IT-systems used in healthcare are not modern nor compatible with each other, which influence the working environment, the lack of resources and the healthcare organization.

3.2 Innovation & digitalization

Within several areas of practice, including healthcare, technology have been globally acknowledged to improve productivity (Awwal Ladan et al., 2018). This has been accomplished due to the development of computers and other information technologies

(ITs). The use of information and communication technologies (ICTs), as well as innovations in e-health can contribute to improving health strategies regarding patient safety, healthcare collaborations, efficiency and healthcare research. Currently, patients, clinicals, managers and others use an increased range of digital services and technologies in order to fulfil different needs (Øvretveit, 2020).

3.2.1 History

In Sweden, the implementation of Digital health technologies (DHTs) is rather advanced (Øvretveit, 2020). Stated by Øvretveit (2020), DHTs are defined as "Digital services and technologies used in health services for different financial, management, and clinical purposes; for promoting, and maintaining health; or for preventing, treating, or caring for illness". In most publicly founded, and owned healthcare services in Sweden, public investment in digital infrastructure has been made. The educated Swedish public citizenry and clinical workforce possess computer knowledge, which is a contributing factor to the digitalization of health services. Personal computers, internet and smartphones were used early, and to a large extent in several countries, where Sweden was one of those. However, the implementation of digital health information services was considered slow compared to other industries. Although the personnel were ready for a digitalization within public healthcare.

Electronic medical and health records were one of the most significant and first areas where DHT was implemented (Øvretveit, 2020). PCs were used by several physicians during the 1970s and 1980s. However, the adoption of PCs and networked Electronic medical records (EMRs) was not carried out until the 1990s at different hospital departments. An Electronic medical record (EMR) is defined as "an electronic record of health-related information on an individual that can be created, gathered, managed, and consulted by authorized clinicians and staff within one healthcare organization". Several companies developed small commercial Electronic health records (EHRs), but due to the problematic and limited adoption, these went bankrupt. Electronic health record (EHR) is described as "a repository of information regarding the health status of a subject of care in computer-processable form, stored and transmitted securely, and accessible by multiple authorized users", according to Øvretveit (2020).

Between the years 2000 to 2010, hospitals and primary care started to rapidly implement EMRs due to larger cloud computing and developments of the EMR (Øvretveit, 2020). In order to structure an EHR, the medical records for the physician, nursing and other health professions had to be integrated into the system. Furthermore, continued developments enabled authorized access to limited patient data for both clinical and welfare processions.

Stated by Øvretveit (2020), the digitalization of the country's national clinic registers was another important achievement. 106 national clinical "quality registers" were included in 2016. For example, data regarding hip and knee replacements were stored and collected in the national orthopaedic register. Further, including patient data, procedures,

prostheses and patient-reported outcomes. Due to the discovery of important deficiencies, of the unusually high re-operation rates, some hip replacement implants were aborted. This is one example of a beneficial outcome of the national clinical "quality registers".

3.3 Emergency ward

Individuals with different kinds of injuries or diseases can seek healthcare at an emergency ward (Statens beredning för medicinsk utvärdering, 2010). Most of these patients are worried about their health, and therefore want healthcare personnel to assess their condition.

It is difficult to predict the number of patients admitting to an emergency ward (Christ et al., 2010). At the majority of the emergency wards, the patients need to wait in order to see a doctor (Statens beredning för medicinsk utvärdering, 2010), since not all patients can be treated immediately, or at the same time (Christ et al., 2010). Some patients are in an urgent need of care, due to their critical condition, while others' conditions are not as severe. This results in the need for a queueing system, such as triage (Statens beredning för medicinsk utvärdering, 2010).

3.3.1 Triage

Triage is a method used at emergency wards, where the patients are assessed according to the severity of their condition (Statens beredning för medicinsk utvärdering, 2010). Based on this, the time waiting to get a medical assessment of a doctor is adapted. There are different kinds of triage methods used at emergency wards around the world, where the prioritization to a doctor is assessed. Most of the methods used today have a scale of severity including five levels. However, methods with three levels also exist. In addition to the use of triage at emergency wards, the method can also be used in other areas within healthcare. Among others, it can be used when the need for a specific examination of a patient is to be determined.

3.4 Maternity ward

At a maternity ward, pregnant women are hospitalized to give birth (Bengtsson, 2019). When a woman about to give birth arrives at the maternity ward, she first meets a midwife. The midwife estimates if the mother is close enough to deliver or not. If the childbirth has started sufficiently, the mother will be enrolled in the ward, and stay there until the baby is born.

Childbirth takes place in special delivery rooms (Bengtsson, 2019). Depending on the hospital, the delivery rooms can look different from each other. Usually, there is a delivery bed as well as comfortable furniture to sit in.

3.4.1 Pain relief

To give birth is painful (Bengtsson, 2022a). However, there are various methods, medical and non-medical, to reduce the pain of a woman giving birth. Non-medical, natural pain relief, includes methods such as acupuncture, massage, or heat (Bengtsson, 2022a) in the form of a hot shower or bath, among others (Bengtsson, 2022b). The possibility to take a shower or a bath is often available either in the delivery room, or nearby (Bengtsson, 2019). Medical pain relief includes methods such as nitrous oxide or anaesthesia to the spinal.

Anaesthesia to the spine

There are three forms of anaesthesia to the spine; Epidural anaesthesia (EDA), Spinal anaesthesia (SPA) and Combined Spinal and Epidural anaesthesia (CSE) (Svensk Förening för Obstetrisk Anestesi och Intensivvård (SFOAI), 2018). All of them are applied by an anaesthesiologist.

Anaesthesia to the spine is the most complicated pain relief method (SFOAI, 2018). However, it is also the most effective pain relief, and is scientifically the best method documented. Furthermore, the method does not affect the consciousness of the mother and the level of stress hormones in the blood is reduced. These qualities are some of the positive effects of using anaesthesia to the spine as a pain relief. Serious complications are very unusual when using the method. However, some smaller drawbacks are more common with the method, such as itching, shaking and difficulty to urinate.

A mother in need of anaesthesia first consults with a midwife or obstetrician (SFOAI, 2018). After this, the anaesthesiologist is contacted. During daytime, the goal is to apply anaesthesia within half an hour, while it is within an hour during on-call hours. The application of anaesthesia to the spinal is expected to require more time if the back of the mother is oblique, or she has had back surgery. This also applies to if the mother is significantly overweight. In these cases, the anaesthesia can have a lower effect, or not be possible to apply at all.

Epidural anaesthesia

An epidural anaesthesia (EDA) is most often applied when the labour pains have been initiated (SFOAI, 2018). However, it is possible to apply an EDA anytime during childbirth. Before an EDA is applied, the woman giving birth receives a peripheral venous catheter. Then, she either lay down in a fetal position, with her chin against the chest and legs raised, or sit on the bedside with the back hunched over. This, in order to make as large a space between the vertebrae as possible. See figure 3 for the application of epidural between

the vertebrae. After this, a local anaesthetic is applied superficially in the skin of the back of the mother. This is done after a sterile wash of the back. An epidural needle is then inserted between the vertebrae of the lumbar spine, and a thin plastic tube is inserted through the needle. See figure 4 for the epidural needle and tube. Finally, the needle is removed and the tube is fastened on the back using tape. The medicine can after this be applied. See figure 5 for an illustration of the application.

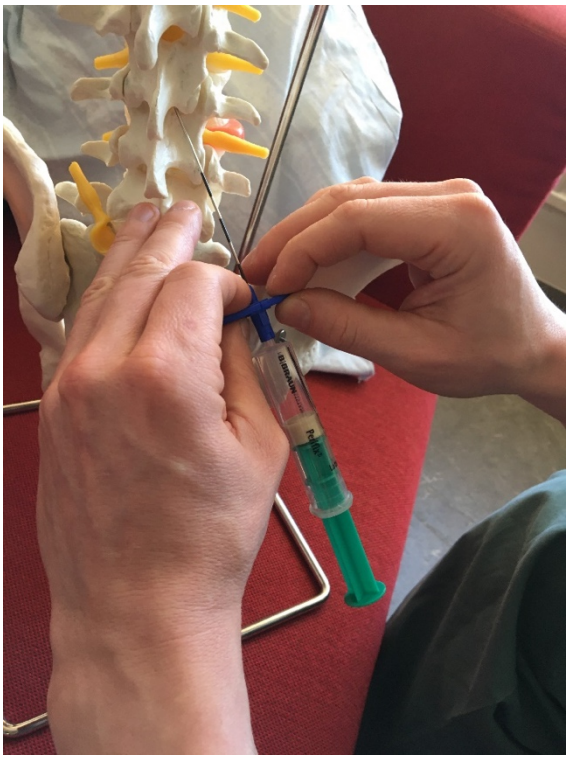

Figure 3. The application of epidural between the vertebrae

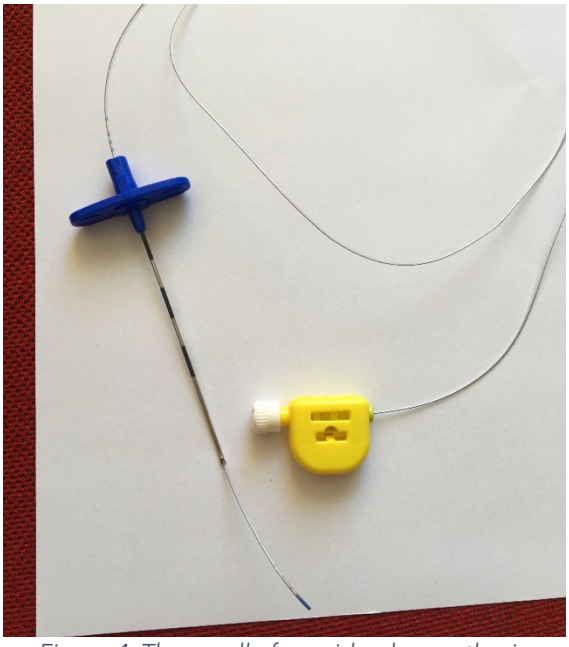

Figure 4. The needle for epidural anaesthesia

Figure 5. Application of epidural anaesthesia

The mother usually feels the initial effect of an EDA after 5-15 minutes, and after 20-30 minutes, the full effect is reached (SFOAI, 2018). If needed, the pain relief can be refilled through the epidural catheter. This can be done either by the midwife or through a pump connected to the catheter. In some maternity wards, it is possible for the mother to control the medicine through the pump. This is called Patient-Controlled Epidural Analgesia (PCEA).

Spinal anaesthesia

For women who have given birth before, and where the process is expected to go faster, a spinal anaesthesia can be applied instead of an EDA (SFOAI, 2018). A SPA is often easier to apply than an EDA. The technique used when applying a SPA is similar to the technique of EDA (SFOAI, 2018). However, a thin needle is used instead of an epidural catheter, see figure 6. The medicine is applied to the spinal fluid and after this, the needle is removed. Furthermore, it has a faster effect, but does not last as long as an EDA.

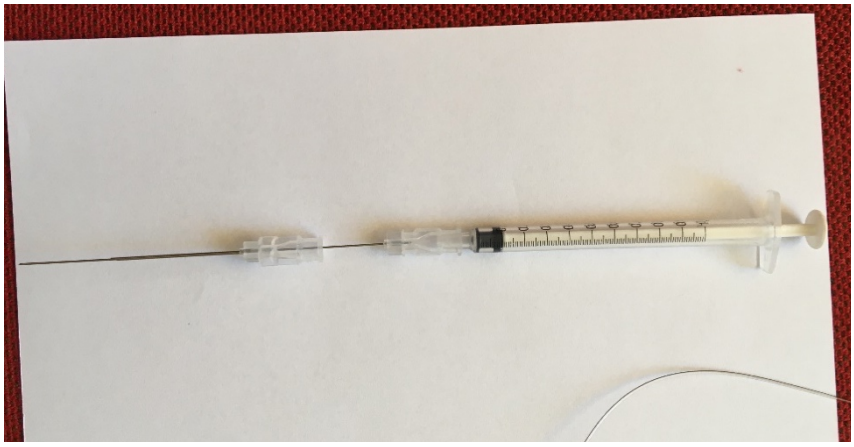

Figure 6. The needle for spinal anaesthesia

3.5 Design aspects

In the sections below, the design aspects applied during the project are presented.

3.5.1 Jordan's 10 design principles

In the book *An introduction to Usability,* Jordan (2002) discusses the ten design principles associated with usability. Presented below are seven of those, which were prioritized for this Master's Thesis.

Consistency

When designing for consistency, similar tasks should be performed in similar ways (Jordan, 2002). When performing one task the user gains experience, learning how to achieve another. The procedure for performing one task is consistent throughout the product for similar tasks. Inconsistency most likely increases the effort needed of the user, and leads to more errors.

Compatibility

When designing for compatibility, the users' expectations, based on the knowledge gained from the "outside world", should be aligned with the usage of the product (Jordan, 2002). A design with a high compatibility enables generalization, where the user can use knowledge from another situation, using "outside sources". The outside sources can be anything from the outside world, affecting the way the user uses a product.

Consideration of user resources

Several resources or "channels" may be used when interacting with a product (Jordan, 2002). For example, the user might be using their hands, eyes and ears when tuning a TV set. When using a product, it is important that none of the user's resources are overloaded. Consideration of the demands placed on the users' resources during interaction needs to be taken into account.

Feedback

After performing an action, it is important that the user gets clear feedback (Jordan, 2002). Clear feedback means that the interfaces should provide confirmation of the performed action, as well as the consequence of the action.

Error prevention and recovery

The design principle error prevention and recovery means designing a product so that the probability of user error is minimized (Jordan, 2002). Further, including easy and fast ways to recover if errors occur. The undo command is one example of a way to enable recovery.

Visual clarity

When designing for visual clarity, it is important to enable the user to read the information presented in a fast and easy way, minimizing the risk of confusion (Jordan, 2002). Visual clarity includes aspects such as the size of the alphanumeric characters, the amount of information presented in a certain space and colour coding.

Explicitness

The meaning of explicitness is designing a product so that it is clear how to use the product (Jordan, 2002). The design principle can be referred to "affordance", which is Norman's way of describing it. This includes providing strong clues, also called affordances, of how to operate with a product, making the usage explicit.

3.5.2 Usability aspects

Presented below are three different usability aspects that have been central during the project.

Efficiency

Jordan (2002) defines efficiency as "the amount of effort required to accomplish a goal". When deviating from the critical path, the efficiency decreases. If approaching a task, using more than the necessary effort required, the user deviates from the critical path.

Jordan (2002) further discusses the rate of error, one of the most commonly used measures. The less errors made; the less effort needed. However, the most widely used measure of usability is the time of the task. The quicker the user can complete a task, the higher efficiency.

Intuitive design

The definition of intuitive design does not yet have an agreed-upon definition (Interaction Design Foundation, n.d.). Informally the expression is used to describe designs that are easy to use. When a user does not have to consciously think about how to use a product, and immediately understands the design, that is what we call intuitive design. Including principles from other well-known domains will provide intuitive usage. However, these principles can vary from user to user since what is considered to be well known differs between different users.

Guessability

"Guessability is a measure of the cost to the user in using a product to perform a new task for the first time", stated by Jordan (2002). The higher guessability, the lower the cost. This means for example the less time is spent on each task, or the less errors are made, the greater ability the user has to learn the product. Further, including factors are the effectiveness, efficiency and satisfaction of which the user can complete specific tasks the first time interacting with the product.

4. Methodology

In this chapter, the methods used for the project are presented. This includes the theory of user studies methods, ideation methods as well as evaluation methods.

4.1 User studies

Presented in the following sections are the empirical methodologies used in this project.

4.1.1 Survey

A survey is used to collect data from a large number of people that can be difficult to reach personally (Bligård, 2015). During a survey, no interviewer is present. Instead, a form is sent out and answered in text. There is no personal contact between the respondent and the person responsible for the survey. A survey is a type of structured interview, containing several questions. The construction of the questions is important in order to receive the desired answer of the question.

4.1.2 Interviews

The aim of interviews is to investigate opinions, attitudes, experiences, behaviours as well as motivations of users, considering services and products (Nilsson Wikberg et al., 2015). Furthermore, the method can be used in order to collect expert information within a specific area.

The method is useful in various phases of the design process, in different ways (Nilsson Wikberg et al., 2015). For example, interviews can contribute at the early stages of the process with greater insights into the experiences of a product, from a user perspective. Furthermore, information about the usage of a product can be investigated. For the later stages of the design process, interviews can be used in order to get feedback on concepts developed.

An interview can be structured in three different ways; structured, semi-structured or unstructured (Nilsson Wikberg et al., 2015). In a structured interview, only the specific questions created for the interview are asked. On the other hand, an unstructured interview is performed more as a conversation, enabling the participant to talk freely regarding a specific area. A semi-structured interview, is something in between a structured and unstructured interview, enabling the participant to answer questions, yet with flexibility.

Probing

During an interview, it is common that less information is given in comparison to what is needed (Taylor-Powell & Camino, 2006). When more in-depth information is required, or when the answers are not clear, follow-up questions can be added, using probing. The method cannot be planned ahead, but usually questions such as “why?” and “how?” are included.

4.1.3 Focus groups

A focus group consists of participants within a specific field, discussing a specific area or issue (Nilsson Wikberg et al., 2015). The purpose of the method is to enable the participants to build on each other's thoughts and ideas. This method can be useful in many different stages of the design process, as an interview. Furthermore, the questions for a focus group can be structured in the same ways as for an interview.

4.1.4 Likert scales

In order to measure attitudes, Likert scales can be used. In a Likert scale, five categories are commonly used, from which the participant can choose (Jamieson, 2004). These can for example be 1 = strongly disagree, to 5 = strongly agree. As stated by Jamieson (2004), a Likert scale contributed to "a range of responses to a given question or statement".

4.1.5 Observations

In order to identify the undiscovered areas of development, and the user needs in specific situations, observations can be used (Nilsson Wikberg et al., 2015). This is done by listening to, seeing, asking about, and experiencing the situation the user is in. The purpose of the method is to facilitate an understanding of what might contribute to a great user experience. Aspects of what is difficult to understand, and what is intuitive to the user, is what observing is about. Further, providing an understanding for important aspects considering the user in relation to the task and the user's goal and attitude towards this task.

The general procedure of observing the user includes participation with the user, when performing a certain task (Nilsson Wikberg et al., 2015). The duration of an observation can varies depending on the situation. Further, notes are taken considering important aspects and questions can be asked if suitable.

4.2 Analysis methods

Presented in the following sections are the analytic methodologies used in this project.

4.2.1 KJ analysis

A KJ analysis is used in order to gather a large amount of data, where an overview of the result is provided (Bligård, 2015). Individual parts of the result from the data collection are written on separate notes. The notes that are related to similar areas are categorized

together and the group is then given a headline. The method is initiated by investigating the details, and eventually an overview of the analysis is reached. No grouping of data is needed from the beginning, which is one of the advantages with the method.

4.2.2 Persona

A persona is a fictional character representing a user group (Nilsson Wikberg et al., 2015). The description of a persona is based on information and material gathered considering the context of the user group. Among others, this can include interviews and observations, or statistics. The method is used in order to convey a better understanding of the user group, including their needs.

4.2.3 Scenario

In order to further convey an understanding of the user group, including how they act and react in a situation or with a design solution, a scenario can be created (Nilsson Wikberg et al., 2015). In a scenario, a story of the user in a specific situation is presented. It can consist either of a story considering a current situation, or a situation of the future.

4.3 Ideation methods

In this chapter, the ideation methods used for this Master's Thesis are presented.

4.3.1 Brainstorming

Brainstorming is an ideation method used in order to generate a variety of ideas (Nilsson Wikberg et al., 2015). This method has a greater focus on the quantity, rather than the quality of the ideas. The method enables the participants to further improve and develop ideas generated by other participants. Furthermore, no limitations exist when using the method. This means that different ideas can be developed, without any consideration of the consequences regarding costs, usability or feasibility. When using the method, it is important not to criticize any ideas of the individuals participating. The ideas are either written or sketched.

Brainwriting

Brainwriting is a method where brainstorming is carried out, using text (Nilsson Wikberg et al., 2015). Individually, the participants write down ideas for a certain amount of time, which are then sent to the next person. All participants are included in the ideas developed and the whole group's creative potential is used.

Braindrawing

Braindrawing includes a similar technique as brainwriting, however using sketches instead of text (Nilsson Wikberg et al., 2015). The use of sketching can generate new perspectives and further stimulate creativity. Several people can commonly develop an idea through sketching.

4.3.2 Morphological matrix

A morphological matrix is a method used in the ideation phase in order to develop different sub solutions out of identified functions and criteria (Nilsson Wikberg et al., 2015). As a starting point, a functionality analysis is used to break down the main function into different sub functions. After this, different solutions are developed for each sub criterion. The sub solutions within each function are then combined with each other in various ways, one solution from each function per concept.

With help of the method, a variety of concepts are developed within a relatively short amount of time (Nilsson Wikberg et al., 2015). The method can be used in order to stimulate the brain, by developing ideas within sub functions instead of the main function.

4.3.3 Prototypes

Prototypes are used in order to investigate the design and other potential solutions, as well as testing a concept (Nilsson Wikberg et al., 2015). A prototype can contribute with greater insights of the design, for further development towards a final design. Prototyping, the verb, is also commonly used, describing the experimenting aspect of the process. Developing an understanding for what the solution needs to be able to deliver, and learning from that, is the purpose of prototyping and prototypes. Further, the purpose is also to gain a better understanding of the design problem and investigate and experience the interaction between the user and the solutions. Prototypes are also used to test the solution's functionality and the user's understanding and experience of the design.

4.4 Concept weighting matrix

A concept weighing matrix is used with the aim of discussing different concepts based on different criteria, rather than personal opinions (Nilsson Wikberg et al., 2015).

A set of criteria are developed, and weighed against each other in order to rank their importance (Nilsson Wikberg et al., 2015). After this, the concepts developed are evaluated according to the set of criteria. In this step, the following gradings are used:

- Do not fulfil the criteria, 0 points
- Barely fulfil the criteria, 1 point
- Probably fulfil the criteria, 2 points
- Fulfil the criteria well, 3 points

A final grade of each concept is created by multiplying the grades of each criteria of a concept with the weighting of the criteria (Nilsson Wikberg et al., 2015). The results for each criterion of a concept are then summarized into a final grade. The last step of the method is to perform an analysis of the final concept with the highest grade. At this step, a discussion of the areas where the concept received low points is performed.

5. Implementation

In this chapter, the implementation of the project is presented. This includes all parts of the process, together with the methods used and in what way.

5.1 Pre-study

The Pre-study aimed at gaining a better understanding of the subject and the current situation. The knowledge gained was used in order to develop the empirical studies of the problem identification phase.

5.1.1 Literature study

In order to gain knowledge regarding the area, a literature study was performed. Different databases, such as Google Scholar, Chalmers Library and healthcare-related websites, were used in order to find relevant articles and books. The literature study included areas such as innovation and digitalization within healthcare and information related to Östra Hospital, the Emergency ward and Obstetrics and Gynaecology department.

5.1.2 Benchmarking

A benchmark was carried out in order to investigate the current workflow at emergency wards and maternity wards of other hospitals in Sweden. Two different surveys, one for the emergency wards and another for the maternity wards, were sent out to the Head of Units at several hospitals in Sweden. In total, 21 emergency wards and ten maternity wards were contacted.

The questions of the survey were adjusted depending on the user group; the consultants and less experienced doctors at the emergency ward or the anaesthesiologists and midwives at the maternity ward. The participants got different questions depending on their profession. The focus of the research was on the users' perceptions, and opinions, of the current situation of the workflow. See appendix 1 for the survey templates used.

Analysis

The data collected from the Benchmarking was analysed using Excel. In Excel, different diagrams and tables were created of the data presented in the surveys. Furthermore, the answers in text from the surveys were summarized and categorized by grouping similar answers.

The data from the emergency wards and maternity wards were structured separately.

5.2 Problem Identification

The aim of the Problem Identification phase was to gain a deep understanding of the user needs as well as identify the problem areas within the current queuing systems of today. The studies were carried out in the real working environment, with the healthcare personnel in question at Östra Hospital. The phase focused on empirical studies, which included interviews, focus groups and observations. The knowledge gained during this phase was used as the foundation of the ideation phase.

5.2.1 User studies

The procedures of the user studies performed at the Emergency ward and Obstetrics and Gynaecology department of Östra Hospital are presented below.

Pilot study

Before performing the interviews at the different departments, a pilot study was performed for each interview template used at the departments. The pilot study was performed in order to improve the quality of the interviews, and was conducted on individuals working within the healthcare organization. However, not at Östra Hospital. After the pilot study, the questions were adjusted to make them more understandable and efficient.

Interviews

Interviews, focus groups and in-depth interviews were carried out in order to gather insights about the current systems. The participants, location and duration and structure of the interviews are presented below.

Participants

The interviews and focus groups were performed with both more experienced doctors, such as senior physicians and residents, as well as newly graduated doctors at the Emergency ward. At the Obstetrics and Gynaecology department, midwives and anaesthesiologists were interviewed. See figures 7 and 8 for all the interviewees participating, including their profession.

In total, 19 individual interviews, and three focus groups, were performed. In addition, two in-depth interviews were carried out with Helena and Maria, the two initiators of the project, as well as an in-depth interview with a focus group consisting of three midwives. See appendix 2 for the full lists of participants and interview constellations at the two departments.

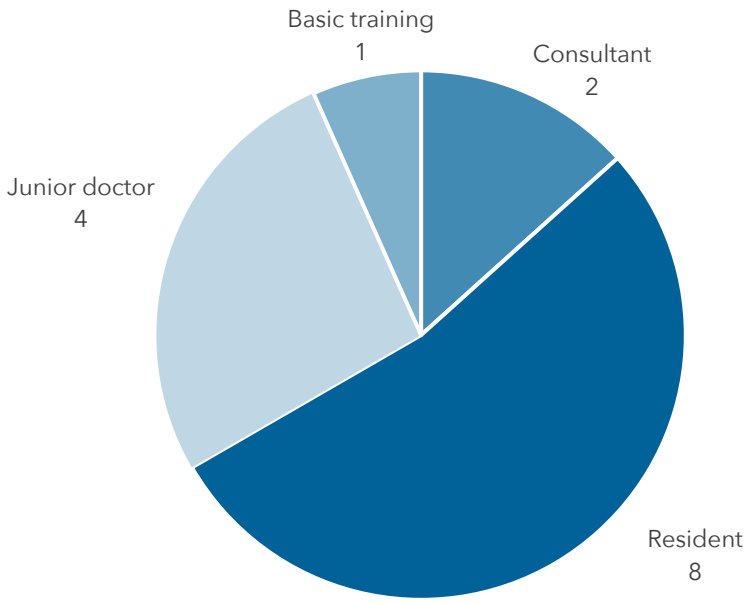

Figure 7. Participants of the Emergency ward

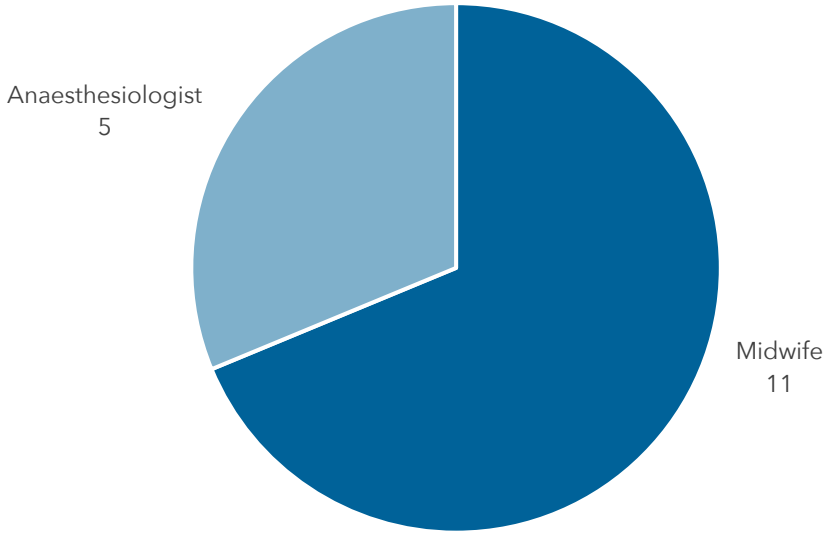

Figure 8. Participants of the Obstetrics and Gynaecology department

Location & duration

In order to avoid disrupting the users during work, the interviews were held during lunch or breaks. The interviews were recorded, with permission from the participants, and notes were taken during the conversations. The duration of the interviews varied depending on how much time the interviewees had, but the majority were approximately ten minutes.

Further, the in-depth interviews were about one hour long, and the in-depth focus group was about 30 minutes. See appendix 2 for the duration of every interview.

During the visits at Östra Hospital, informal discussions were also conducted with the employees of the departments. Among others, these discussions concerned the working situation generally, and included collection of data regarding the different shifts.

Interview structure

The interviews were semi-structured, using probing. This enabled the participants to express themselves further, in addition to the questions asked, and contributed to a more casual environment.

The interview template was sectioned with questions related to the participant's profession and their work, the current queuing system of today, perceived time intervals, as well as the interviewees' opinions regarding the matters. The interview templates were adjusted according to department and user group. Furthermore, for the in-depth interviews and focus groups, expanded versions of the original templates were used. See figure 9 for one of the interview occasions.

The questions were complemented with three Likert scales, including statements related to the perceived efficiency, usability and usefulness. The participants got to agree, or not agree, on a scale from one to five. See appendix 3 for all interview templates and the Likert scales.

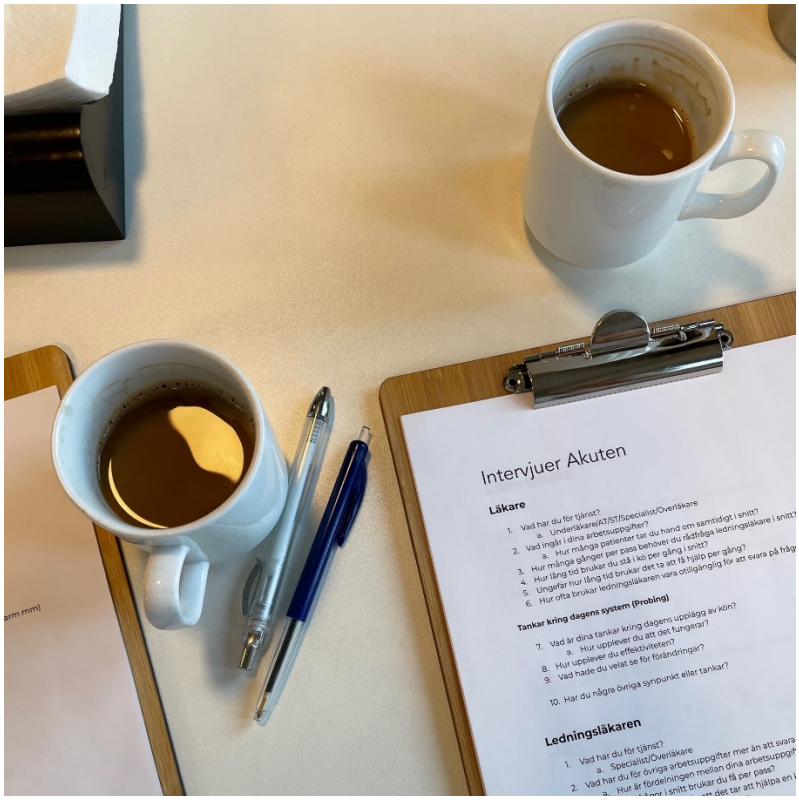

Figure 9. Interviews at the Emergency ward

Observations

Observations were performed at the two departments in question at Östra Hospital in order to gain greater insights into the current systems and workflows. The purpose of the observations was also to collect data on several parameters, such as different time spans and the exchange of information between the employees.

Location & duration

The observations at the Emergency ward were carried out on three different occasions, covering the whole timespan the consultant is attending as a consultant. In total, 13 hours and 20 minutes of observations were carried out, see table 2 for all the observations. However, there were breaks for lunch and interviews when consultation was not observed.

The observations were carried out from one of the corridors of the Emergency ward, enabling visual observation of the consultation office. However, auditory observation was not included.

Table 2. The observation at the Emergency ward

Occasion	Time of observation	Duration of observation
1	14:00-16:37	2 h 37 min
2	10:18-17:00	6 h 42 min
3	09:50-12:14 | 13:23-15:00	4 h 1 min
Total	13 h 20 min	

At Östra Hospital, there are three Maternity wards belonging to the Obstetrics and Gynaecology department, together with the Surgical ward 2, see chapter 1.2.2. The observations at the Obstetrics and Gynaecology department were carried out during six different occasions, including all four departments in question, covering all hours of the day. In total, 49 hours and 45 minutes of observations were carried out, see table 3 for all the observations. More time was spent at the Obstetrics and Gynaecology department due to the higher complexity of the current queueing system, compared to the Emergency ward. In addition to the ward stationed at, contact with the other Maternity wards was kept in order to observe the application of anaesthesia at all floors, which occurred sometimes.

Table 3. The observations at the Obstetrics and Gynaecology department

Occasion	Ward	Time of observation	Duration of observation
1	Maternity ward 312	07:40-16:45	9 h 5 min
2	Maternity ward 308	07:40-16:00	8 h 20 min
3	Maternity ward 314	07:40-16:00	8 h 20 min
4	Surgical ward 2	08:00-15:00	7 h
5	Surgical ward 2	15:00-23:30	8 h 30 min
6	Surgical ward 2	23:30-08:00	8 h 30 min
Total	**49 h 45 min**		

At the Maternity wards, the observations were carried out with the point of view of the midwives, who informed when anaesthesia was to be ordered. The majority of times, the orders were observed both visually and auditory. However, sometimes the information of the order was given after the call was made. Furthermore, the majority of the applications of anaesthesia were observed, with permission from the patients. In some cases, observations were also carried out from the corridor.

During the observations at the Surgical ward 2, an anaesthesiologist was followed during the workday. Since the anaesthesiologist could be contacted anytime, both considering incoming high emergency cases and the orders of the epidural anaesthesia, the anaesthesiologist was followed everywhere. The majority of times, both visually and auditory observations could be performed by following the anaesthesiologist to the patients. Further, when the anaesthesiologist received an order of the epidural anaesthesia, the speaker was on enabling observation of two-way communication.

Data collected

During the observations, several parameters were investigated in the departments in question. At the Emergency ward, this included time intervals considering the queue, consultation and absence of the consultant. Further, notes were taken regarding other relevant aspects, such as if someone was prioritized in the queue, or left the queue and went back to other work tasks. See appendix 4 for the observation template used.

At the Obstetrics and Gynaecology department, the duration between the order of the EDA and the arrival of the anaesthesiologist, as well as the duration of application, were investigated. Further, notes were taken regarding other relevant aspects, such as the exchange of information between the midwife and anaesthesiologist. In addition, the course of events of an epidural application was noted. See appendix 4 for the observation template used.

5.2.2 Analysis

In order to structure and analyse the data collected from the user studies, both a qualitative and quantitative analysis were conducted. The data collected from the two areas, the Emergency ward and the Obstetrics and Gynaecology department, were analysed separately.

Qualitative analysis

The data collected from the interviews performed were structured and analysed using the KJ-analysis, see chapter 3.2, one for each area.

As previously mentioned, the interviews were recorded which enabled transcription of the answers. The answers of each interview object were distinguished by different colours. After transcription and colouring, the results were printed, and the different quotes were separated.

The quotes were then grouped depending on the area discussed, according to the KJ-analysis method, see figure 10. The same process was performed both for the interviews at the Emergency ward, as well as the Obstetrics and Gynaecology department.

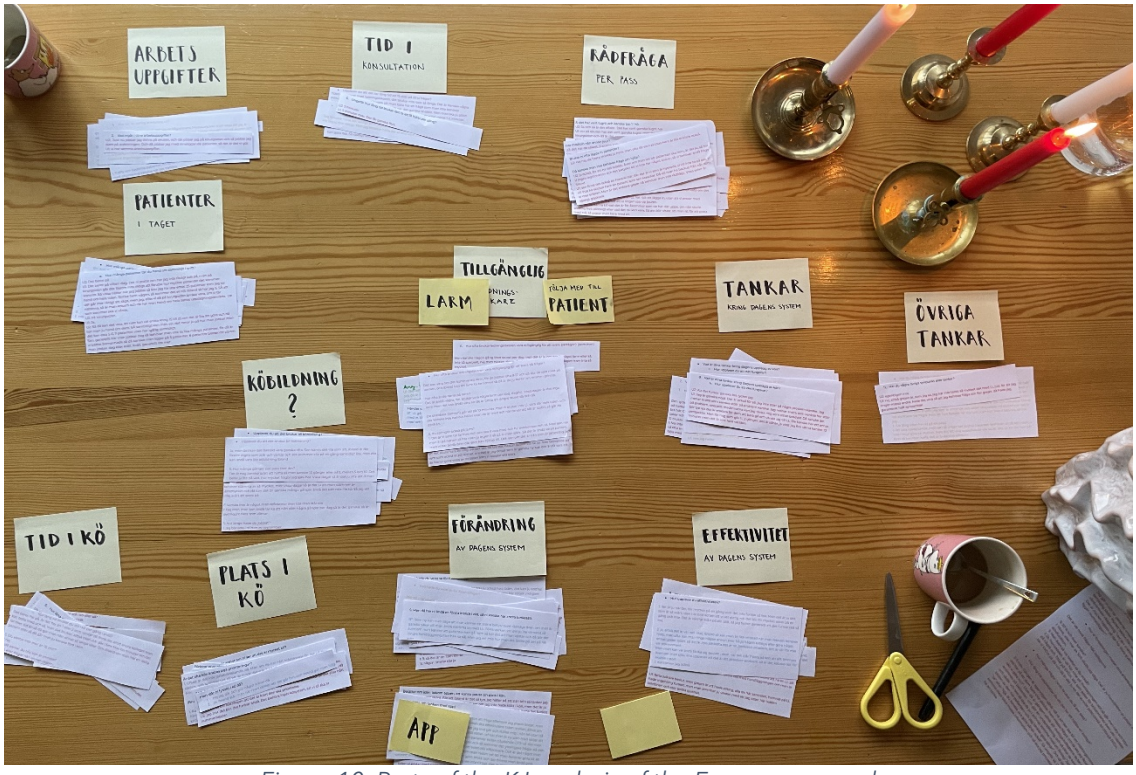

Figure 10. Parts of the KJ analysis of the Emergency ward

Quantitative analysis

In addition to the qualitative analysis, a quantitative analysis of the data from the observations was carried out.

The time parameters investigated at both departments were structured, analysed and summarized using excel. Further, sections were marked in different colours regarding aspects such as if a doctor was prioritized, for example.

Lastly, the data was summarized, calculating the mean values for all time intervals and summarizing the total numbers of consultations carried out, anaesthesia applied and the formation of a queue.

5.2.3 System illustration

In order to organize, visually, how the different departments investigated at Östra Hospital are structured, system illustrations were developed. One for each ward.

In order to develop the system illustrations, the different wards were visualized using paper and pen during the observations performed. After this, the illustrations were refined using Adobe illustrator.

5.2.4 Personas & Scenarios

In order to communicate the users' needs, and the current systems of today, personas and scenarios were created.

In order to include all user groups' points of views, four personas were developed; a resident, a consultant, a midwife and an anaesthesiologist. General thoughts considering their job, and the current situation of today, were included.

Two scenarios were created in order to communicate the current systems and problem areas. The general course of events was included together with some complications that were found during the empirical studies.

One of them was developed related to the situation at the Emergency ward: a resident in need of consultation with the senior physician. The scenario was created from the resident's point of view, due to the problem areas mostly affecting the doctors in question.

For the Obstetrics and Gynaecology department, the scenario communicated the situation when a midwife is in need of anaesthesia from the anaesthesiologist. Both the midwife's and anaesthesiologist's points of view were included, due to problem areas arising for both parties.

5.2.5 Requirement specification

A requirement specification was developed in order to structure and define the user needs, as well as determine which ones are of higher importance.

The knowledge gained during the problem identification phase was used in order to construct the requirement specification, in combination with the set requirements from the initiators of the project. A common list, considering both the two departments, of requirements and desires, as well as a common list for guidelines were developed. Further, one requirements and desires list were constructed individually for each department. The requirements and desires were categorized according to the user group concerned, and marked with a “D” or “R”. Further, all desires and guidelines were weighted from one to five in order to prioritize the importance.

5.3 Design process

In this section, the concept development phase is presented. The phase aimed at creating the first set of ideas, as well as developing the concepts for user testing.

5.3.1 Initial ideation

The first step of the ideation phase was to structure the different interactions with the application into three main areas; the Emergency ward, the Obstetrics and Gynaecology department, and common features. This was performed by proceeding from the requirement list.

After structuring, the first ideation session was performed, with a focus on the common features of the application. The session included a modified version of brainwriting 6-3-5 and braindrawing, see chapter 3.4.1, including ideation individually for five minutes, followed by a discussion of the ideas developed. Solutions were developed considering areas such as the structure of the start page, the presentation of information, and the marking of triage and position in the queue, see figure 11.

After ideation of the common features, a session related to the Emergency ward was performed. For this session, ideation was performed from the different views of the user groups; the doctor and the consultant. For the interface of the doctor, ideas were developed considering areas such as how to get in line for consultation, and how to pause or delete one's position in the queue. For the consultant, ideas were developed considering areas such as how to initiate and finish consultation, and how to pause the entire queue due to incoming high emergency cases.

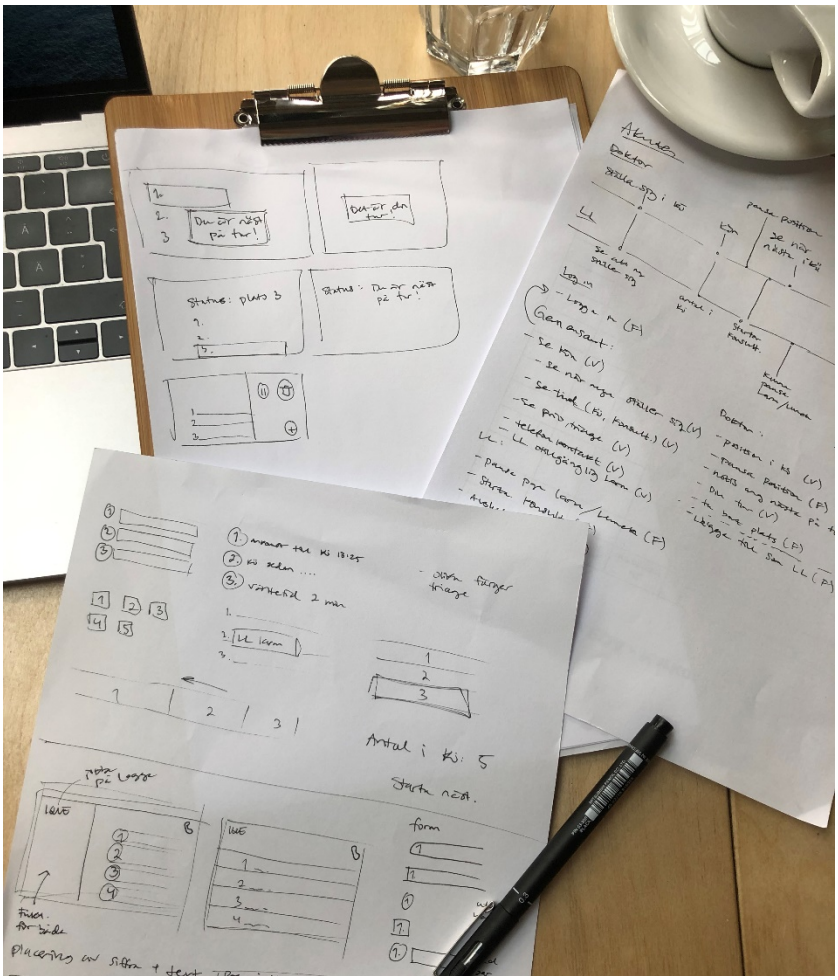

Figure 11. The initial ideation

The ideation of the Obstetrics and Gynaecology department was performed in a second session. For this session, ideas of additional features only related to the Obstetrics and Gynaecology department were developed. Accordingly, the design and structure of different symbols and features such as buttons and the queue were not further ideated. This, since it had already been designed during the ideation of the Emergency ward.

The ideation session was performed from the different views of the two user groups concerned; the midwife and the anaesthesiologist. For the interface of the midwife, ideas were developed considering how to order anaesthesia and the status of their order, among others. For the anaesthesiologist, ideas were developed considering areas such as how to inform the midwife to prepare the patient, initiate and finish application of anaesthesia, and how to pause the entire queue due to incoming high emergency cases.

5.3.2 Visualization

After the initial ideation sessions, the sub solutions developed were further discussed and visualized using Adobe Illustrator. This, in order to clarify the different ideas further, to include them in the morphological matrices.

5.3.3 Morphological matrix

In order to further develop ideas, a morphological matrix was used, see chapter 3.4.2. One for the Emergency ward, and one for the Obstetrics and Gynaecology department.

Ideation 1

The morphological matrix of the Emergency ward was structured in several categories. In each category, five to eight ideas were included.

New concepts were developed by choosing one sub solution per category, for each new concept. Eight initial concepts were developed for the Emergency ward. After this, a discussion was performed regarding the concepts developed. Furthermore, the most preferable ideas from each sub solution were summarized and four new concepts were developed out of these.

Ideation 2

For the Obstetrics and Gynaecology department, the same process was carried out. However, some parts already discussed for the Emergency ward were not included during the second ideation.

The morphological matrix was structured in several categories, with the majority of alternatives intended for both the midwives and anaesthesiologists. In total, four concepts were developed using the morphological matrix.

5.3.4 Concept Development

The aim of the Concept Development phase was to further develop, and modify, concepts, in order to enable proper user evaluation.

During this phase, the concepts developed from the morphological matrices were tweaked, prototyped and visualized using Figma. Furthermore, the interactions with the application were also mapped. In total, four concepts of the application for the Emergency ward were prototyped, and four concepts for the Obstetrics and Gynaecology department.

5.4 Evaluation

The Evaluation phase aimed at gaining an understanding of the usability and functionality of the different concepts. This phase was divided into two parts; evaluation with the users

and evaluation using a concept weighting matrix. The outcome of this phase was used to develop the final concept.

5.4.1 Evaluation with the users

Evaluation of the concepts developed was performed both with the users of the Emergency ward, as well as the Obstetrics and Gynaecology department. During the evaluation sessions, prototypes conducted in Figma were used in order to present the concepts developed.

Emergency ward

From the Emergency ward, Maria, initiator of this project, as well as a resident in emergency medicine, participated in the evaluation. The session was about 45 minutes long, and included a discussion about the flow, and aesthetics, of the application for the Emergency ward. In this session, both the view of the consultant, as well as the doctor in need of consultation, were presented and discussed. See appendix 5 for the template used during the evaluation session.

Obstetrics and Gynaecology department

The evaluation of the concepts developed for the Obstetrics and Gynaecology department was performed in two sessions. One session with three midwives and one anaesthesiologist, and a second session with the anaesthesiologist initiating this project, Helena.

The first session was about an hour long and divided into three parts. To begin with, the flow of the different concepts developed in Figma was presented to all participants. This, in order for the users to gain an understanding of how the interaction with the application is intended to work. After this, evaluation was performed with the midwives and the anaesthesiologist separately. In this part, the midwives got questions regarding the design and interactions with the application connected to the midwives. The same was applied to the anaesthesiologist, but from the view of the anaesthesiologist. All the participants were asked about what layout they preferred, if any information was missing or if there was an overload of information.

For this part, the different views of the applications were presented physically, printed on paper, in order for the participants to be able to view the different concepts developed at the same time, see figure 12. This also enabled the participants to express their thoughts and ideas of the application directly at the concepts presented on the papers.

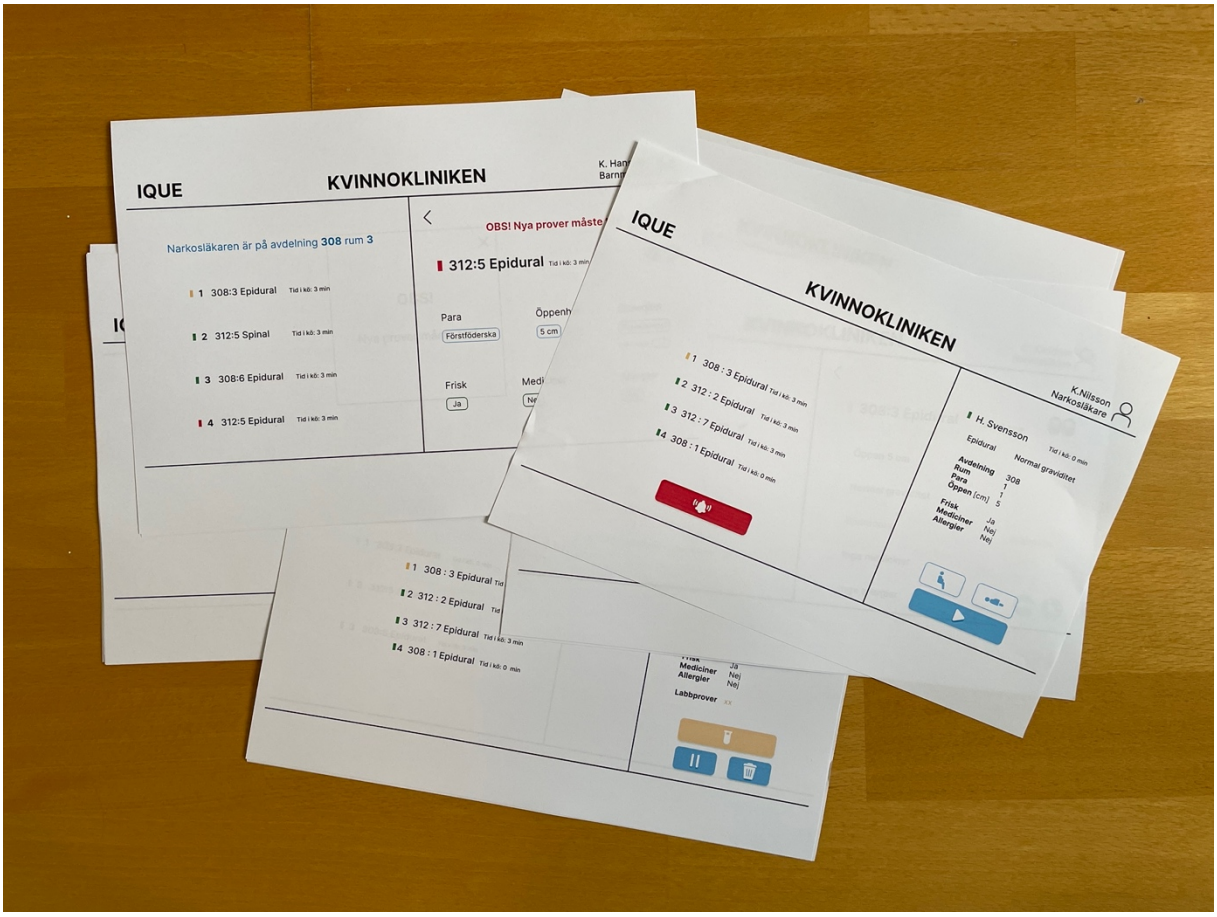

Figure 12. The concepts printed on paper

In the last part of the evaluation session, a general discussion with both the anaesthesiologist and the midwives was performed. In this part, further discussion of the different concepts was carried out, including what kind of information to share. See appendix 5 for the template used during the evaluation sessions of the Obstetrics and Gynaecology department.

The second session was also about one hour long, but performed digitally. As for the first session, it started with a presentation of the different concepts prototyped in Figma. After this, a discussion was performed regarding the different concepts, including the same questions asked in the first session. The evaluation included both discussion regarding the view of the anaesthesiologist, as well as the midwife.

5.4.2 Concept weighting matrix

In addition to the evaluation with the users, a concept weighting matrix was used for the two different departments, see chapter 3.5. This was performed in order to further evaluate the concepts objectivity, according to the guidelines. The criteria included were related to a selection of Jordan's design principles and the solutions efficiency, intuitiveness, guessability, see chapter 2.5.1 and 2.5.2.

5.5 Finalization

The aim of the final phase, Finalization, was to develop and prototype the final concept. The final concept was developed based on the insights gained from the Evaluation phase, including insights from the user evaluation as well as the concept weighting matrices.

The final concept was developed in Figma, where the different views and interactions of the application were created. This included a login page, intended both for the Emergency ward as well as the Obstetrics and Gynaecology department. In addition, the interaction flow of the application connected to the consultants and doctors at the Emergency ward was developed, as well as the interaction flow of the anaesthesiologist and the midwife at the Obstetrics and Gynaecology department. Lastly, a logotype for the application was developed using Adobe Illustrator.

5.5.1 Scenario with the final concept

A reconstruction of both scenarios was developed, including the final concepts instead of the current solutions. This was made in order to evaluate how the usage of the final concept could look like in a real situation and user environment.

6. Findings at the Emergency ward

In this chapter, the findings from the Problem Identification phase of the Emergency ward are presented.

6.1 Benchmarking

A survey was sent to the emergency ward of 21 different hospitals in Sweden. Out of these, 73 participants from eight different hospitals responded. In figure 13, the hospitals together with the number of participants are presented. The respondents got different questions depending on their profession. Junior doctors, interns and residents got the same questions, while specialists and senior physicians got others. See the distribution between the two groups in figure 14.

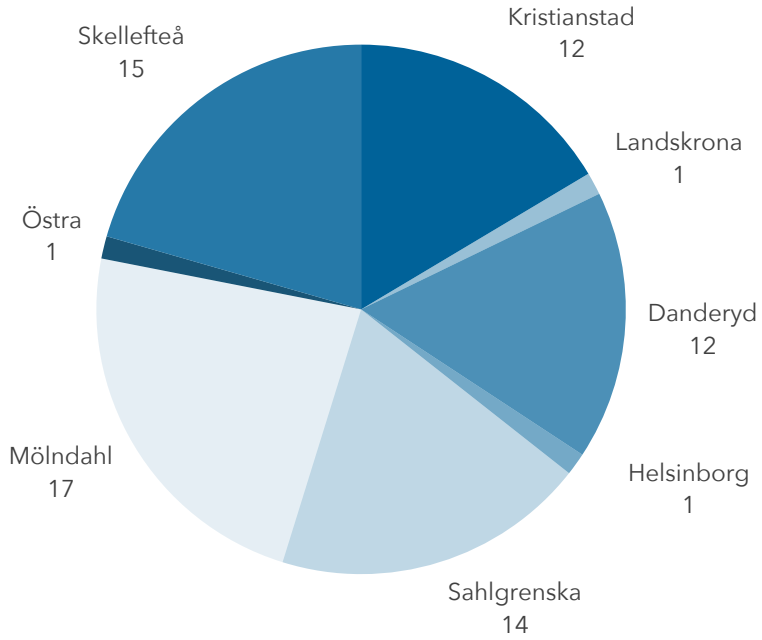

Figure 13. Number of participants at the emergency wards

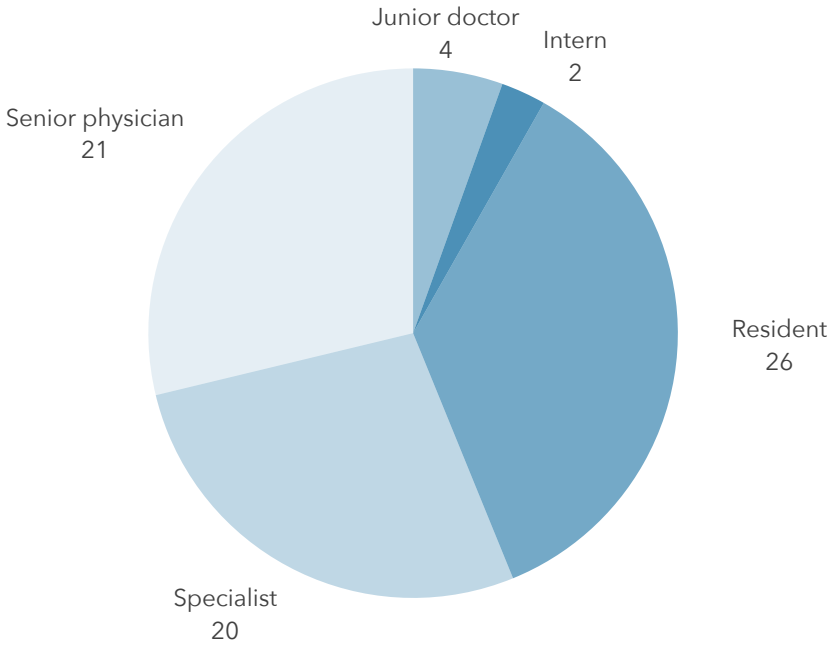

Figure 14. Distribution of participants at the emergency wards

The majority of the participants expressed that their main work task is to diagnose and treat patients at the emergency ward. Furthermore, many of the participants also explained that they work as a consultant, supervising less experienced colleagues. Some of these participants only worked as a consultant, while others also treated patients themselves.

According to the majority of the participants, consultation is conducted either by phone or personal contact. Most often, the less experienced doctors present the current state of a patient, and then a discussion of how to move forward with the patient is performed. Some of the participants mentioned that they use SBAR[6] for this. In some cases, the doctors also look at samples taken, or discuss x-rays. Furthermore, some of the more experienced doctors explained that the consultations can vary depending on how experienced the less experienced doctor is. For the more inexperienced doctors, more supervision and guidance are needed. In addition, some of the consultants mentioned that they sometimes also follow the colleague to a patient if needed.

6.1.1 Consultants

For all the specialists and senior physicians, excluding one, it is included in their work tasks to support the less experienced doctors of the emergency wards. However, the respondent answering that consultation was not included, mentioned that there is a possibility for consultation through phone calls with doctors on call.

The majority of the consultants spend 40-60 percent of their working hours to supervise and instruct less experienced colleagues, and the consultations take five to ten minutes on average.

Regarding areas of improvement, some of the participants believed the system of today could become more efficient, and the communication work better, while others believed it worked well. These areas were all pre-typed in the form. In addition, some participants expressed their own areas of improvement. For example, several respondents expressed the need of a consultant working full time answering questions. This in order to enable better and more proper consultation. Some others mentioned the need for more prepared doctors when consultation is initiated. Furthermore, some participants mentioned the time pressure and high workload at the emergency wards. Too many questions from different doctors can in these situations make the workflow inefficient. See appendix 6 for more details regarding the results.

[6] SBAR stands for Situation-Background-Assessment-Recommendation (Medical Dictionary, 2009)

6.1.2 Doctors

Out of the doctors not working as consultants, the majority have the possibility to consult with a more experienced doctor. The remaining participants explained that they have the possibility to call a doctor on call, but did not have a consultant located at their emergency ward.

On average, the majority of the participants consult with a more experienced colleague less than five times per work shift. Furthermore, they have to wait less than five minutes on average for consultation.

The areas of improvement according to the less experienced doctors regarded both the efficiency of the system, the communication with the consultant as well as the queueing system. However, most participants believed the system of today worked well. In addition to the already stated alternatives, some of the participants also mentioned the need for better availability of consultants. See appendix 6 for more details regarding the results.

6.2 User studies

In this chapter, the result of the user studies performed at the Emergency ward at Östra Hospital is presented.

6.2.1 Structure of the Emergency ward

In this section, the structure of the Emergency ward at Östra Hospital is explained, together with a system illustration, see figure 15. The information below is collected from the observations, combined with clarifications from the in-depth interview. The system illustration is not created with fully correct dimensions. However, it is used in order to get a better picture and understanding of the structure of the ward.

Figure 15. System illustration of the Emergency ward

Patient & waiting rooms

The emergency ward of Östra Hospital is structured in two sections, one part for medicine cases and one for surgical cases. In total, there are 19 patient rooms. The rooms 1-9 are intended for the medicine section, and the rooms 10-17 are intended for the surgical section. In addition, room 18 and 19 are used for observation. Furthermore, six monitoring sites exist, as well as six sites for lying wait for patients in need of a bed instead of sitting in the waiting room.

Two emergency rooms are located in connection to the ambulance entrance. In these rooms, the patients arriving with the ambulance are taken care of. Furthermore, there are two waiting rooms connected to the emergency ward. Outside of the ward, where incoming patients are waiting, as well as inside the emergency ward, where patients for example are waiting for test results.

Shared office space

At the centre of the emergency ward, all the doctors and nurses have a shared office space, enclosed by glass. This enables the healthcare personnel to have an overview of the ward, including the patients placed at the monitoring sites and lying wait sites. The personnel are divided into different teams consisting of a mix of doctors, nurses and assistant nurses.

Medical and surgical team

Team 1 and 2 belong to the medical section, where Team 1 consists of more experienced doctors and Team 2 of less experienced doctors. The medical team takes care of patients arriving at the emergency ward for all sorts of reasons, for example elderlies with very diffuse problems.

Team 3 and 4 are the surgical teams, where Team 4 are more experienced doctors, and Team 3 consists of less experienced doctors. The surgical team handles the patients who for example have more specific abdominal pain, which is the most common cause when going to the emergency ward. The cause of abdominal pain can be a number of reasons, everything from gastric catarrh to a twisted ovary.

In the working area of Team 4, a medicine room is placed. From here, the nurses get medicine to the patients. Team 3 is not located in the glass area, but in one of the surgical corridors. Next to their office, a candidate room is located where medical students have their room.

Consultant

In addition to the four teams, a consultant is working at the emergency ward during the day. The office of the consultant is also located in the large shared office space. However, it is entirely enclosed by walls and a door in glass. This enables the consultant to work without being interrupted, while still being able to monitor the ward. Currently there are 7-8 consultants working at the emergency ward, however during different shifts.

PTB team

In addition to the consultant, the doctors working in the PTB office also have their work area completely enclosed by glass. In Swedish, PTB is an abbreviation of *primär teambedömning*, meaning primary team assessment in English.

In the PTB team, more experienced doctors are working. Furthermore, the PTB nurses have their workplace in connection to the PTB office of the doctors. As for the doctors, the nurses working in the PTB team are more experienced. Neither the consultant nor the doctors working in the PTB office belong to one of the teams at the emergency ward, but are working with both medical as well as surgical cases.

Co-ordinator

A nurse responsible for the management is seated on one of the short sides of the shared office space. This nurse has an overview of the patients at the emergency ward, how many patients each team is in charge of, and the number of patients waiting to get help. The nurse is also in charge of the incoming emergency calls. Next to the nurse, a clerk is positioned.

Working shifts

The working hours of the doctors in the teams are divided into three shifts. Further, the PTB doctors are working during the day and evening, but the consultant is only available during the day. See table 4 for the different working hours.

Table 4. Working shifts at the Emergency ward

Profession	Day	Evening	Night
Doctors	08:00 - 16:00	13:00 - 21:00	21:00 - 08:00
Consultant	09:00 - 17:00	-	-
PTB doctors	08:00 - 16:00	15:00 - 21:00	-

6.2.2 Interviews

Presented in this section is the result of the interviews performed with the doctors and consultants at the Emergency ward. The data includes the findings from the interviews, focus groups and the in-depth interview.

Doctors

In the sections below, the findings from the interviews with the doctors of the Emergency ward are presented.

The majority of the interviewees participating in the user studies work as residents. As part of their residency training, the residents working at the Emergency ward are also working on other departments. However, the majority of their residency training, is spent at the department of their specialty. In addition to the residents, some junior doctors and a doctor performing the basic training participated.

The majority of the participants worked at the surgical department of the Emergency ward, and some were stationed at the medical department.

Work tasks

The main work tasks mentioned by the doctors were seeing and evaluating patients, and being available at incoming high emergency cases. During the in-depth interview, it was stated that the main work task at the Emergency ward is to assess the severity of the patients and to exclude everything that is dangerous.

At the Emergency ward, the doctors are not investigating long term problems. If the patient is seriously ill, it is the doctor's job to stabilize the patient to make it 24 hours. If

the doctor does not find any severe problem, the patient can go home. The majority of times, the patients do not get hospitalized. The resident participating in the in-depth interview estimated that seven to eight per cent of the patients of the Emergency ward get hospitalized.

Further discussed during the in-depth interview were the work capacity in relation to the number of patients. As mentioned by the resident, it has been calculated that a hospital should be occupied 80-90 per cent of its full capacity to be able to perform good care. A hospital should be staffed ten per cent more than what is necessary. At Sahlgrenska, the average value of occupancy is 123 per cent, which means that the hospitals are constantly understaffed with approximately 20 per cent.

Number of patients

Generally, the doctors at the Emergency ward handle between one to five patients at the same time. Some of the junior doctors mentioned that they did not want to handle as many patients at a time, due to their lack of experience. However, the majority of the participants agreed that the number varied depending on several different factors. For example, the condition of the patients affects the number of patients the doctor can see at a time. Several interviewees mentioned that parts of the examination such as x-rays, waiting for test results and similar, could make time for additional patients. Further mentioned was that ideally, they wanted to finish cases before taking on additional patients.

During the in-depth interview, it was shown that the experienced resident usually handles approximately five patients at a time, varying depending on which team the resident is stationed in. When working in the surgical team, up to seven to eight patients can be handled at the same time, due to the wait for x-rays and similar. Further, the patients who come to the surgical team are most often relatively young and stable. However, in the medical team, the resident sees three to four patients, since they often have a more problematic medical history and their physical state can change more quickly.

During the night

During the night, fewer doctors are working which contributes to an increased workload for the doctors on site. Therefore, the number of patients, per doctor, was considered to be higher during night hours, estimated to approximately five to seven patients. However, one participant perceived the workflow during the nights as faster due to the decreased amount of healthcare personnel. Therefore, the time spent on every patient was considered to be shorter. This was also mentioned by the experienced resident. Further, an experienced doctor working 18:00-00:00, handles all patients who take less time and answers to all incoming high emergency cases. As a less experienced doctor, you therefore focus fully on your patients and can also consult with the doctor working 18:00-00:00, since it is an experienced emergency physician. Further, around 01:00 the flow usually pauses for a while.

Number of consultations

The number of occasions per work shift that the doctors need to consult with the consultant varied extensively according to the interviewees. It depends on different factors, such as the number of patients at the Emergency ward, as well as the severity of the patient's condition. Furthermore, less experienced doctors, like junior doctors, tend to ask more questions than, for example, residents. However, the majority of the participants believed they consult with the consultant at least once per patient, while some discussed every other patient.

From the in-depth interview it was discussed that the need for consultation decreases as the experience increases. The resident described the experience as an individual patient library with references of different cases. The more patients a doctor meets, the larger the library gets, and the easier it gets to recognize a certain illness. When being less experienced, the doctors need more guidance considering the continued assessment of the patient, while the more experienced doctors usually have come to a conclusion and want to make sure they have not missed anything.

Several of the interviewees expressed the access of consultancy as an exceptional asset. They consult with the consultant both in order to get help, but also to confirm and double check patients, as well as learn more. The experienced resident believed that the discussions held are also a way of learning, listen to different points of views.

In addition to talking with the consultant, many of the interviewees also mentioned that they discuss patients with each other. Furthermore, they also have the opportunity to call the emergency services in other departments.

Queueing for consultation

All interviewees experienced that queuing for the consultant occurs at least a couple of times a day. However, the time spent in the queue is not more than 10 minutes. Further, if a doctor has an urgent question, this is prioritized and the doctor may precede the queue. This could for example be due to a higher level of triage of the patient in question.

If the doctors choose to leave the queue, they lose their position. The experienced resident believed that there is always a queue, or that the consultant is occupied when being in need of consultation. Approximately 50 per cent of the time when the resident wants to ask a quick question, that is not possible. If the queue seems to be too long, several of the interviewees mentioned that they wait until it has decreased, or discuss their cases with another experienced doctor. The resident participating in the in-depth interview does not get in line the majority of times there is a queue, but sometimes, in order to get a small break or talking to colleagues while waiting.

Duration of consultation

According to the majority of the participants, the discussions with the consultant only take a few minutes. However, some exceptions occur, where consultation takes up to 10 minutes. The duration of the consultation is varying depending on which consultant it is, according to the experienced resident.

When a doctor is consulting with the consultant, they often present their cases using the communication model SBAR. SBAR stands for Situation, Background, Assessment and Recommendation. To begin with, the doctor presents the current situation of the case to the consultant. Further, the doctor gives information about the relevant background of the situation, followed by the current assessment of the case. After this, a discussion takes place where the doctor either presents the intended continued work, or gets recommendations from the consultant.

Most often, only discussion is needed. However, the consultant can follow the doctor to the patient concerned if needed, but this is not as common as only discussion. As mentioned in the in-depth interview, the resident learned over time to only mention the most significant aspects of the case, which decreased the duration of the consultation. Today, the resident presents the patient in 1 minute, presents how to move forward and then discusses with the consultant for 2-3 minutes.

Availability of the consultant

The consultant is available during the day between 9:00-17:00. For the remaining hours of the day, there are doctors on-call available to contact if consultation is necessary. Further, during the night the doctors usually call the standby duty. The on-call 3 team at the hospital can also be contacted with more simple questions related to electrocardiograms for example.

Incoming high emergency

If the consultant needs to attend to an incoming high emergency case, this is prioritized before anything else and the queue is paused until the consultant is back. An incoming high emergency occurs at least once a day, and can take from 20 minutes up to an hour, depending on the case.

If there is an incoming high emergency case arriving with an ambulance, the consultant needs to participate. Most often, the consultant has a helicopter perspective of the situation, having the responsibility of the patient, while a more experienced doctor handles the patient. However, in some cases the consultant also takes care of the patient. This depends both on what type of emergency it is, but also how experienced the doctors in the emergency team are.

Furthermore, the other type of incoming high emergency that the consultant needs to attend is if a cardiac arrest occurs at the hospital. In these cases, the consultant leaves the Emergency ward to other departments.

During the incoming high emergency cases, the doctors usually consult with each other instead, if possible. Further, during the in-depth interview, it was mentioned that the doctors usually consult with the residents who are almost about to become specialists. This is common if the queue is long or during night shifts when the consultant is not available.

Opinions of the current system

The majority of the participants experience that the system of today works well, and is perceived as efficient. Some mentioned that it would be preferable if the consultant is available more hours a day. However, several of the interviewees explained that it is always possible to help each other, or call doctors on duty if the consultant is unavailable. One of the participants suggested having other doctors than the consultant available to answer questions. For example, these doctors could help the less experienced doctors with more simple questions, while the consultant gets more time for the more complicated questions. This would also result in a shorter queue to the consultant.

Efficiency

A few participants believed the system is inefficient, and that it is difficult to prioritize the importance of the questions. During the in-depth interview it was mentioned that the system of today works well except for when the queue hinders the workflow. Not only considering new patients, but the current patients the doctor is responsible for. Further, the resident believed that the opportunity of consulting is exceptional, as well as necessary, but that the efficiency of the system could be improved.

Changes of the system

Some interviewees believed the system of today is difficult to change. Since it is an emergency ward, it is not possible to predict the amount of patients, and their condition at the ward. However, some of them also expressed that a new solution is worth a try.

Consultants

In the sections below, the findings from the interviews with the consultants of the Emergency ward are presented.

Work tasks

As stated previously, two interviews were conducted with two of the consultants working at the Emergency ward at Östra Hospital. The participants were both working as consultants, but also seeing patients and performing regular tasks as doctors, such as performing ultrasounds of the heart, talking to the ambulance personnel or consulting

with the health centres. Both consultants were working the majority of their time with the consultation, at least 50 percent, or more.

Queue

Both participants agreed that a queue could appear during the afternoon, and did at least once. Two or three doctors can be queueing for shorter periods, and sometimes the queue can last for about an hour. One consultant mentioned that the queue during the afternoon was partially longer due to the increased number of doctors. The evening personnel arrive after lunch which means that twice as many doctors can have questions. Further, at the beginning of the week, especially on Mondays, there were always more questions. This occurred due to the unexperienced doctors starting on Mondays, having more routine-related questions. These types of questions usually decrease during the week. Further, the consultants did not believe the queue bothered them in any way, for example considering the feeling of stress.

Consultation

One of the interviewees mentioned answering approximately 30 to 40 patient-related questions per working period. Each consultation was estimated to be around five to ten minutes or two to three minutes. The length of the consultation depended on the personal relationship with the doctor in question, mentioned by one of the consultants. If the doctor was new to the consultant, the consultation could require more questions compared to a well-known doctor. The goal of the consultation is that the doctor should learn something, rather than just asking several questions. Preferably, the doctors should reflect on the case before consulting, suggesting how to move forward instead of asking.

Incoming high emergency cases

The number of times the consultants had to attend incoming high emergency cases was estimated to be one to three times per day. Further explained by one of the participants, these cases consider only the cardiac arrests, however at every adult department at the hospital. The time spent with the incoming high emergency cases differed depending on the severity of the patient. If the patient is not that ill, or if there is a cardiac arrest at the cardiac intensive care, the consultant can come back after approximately 15 minutes. However, if the severity of the patient is bad, for example, if one patient at the psychiatric department has hung oneself, a longer attendance can be needed.

Opinions considering the current system

The consultants believed there is no problem with the queueing system of today. One of the participants was included during the development of the queueing system and had a positive attitude towards it. The consultation system enables inexperienced doctors to practice their knowledge in a more tough environment. The other consultant discussed the general workflow of the Emergency ward. Today there is a need for consultation, due to the high number of inexperienced doctors working at the Emergency ward. The

participant believed that in the best of worlds, the consultation function would not be necessary. If the basic competence would be higher, the need for consultation would not be necessary during routine cases.

Efficiency

The efficiency of the queueing system was considered to be high according to one of the consultants. The other one stated that the queue is not a problem, but could relate to the problem of having an ill patient and not feeling like the queue is moving forward. However, the participant also believed that one could see the next patient instead of waiting and doing nothing if the queue is long.

Changes of the system

Considering changes of the queueing system, one of the participants believed that the queueing system in particular is a problem. The level of competence of the doctors influences the flow of the consultation. However, more experienced doctors or specialists, not responsible for the consultation, can always answer questions if the pressure is high. Further, one of the consultants believed that the consultation should preferably be available during the night as well. However, the other consultant mentioned a more negative aspect of having the consultant available. If the possibility is given at all times, this could also contribute to the doctors asking more questions than what is necessary. Further, the discussion between the doctors might also decrease.

6.2.3 Observations

Presented in this section are the findings of the observations at the Emergency ward. The result is related to the flow of patients, consultation and the queue. Further data presented are the time parameters and general aspects considering the workflow.

Personnel working during the observations

The scheme of the personnel working at the emergency ward is kept on paper at the ward. Presented in table 5 and 6 are the total number of doctors and nurses, as well as assistant nurses, working during the day and evening of the observations. Further, the majority of times, there was one doctor in the PTB team during the day and evening.

Table 5. The total number of doctors, nurses and assistant nurses working during the day shifts of the observations

Occasion	Doctors	Nurses / assistant nurses
1	7	10
2	7	10
3	6	9

Table 6. The total number of doctors, nurses and assistant nurses working during the evening shifts of the observations

Occasion	Doctors	Nurses / assistant nurses
1	4	8
2	4	8
3	6	7

Time intervals

Presented in this section are the time parameters related to the consultation, the queue and the consultant.

Queue

Table 7 summarizes the most important data related to the queue. A queue was formed 37 times, where the doctors queued for 2 hours and 15 minutes in total. When consultation was performed, a queue was formed approximately 40,7% of the time. The mean queueing time, when a queue occurred, was approximately 3 minutes and 39 seconds. The majority of times, the doctors only had to wait for around one minute, but sometimes up to ten minutes. On one occasion, a doctor had to wait for 22 minutes due to a cardiac arrest the consultant was attending. However, the doctor did other things during this time, such as working with other tasks.

Table 7.Summarizing data related to the queueing occasions

Occasion	Number	Total time	Mean duration
1	6	14 min	2 min 20 s
2	19	1 h 15 min	3 min 55 s
3	12	46 min	3 min 8 s
Total	**37**	**2 h 15 min**	**3 min 39 s**

Consultation

Table 8 summarizes the most important data related to the consultations. During the 13 hours and 20 minutes observed, 91 consultations were performed, with a total duration of 5 hours and 37 minutes. The mean time of consultation was approximately 3 minutes and 42 seconds. However, some consultations were less than 30 seconds while others were around 10 minutes.

Table 8. Summarizing data related to the consultations

Occasion	Number	Total time	Mean duration
1	21	1 h 4 min	3 min
2	44	2 h 51 min	3 min 53 s
3	26	1 h 42 min	3 min 9 s
Total	**91**	**5 h 37 min**	**3 min 42 s**

Consultant

Table 9 summarizes the most important data related to the consultant observed. The consultant was attending incoming high emergency cases for 2 hours and 31 minutes in total. During the observations, two cardiac arrests and one severe ambulance case occurred. When the consultant was absent, consultation was carried out with one of the specialists in the PTB office instead during one occasion.

After three consultations, the consultant accompanied the doctors to their patients. Further, during one occasion, the consultant was unavailable for 1 hour and 35 minutes due to a meeting and lunch. During the meeting, it was observed that one doctor was in need of consultation, seeking the consultant in the lunchroom. Furthermore, during 2

hours and 3 minutes of the observations, the consultants were not in the consultation office, however nearby talking to colleagues, talking on the phone or similar.

Table 9. Summarizing data related to the senior physicians

Occasion	IHEC*	Seeing patients	Nearby	Lunch/meeting
1	31 min		45	
2	26 min	19 min	29	1 h 35 min
3	76 min	2 min	49	
Total	**2 h 31 min**	**21 min**	**2 h 3 min**	**1 h 35 min**

*Incoming high emergency cases such as cardiac arrest at the hospital or a severe ambulance case

Additional aspects

Presented in this section are the general observations made, considering the flow of consultations and the queue.

Flow of patients

From the observations and informal conversations with the doctors, it was shown that the overall patient flow at the Emergency ward was low during the empirical study. As mentioned during the in-depth interview, the patient flow is usually around 140 to 190 patients per day at the Emergency ward. Around 140 patients were considered low according to the resident.

The number of patients seeking medical care at the Emergency ward during the days of observation was between 144 and 135. The lists were shown by a nurse who also mentioned that the numbers in the system could be higher than reality, due to patients being relocated.

Consultations

The overall flow of consultations was consistent throughout the days. Generally, there was a lot of movement within the office space, where the different doctors and nurses were discussing and working together. Further, the consultant was also walking around in the office space talking to colleagues.

The majority of times it was the doctors who consulted with the consultant. However, occasionally the nurses did too. During some consultations, information via the computer was included, while others only discussed the case without additional resources. Some doctors brought papers with notes, while others did not. Sometimes, additional doctors

entered the office asking quick questions. Further, doctors in the queue often joined the discussion inside the consultation office.

Queue

From the observations, it was shown that few doctors stood in line for longer periods of time. Usually, the occupation of the consultation office was monitored by the doctors. It was further discovered that the majority of the doctors did something else when the consultant was unavailable. However, several doctors glanced towards the consultant's office when the need for consultation occurred, rather than forming a queue. Further, the doctors who were stationed further away had to walk to the consultation office in order to discover that the consultant was occupied. Some doctors choose to interrupt their work to go to the consultant multiple times instead of waiting.

It was also observed that some left the queue, losing their position, if the wait was too long. Due to this, a queue, consisting of two doctors in line, only occurred three times during the observations. The queue, consisting of two doctors, did only last for about one minute. Further, two doctors were prioritized in the queue. One of these events occurred due to a phone call that the doctor first in line received.

6.2.4 Likert scales

After each interview, the participants got to fill in three Likert scales including statements related to the perceived efficiency, usability and usefulness of the current system. The scales included five steps, where the value on the left corresponds to "Disagree" and on the right "Agree completely". The mean values of the three Likert scales are presented in figure 16.

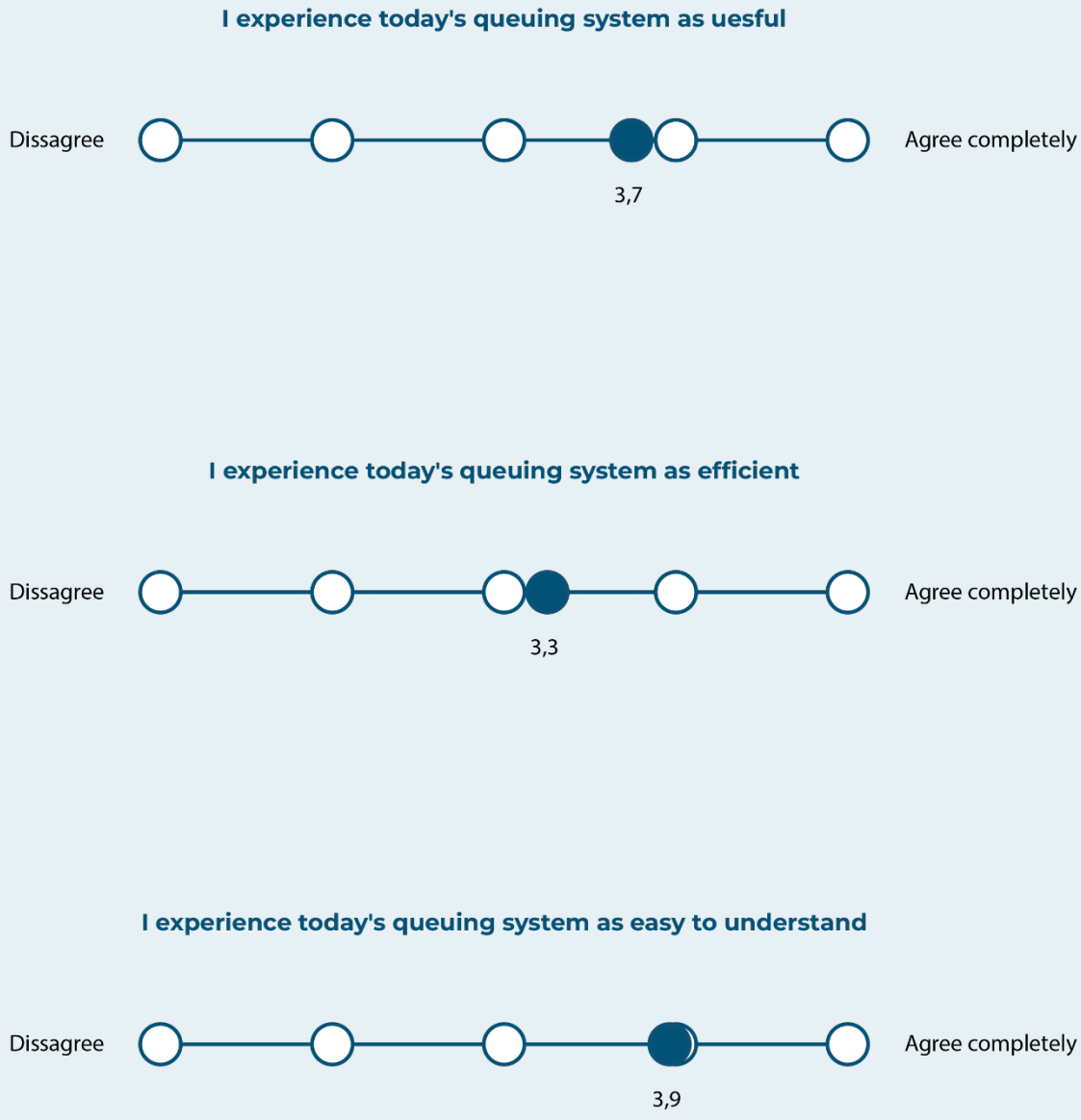

Figure 16. Mean values of the Likert scales

6.3 Personas & scenario

Based on the findings from the user studies, two personas and one common scenario were developed for the Emergency ward. Presented below are the two personas Kate and Peter and a scenario of when Kate consults with Peter.

Kate

Kate is a curious and committed doctor with a lot of energy. She is a resident in her first year, of five, of her specialization in emergency care. Currently, she is working at the surgical section at the emergency ward of Östra Hospital. She enjoys her work very much and always wants to learn new things. See figure 17.

Kate believes that consultation with a senior physician is an amazing asset, that she is more than happy to take advantage of. Sometimes, she chose to discuss with the senior physician, to double check the treatment of a patient, although she is quite certain of how to take care of the patient herself.

Kate gets along with her colleagues very well. When a queue is formed to the consultation office, which she believes happens a little bit too often, she still believes everyone has respect for each other and the most urgent cases are always prioritized. It is also possible to discuss with other colleagues than the senior physician, when the senior physician is not available but consultation is necessary.

Figure 17. Kate

Peter

Peter works as a senior physician at the emergency ward of Östra Hospital. He is a social man, enjoying his work and colleagues. See figure 18.

Peter believes the consultation function is an excellent resource since it enables better treatment of patients, but is also a great possibility for doctors to develop. However, he sometimes believes doctors use the asset a little too much and do not think by themselves before getting help. He believes it is important that the employees become self-reliant and trust their own abilities.

Sometimes, a queue is formed to the consultation office. However, this is not disturbing Peter in his work. He believes it is important to take the time needed for each consultation. Still, the work flow of the ward pauses and resources are not utilized, which is not preferable and therefore something he would like to see a change of.

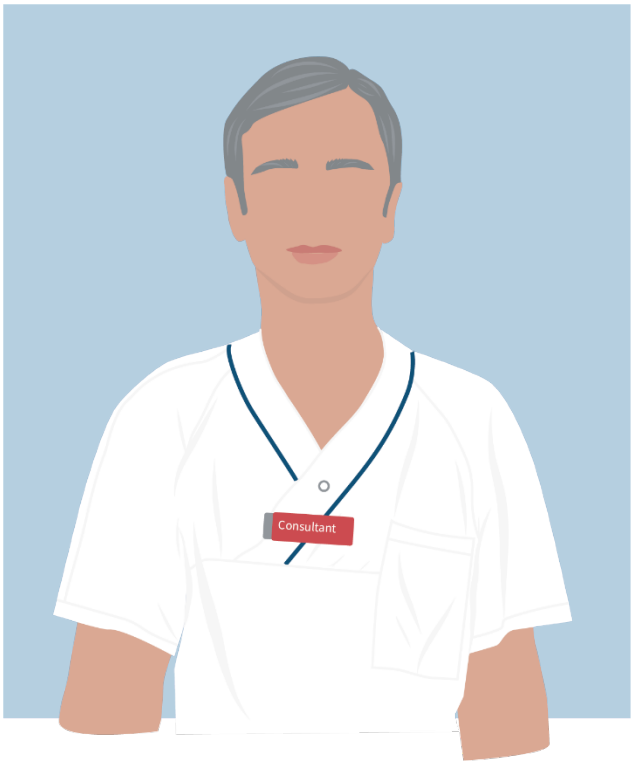

Figure 18. Peter

Scenario

It is 13:30 and Kate has just had her lunch. It has been a normal day so far, except for one patient which she is not entirely certain of how to treat. Kate knows that the senior physician might be more occupied after lunch due to the evening shift doctors arriving. However, she needs to consult with Peter before moving forward with the patient.

Since Kate currently works in team 4, she has her seat quite far away from the senior physician's office. Therefore, she needs to walk to the consultation office in order to find out if Peter is available. Kate grabs her notebook and walks toward the office. After only a few steps, she notices that Peter is occupied with another doctor. Of course, he is busy, I only have one quick question, Kate thinks to herself. Since she does not like to be unproductive, Kate goes back to work.

Five minutes later she walks past the consultation office again. Another doctor is in the office, so she goes to a patient instead. When going back Kate decides to wait outside, hoping that the previous consultation is finished soon. From experience, she knows that it is hard to beat the doctors in the medical teams who are sitting right outside the consultant. At least there is not a queue yet, which occurs sometimes.

As most times, she only has to wait for a few minutes. Since Kate knows Peter well by now the consultation takes only a few minutes. Afterwards, she feels much more confident in her assessment and can now finish her case and take on new ones.

7. Findings at the Obstetrics & Gynaecology department

In this chapter, the findings from the Problem Identification phase of the Obstetrics and Gynaecology department are presented.

7.1 Benchmarking

A survey was sent to the maternity ward of ten different hospitals in Sweden. Out of these, 69 participants from five different hospitals responded. The hospitals, as well as the number of participants per hospital is presented in figure 19. The participants consisted of both anaesthesiologists as well as midwives. They got different questions depending on their profession. See the distribution between the different groups in figure 20.

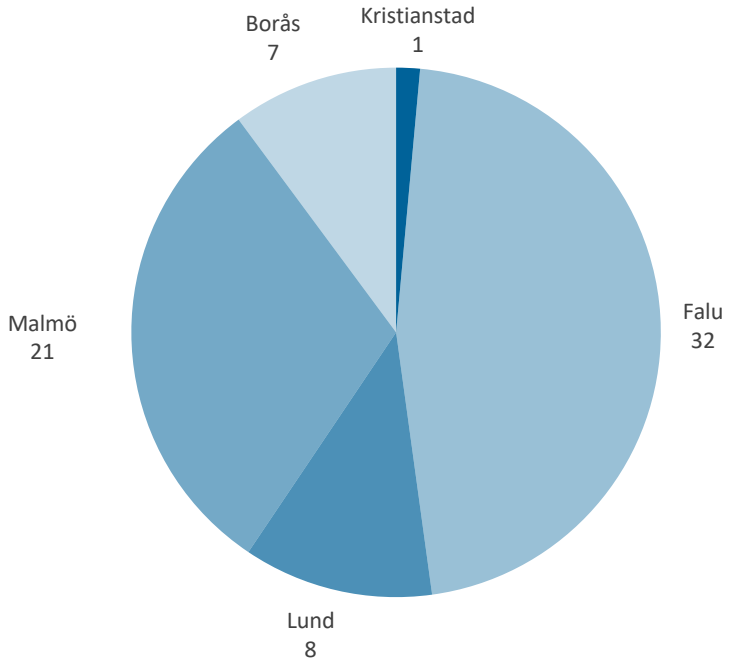

Figure 19. Number of participants of the maternity wards

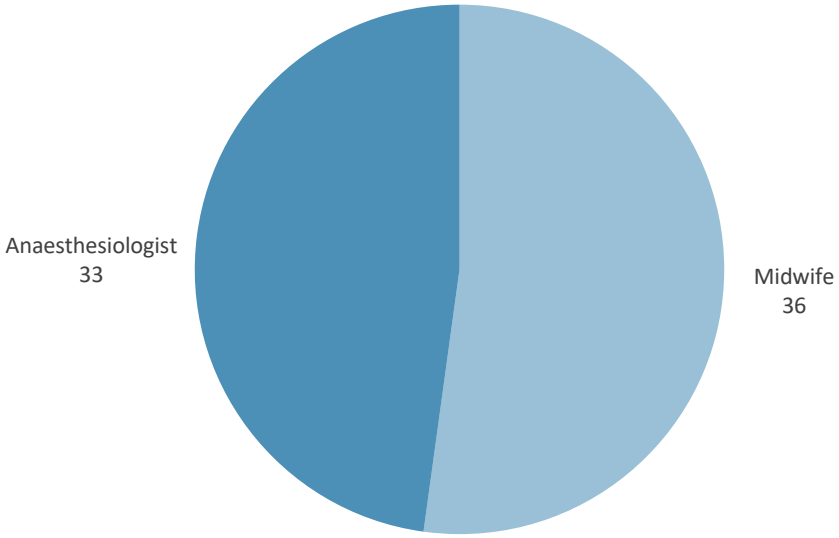

Figure 20. Distribution of participants of the maternity wards

The participants were asked to explain the course of events of the order of anaesthesia. The answers varied between two methods; either that the anaesthesiologist was contacted through a phone call, or their seeker. Some of the participants specified how the order is performed during day shifts or on-call hours, while others explained the process in general. The most common method was that a midwife at the maternity ward calls the anaesthesiologist by phone to order an epidural. Some further explained that the midwife or a coordinator of the maternity ward calls the anaesthesiologist head of management during day shifts, which in turn delegate the task to an anaesthesiologist, while the midwife directly calls a responsible anaesthesiologist on-call.

7.1.1 Anaesthesiologists

On average, the majority of the anaesthesiologists participating applied less than five epidural anaesthesia per work shift. Furthermore, they spend less than 20 percent of their work applying anaesthesia in relation to other working tasks.

The majority of the participants believed the time interval from the order of an anaesthesia to the application takes 20-40 minutes, on average. Furthermore, the application of the EDA was believed to take less than 20 minutes by most of the respondents.

As for the employees at the emergency wards, the participants were asked what kind of areas for improvement they found with the current system. The main areas of according to the anaesthesiologists were the communication with the midwives and the exchange of information. In addition to the already existing alternatives, some participants mentioned additional areas such as the need for better planning for epidural anaesthesia and that EDA should be ordered earlier in the process.

Additionally, some of the participants mentioned the need for better preparations at the room before the anaesthesiologist arrives, both regarding the material and medicine needed, but also the patient. This in order to make the process more efficient. The need for better information about the patient was also mentioned, but also better information to the patient before the EDA is applied. See appendix 6 for more details regarding the results.

7.1.2 Midwives

As for the anaesthesiologists, the majority of the midwives believed the time interval from the order of anaesthesia to the application takes 20-40 minutes, on average. Furthermore, almost all of the midwives mentioned that the preparations needed before an epidural anaesthesia is to be applied are to insert a peripheral venous catheter on the woman giving birth as well as prepare the equipment needed, including bringing the medicine.

Some also mentioned that they prepared Ringer-acetate[7], and examine the mother, and the baby, before calling the anaesthesiologist. In addition, some mentioned that they inform the patient and the partner about the procedure, as well as prepare the patient in the right position.

Regarding areas of improvement, the answers varied. Some thought the efficiency and communication with the anaesthesiologist could be improved, while others believed the system of today worked well. In addition, some respondents also expressed that the anaesthesiologist often has a lot to do, and is late for the epidural anaesthesia. This since an application of an anaesthesia is not vital, and therefore not prioritized. Therefore, they expressed the need of further resources to the maternity ward. See appendix 6 for more details regarding the results.

7.2 User studies

Presented in this chapter is the result from the user studies performed at the obstetrics and gynaecology department at Östra Hospital. The findings from the observations and interviews have been analysed and summarized below.

The anaesthesiologists participating in the interviews and observations were briefly informed of the intended end result, how the current application and its features are structured. Further, some of the midwives were also aware of this.

7.2.1 Structure of the Obstetrics & Gynaecology department

In this section the structure of the Obstetrics and Gynaecology department of Östra Hospital is presented, together with system illustrations of the different Maternity wards as well as Surgical ward 2.

The information below is collected from the observations, combined with clarifications from interviews. The system illustrations are not created with fully correct dimensions. However, they are created in order to get a better picture and understanding of the structure of the department.

To the maternity wards 308 and 312 healthy women come to give normal childbirth. Special deliveries are carried out at the maternity ward 314 where the women can suffer from early prematurity, diabetic or being pregnant with twins for example. Read more chapter 1.2.2. Department 312 and 314 have seven delivery rooms each. Further, department 314 has an operation theatre. Department 308 has eleven delivery rooms.

[7] Ringer-Acetate is used in order to replace lost electrolytes and body fluids, and as a short-term treatment when the blood volume is decreased (Fass, n.d.)

However, they are only staffed for eight. Department 308 also has a special children's emergency room. See figure 21, 22 and 23 for the system illustrations of the three Maternity wards.

Furthermore, at the Surgical ward 2 there are six operating theatres. During the day, gynaecological patients are treated electively. For example, prolapse operation can take place, or elective caesarean section can be scheduled.

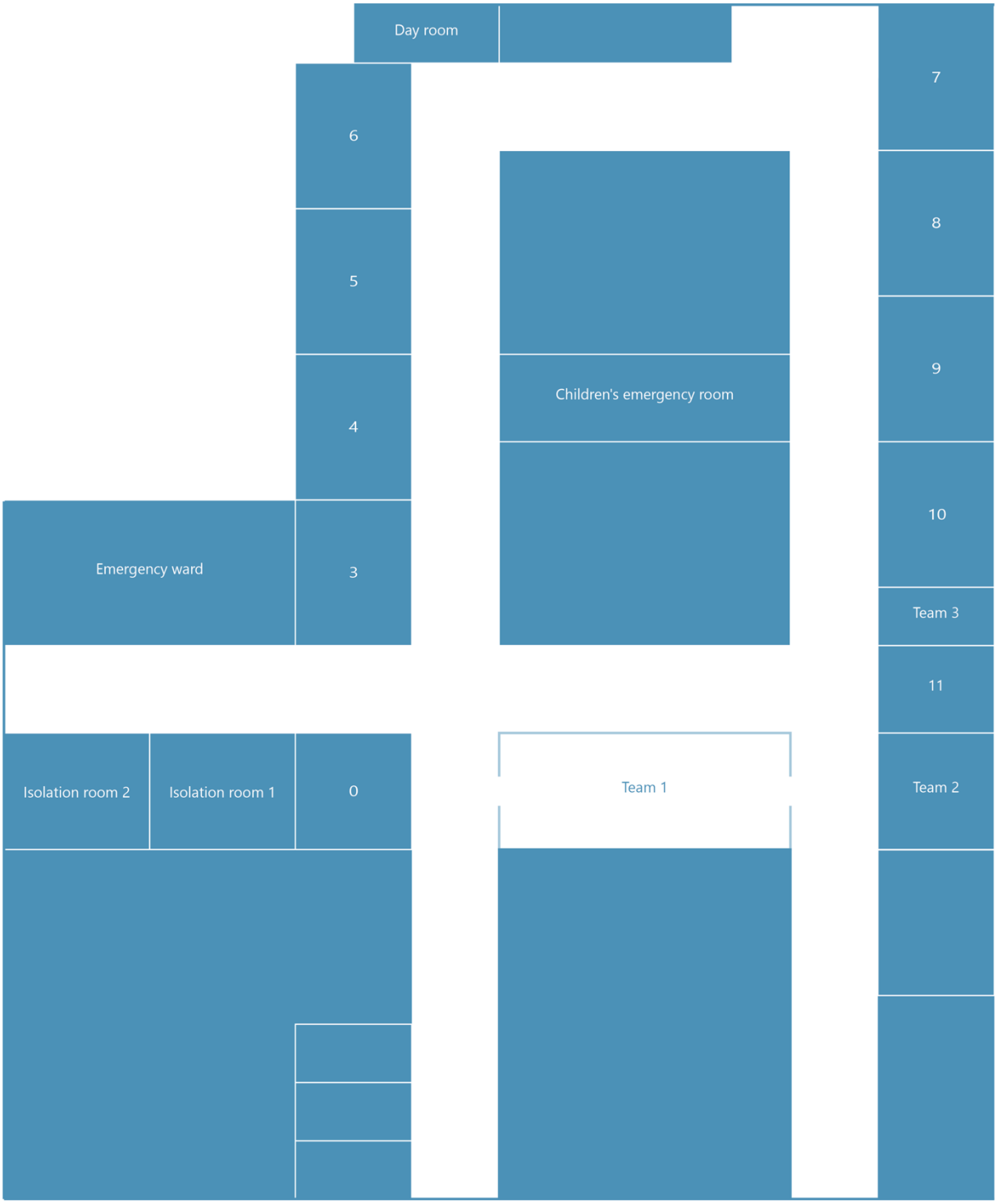

Figure 21. System illustration of Maternity ward 308

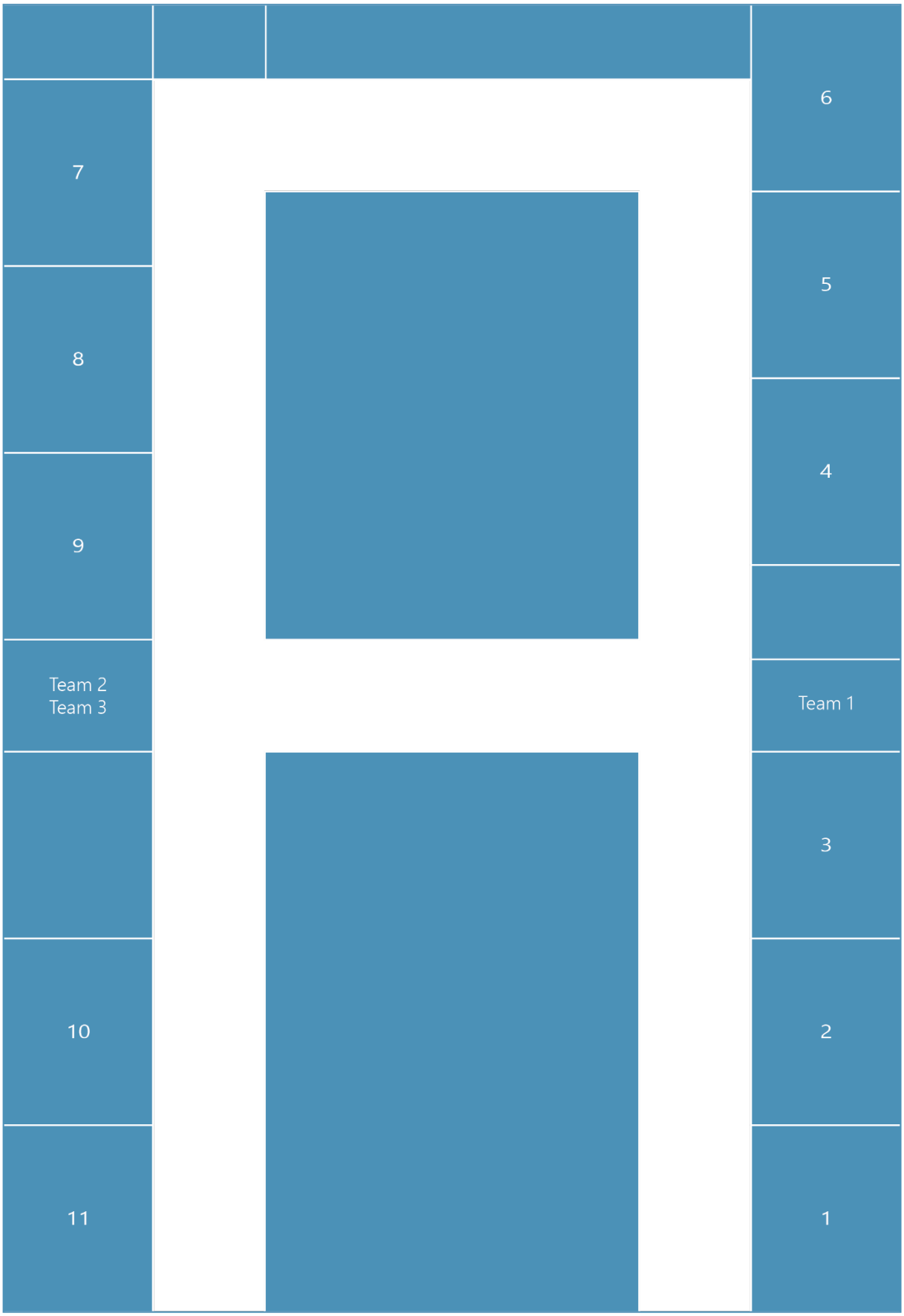

Figure 22. System illustration of Maternity ward 312

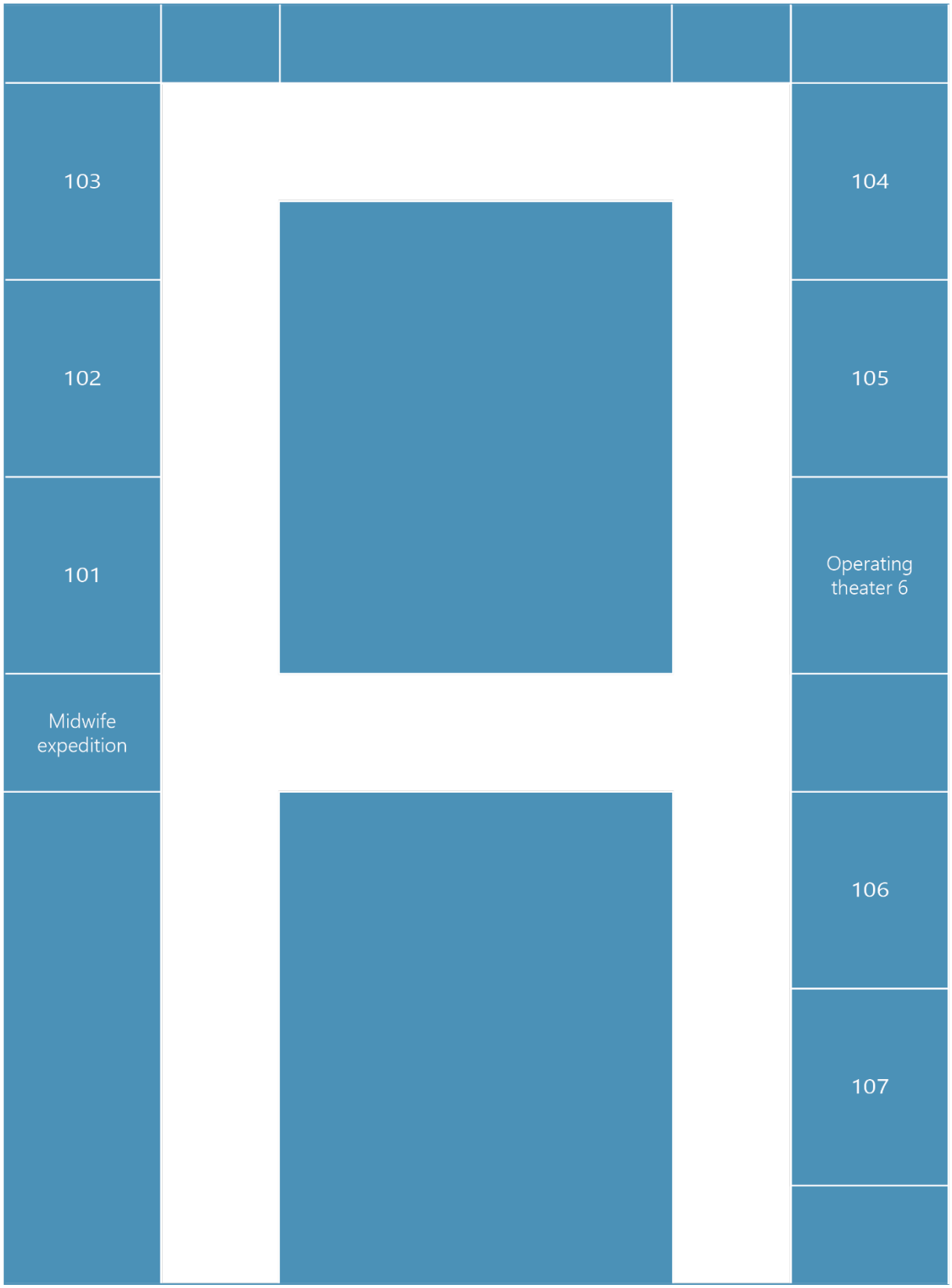

Figure 23. System illustration of Maternity ward 314

Working shifts

At the Obstetrics and Gynaecology department several different professions work, amongst others midwives, nurses, maternity nurses, assistant nurses and anaesthesiologists. The working hours of the teams are divided into three shifts. However, there are different time spans for the teams at the Surgical ward 2, respectively the Maternity wards. See table 10 for the different working hours at the different departments. The shifts of the Maternity ward concern the midwives and assistant nurses and the shifts of the Surgical ward 2 concern the anaesthesiologists.

Table 10. Working shifts at the Obstetrics and Gynaecology department

Ward	Day	Evening	Night
Maternity ward	06:45 - 16:00	14:00 - 22:00	21:00 - 07:00
Surgical ward 2	07:30 - 16:15	12:00 - 19:30	19:30 - 08:00

7.2.2 Observations at the Maternity wards

Presented below is the result from the observations of the Maternity wards.

Personnel working

At all the Maternity wards there are midwives, assistant nurses and maternity nurses working. Further, the Maternity wards have one obstetrician at each department. Presented in table 11 are the total number of midwives and assistant nurses generally working. The different Maternity wards are staffed with the same number of midwives and assistant nurses during the different shifts of the day.

Table 11. The total number of midwives and assistant nurses generally working at the different Maternity wards

Maternity ward	Midwives	Assistant nurses
308	6	3
312	6	3
314	5	2-3

Work tasks

The general work tasks of the midwives, assistant nurses and maternity nurses are supporting the mother and partner when giving birth. The personnel working at the maternity wards help the patient and partner from arrival, to after the birth of the baby. The personnel can perform medical related tasks such as inducing labour or injecting different kinds of drugs needed, but also providing clean sheets, clothes and bringing food to the mother and partner. Included in the work tasks is the order of anaesthesia if the patient desires. However, it is only the midwives who call the anaesthesiologist regarding the anaesthesia. The midwives do not have personal phones, but only the responsible management nurse for each maternity ward. The course of events when ordering and applying anaesthesia is described below, with focus on the personnel at the Maternity wards.

Order & application

After consulting with the patient, the responsible midwife calls the anaesthesiologist by phone, informing that the patient desires anaesthesia. Further, reporting relevant information such as if the mother is a primigravida, in latent phase, has any allergies, medication or diseases. A general discussion of the situation and patient is also performed. The call is usually less than one minute.

Further, the midwife brings the "EDA chart" with the medicine and other equipment for the application, prepares the patient, and sometimes, initiates the proper position of the mother. During the application of the anaesthesia, the anaesthesiologist, midwife, assistant nurse and maternity nurse, can be present. However, the constellation of personnel attending varied depending on the situation and patient. Sometimes during the observations, there was only one assistant nurse with the patient, and sometimes there was one midwife, assistant nurse and maternity nurse present.

During application, the midwife supports the mother and assists the anaesthesiologist with drugs, among others. After application, the midwife is usually responsible for taking blood pressure and helping the patient on her back, enabling even spread of the drug. Further, the midwife monitors the effect of the anaesthesia when the anaesthesiologist has left.

Anaesthesia at the Maternity wards

During the three observations at the Maternity wards 312, 308 and 314, the application of six anaesthesia was observed. Out of these, three applications were observed in the delivery rooms. As stated previously, the observations were mainly carried out from one of the maternity wards. However, sometimes phone contact with the other wards were performed, enabling observation at those wards as well. Read more about how the observations were performed in chapter 4.2.1. See table 12 for the time intervals of the duration from order to arrival and application of all six anaesthesia applied.

During the first epidural, the midwife had to call the anaesthesiologist again. During the first call the midwife was informed that the anaesthesiologist would arrive in approximately 15 minutes. When 41 minutes had passed, the midwife called again and 12 minutes later, the anaesthesiologist arrived.

During epidural 2 and 4 there were no complications. The anaesthesiologist arrived within 5 minutes and the applications took around 20 minutes.

During epidural 3 and 5 there were some complications during the application, such as blood in the tube and difficulties finding the right EDA location between the vertebrae of the lumbar spine. During epidural 5 the anaesthesiologist had to call another anaesthesiologist who came and applied the anaesthesia instead.

Lastly, during epidural 6 the process was not observed. Therefore, the data could not be established since the time of order, and arrival of the anaesthesiologist, were unknown. The observation was carried out from the hallway and was initiated when the anaesthesiologist was already inside the delivery room. However, the duration from when being informed, to the anaesthesiologist leaving the room was 13 minutes. Furthermore, epidural 6 was applied at the same time as epidural 5.

Table 12. The data of anaesthesia observed at the Maternity wards

Anaesthesia	Occasion	Ward	Order to arrival	Duration of application
1 Epidural	1	312	53 min	19 min
2 Epidural	2	308	5 min	25 min
3 Epidural	2	312	5 min	39 min
4 Epidural	2	312	5 min	20 min
5 Epidural	3	314	4 min	48 min
6 Epidural	3	312	-	-

7.2.3 Observations at the Surgical ward 2

Presented below is the result from the observations of the Surgical ward 2.

Personnel working

At the Surgical ward 2 there are anaesthesiologists, nurses, assistant nurses, care workers and surgeons working. Presented in table 13 are the total number of anaesthesiologists and nurses or assistant nurses generally working. As previously stated, the general

working shifts at the Obstetrics and Gynaecology department are divided into three different intervals: day, evening and night. The on-call hours at the surgical ward 2 are approximately between 19:30 to 08:00.

Table 13. The total number of anaesthesiologists and nurses/assistant nurses generally working at the Surgical ward 2

Profession	Day	Evening	Night
Anaesthesiologist	4-5	1	1
Nurse/assistant nurse	20	7	6-7

Work tasks

The general work tasks of the anaesthesiologist are to provide anaesthesia to the patients at the Surgical ward 2 and the Maternity wards 308, 312 and 314. This can be performed both at the delivery rooms of the Maternity wards, as well as at surgeries at the Surgical ward 2. When applying anaesthesia, the anaesthesiologist most commonly leaves the patient after the application and routine check-ups. However, if it is a complicated case or an unstable patient, the anaesthesiologist stays, monitoring the patient throughout the surgery. Further, it is the anaesthesiologists' work task to make sure that the anaesthesia is working well for their patients. For example, if there would be any complications after application, the anaesthesiologist takes care of it. The anaesthesiologist also assesses patients before surgery, for example before an elective caesarean section.

If anaesthesia is needed, the anaesthesiologist usually receives the information through the on-call 2 phone. However, all anaesthesiologists have their own personal phone as well. One anaesthesiologist is responsible for the on-call 2 phone and pager during all hours. However, during the day, the phone and pager can shift between the anaesthesiologists. The on-call 2 phone is called regarding the orders of epidural and spinal anaesthesia, as well as incoming high emergency cases such as emergency caesarean sections or concerning general questions. The on-call 2 pager is only contacted when there is a high emergency caesarean section or a cardiac arrest.

Usually, one anaesthesiologist is responsible for the on-call 2 phone and pager during the morning, until 12:00 when the anaesthesiologist working until 19:30 takes over. After that, the anaesthesiologist working at night carries the phone and pager between approximately 19:30 to 8:00. The main difference between day and night is that there are more anaesthesiologists working during the day who can distribute the workload. The course of events when ordering and applying anaesthesia is described below, with focus on the anaesthesiologist.

Order & application

The anaesthesiologist receives the order of epidural or spinal anaesthesia through the on-call 2 phone. During this call, the anaesthesiologist investigates if anaesthesia can be applied, discussing aspects that can affect the application. When agreed that anaesthesia is going to be applied, the anaesthesiologist writes down the information on a piece of paper called the EDA paper. Sometimes the anaesthesiologist informs the midwife that (s)he is coming, or is occupied at the moment.

When arriving at the delivery room, the anaesthesiologist informs the patient of the procedure and asks questions regarding the patient's health. Further, the anaesthesiologist sterilizes, puts on protective mask, apron and gloves, and starts preparing the materials and drugs. The anaesthesiologist instructs the patient how to be positioned while informing the importance of collaboration during the application. The anaesthesiologist starts by locating, and sterilizing, the right area of application of the patient's back. A sterile cloth is applied and local anaesthesia is injected. The epidural needle is inserted, and sodium chloride is used in order to identify if the right position, between the vertebrae of the lumbar spine, has been located. Further, a plastic tube is inserted through the needle and an initiating dose of anaesthesia is injected.

The tube is secured using a large patch and tape and is then connected to the EDA device that starts automatically injecting the medicine continuously. Commonly, the patient can also give small extra doses herself if needed.

Further, the anaesthesiologist goes through the routine check-ups, such as making sure that the patient can lift both her legs. Lastly, the EDA journal is filled in, the midwife takes the blood pressure, and the anaesthesiologist gives another dose of extra medicine.

Anaesthesia at the Surgical ward 2

As stated previously, during the observations, an anaesthesiologist responsible for the on-call 2 phone and pager, was observed. Read more about how the observations were performed in chapter 4.2.1.

During the three observations at the Surgical ward 2, the application of 14 anaesthesia was observed, 12 epidural anaesthesia and two spinal anaesthesia. The observations included all of the three Maternity wards and all applications were observed in the delivery rooms. However, in total 15 orders of anaesthesia were observed. See table 14 for the time intervals of the duration from order to arrival and application of all 15 anaesthesia.

During the majority of the applications of anaesthesia, there were no complications and the applications took around 20 minutes. However, during the fifth occasion of observation, there were eleven orders of anaesthesia in 8 hours and 30 minutes. Therefore, a queue was formed several times, resulting in an increased wait for the women. It occurred that a midwife called, asking for anaesthesia, just when the

anaesthesiologist had arrived at another the delivery room. However, no patient had to wait for longer than 24 minutes. Further, when arriving to order (11), the woman was about to give birth and anaesthesia could not be applied.

Except for applying anaesthesia, the anaesthesiologists got several calls throughout the day. For example, a midwife called, discussing the options of anaesthesia regarding a more complicated case. Further, if there was a problem with an EDA of a patient, the anaesthesiologist was called. Lastly, there were also two calls regarding anaesthesia at non elective surgeries, where the application of a spinal anaesthesia was carried out and observed.

Table 14. The data of the anaesthesia observed at the Surgical ward 2

Anaesthesia	Occasion	Ward	Order to arrival	Duration of application
7 Epidural	4	312	6 minutes	20 minutes
8 Epidural	5	314	7 minutes	29 minutes
9 Epidural	5	312	24 minutes	20 minutes
10 Epidural	5	308	7 minutes	24 minutes
(11)	5	308	23 minutes	-
11 Spinal	5	312	4 minutes	21 minutes
12 Epidural	5	312	16 minutes	22 minutes
13 Epidural	5	312	5 minutes	26 minutes
14 Epidural	5	308	14 minutes	23 minutes
15 Epidural	5	308	14 minutes	16 minutes
16 Epidural	5	308	5 minutes	23 minutes
17 Epidural	5	308	7 minutes	24 minutes
18 Spinal	6	312	5 minutes	15 minutes
19 Epidural	6	308	10 minutes	27 minutes
20 Epidural	6	314	4 minutes	22 minutes

7.2.4 Anaesthesia at the Obstetrics & Gynaecology department

In total the application of 20 anaesthesia was observed. 18 epidural anaesthesia were applied and two spinal anaesthesia. See table 15 for the mean intervals and queueing occasions during anaesthesia.

Considering the observations at the Maternity wards, only five of the time intervals are included due to lack of data for the sixth anaesthesia. Further, at the Surgical ward 2, 15 orders of anaesthesia were observed. However, the duration from arrival to finish is not included for one of the orders at the Surgical ward 2 since no anaesthesia was applied.

The total mean duration from order to arrival of the anaesthesiologist was approximately 11 minutes. However, the longest duration from order to arrival was 53 minutes, and the fastest four minutes. The total mean duration of the application was 24 minutes. The longest duration of application was 48 minutes and the fastest 15 minutes, where the latter was a spinal anaesthesia. A queue was formed seven times in total, with one order in line at the same time. When a queue occurred, the mean queueing time was 16 minutes, from order to arrival at the Surgical ward 2. No mean queueing time at the Maternity wards could be included due to the lack of data. Further, during one observation at the Maternity wards, two applications of anaesthesia were observed at the same time.

Table 15. The data of all the anaesthesia observed at the Obstetrics and Gynaecology department

Department	Anaesthesia	Mean: order to arrival	Mean: duration of application	Queueing occasions	Mean: queueing
Maternity wards	6	14 minutes	30 minutes	1	-
Surgical ward 2	14	10 minutes	22 minutes	6	16 minutes
Total	**20**	**11 minutes**	**24 minutes**	**7**	**16 minutes**

7.2.5 Interviews

Presented in this section is the result of the interviews performed with the midwives and anaesthesiologists at the Maternity wards 308, 312 and 314, and the Surgical ward 2 of the Obstetrics and Gynaecology department at Östra Hospital. The data includes the findings from the interviews, focus group and the in-depth interview. See chapter 4.2.1 for the structure of the interviews and the participants.

Order of anaesthesia

The anaesthesiologist receives the orders of anaesthesia though the on-call 2 phone, where information is given considering the department and room in question or if the patient has any diseases such as preeclampsia, or allergies. Further, the degree of openness of the woman giving birth and if she is a primigravida should be included. This was discussed during the in-depth interview with the anaesthesiologist.

Time of anaesthesia

Further, the time of when to apply anaesthesia, related to the course of events during the delivery, was discussed during the in-depth interview. The medical indication is unknown before the mother is in the latent phase. The patient, midwife and anaesthesiologist do not know beforehand if anaesthesia will be needed. The delivery might be fast and the mother does not feel the need for anaesthesia, even if she desired it initially. Therefore, anaesthesia is not applied before it is actually needed, since anaesthesia is not free of complications.

Difficulties

During the in-depth focus group, and interview, the difficulties arising around anaesthesia were discussed. It was mentioned that anaesthesia can be hard to apply due to a high BMI of the mother giving birth, or if she has scoliosis for example. Further, the application might be painful and take time, which can be problematic for the mother who is already in pain. After application a drop in blood pressure can occur, or that the anaesthesia is only effective on one side. Further, the midwives perceived that the anaesthesia can cause the delivery to slow down slightly. They also mentioned that the woman can be too far gone in her delivery if anaesthesia is delayed.

The anaesthesiologist also mentioned a few problems that can arise during the application. Durapunction can occur if the needle has been inserted too far in, which can cause headache. Further, the needle might hit a blood-vessel which causes blood in the tube. If the anaesthesia is given in the blood-vessel, instead of the right space for anaesthesia, the drug will not be effective.

Midwives

In the sections below, the findings from the interviews with the midwives of the Maternity wards are presented.

Work tasks

The midwives are working in different teams and start their shift with receiving a report of the current patients of the team. Further discussion is carried out regarding how to proceed the day. The main work task of the midwives is to support the woman giving birth,

and her partner, during childbirth. This applies to both the phase when the woman is giving birth, as well as the postpartum phase, when the child is delivered.

Order of anaesthesia

When a patient desires an epidural or spinal anaesthesia, the midwife assesses the state of childbirth. If the midwife considers the mother to be in an appropriate state, the anaesthesiologist is called by phone. However, before the anaesthesiologist is called for an anaesthesia order, the midwife performs some preparations.

All of the midwives interviewed mentioned that they insert a peripheral venous catheter on the mother. Some also expressed that they control the blood pressure and do an examination of the mother, as well as look at the cardiotocography curve in order to control the state of the baby. Furthermore, all of the interviewees mentioned that they bring the medicine as well as a drug cart, called the "EDA cart". However, this preparation was performed before the call to the anaesthesiologist by some of the midwives, while others did this step after the call.

A few of the participants also explained that in some cases, a discussion with the obstetrician is necessary before an order of epidural or spinal anaesthesia is possible to make. This is for example when the mother is in an early state of childbirth, and not open enough. However, most often, the midwife can call the anaesthesiologist for an anaesthesia without discussion with the obstetrician.

Information shared

When the midwife calls the anaesthesiologist, information about the patient and current situation is shared. To begin with, the midwives explain that they want to order an epidural or spinal anaesthesia to a specific room at a specific department. Furthermore, all of the midwives interviewed mentioned that they report if the woman has given birth before or not. This since the process can be considered to be faster for women giving birth earlier. In addition, the majority expressed that they report if the woman is healthy or not as well as how open she is in the delivery state. Some also mentioned that they report any deviations, such as if the mother has preeclampsia, allergies, scoliosis or is obese.

According to most of the midwives, the anaesthesiologists usually mention if they are coming immediately or if they will be late, due to other orders in line, or that they have to attend an operation. However, they rarely give a specific indication of time, but rather express "I am coming as soon as I can" or "It may take a while".

From order to arrival

The majority of the interviewed midwives believed that the time it takes from the order of epidural anaesthesia, to the moment the anaesthesiologist arrives varies. Sometimes, the anaesthesiologist arrives within a few minutes, while it can take much longer if the anaesthesiologist is occupied with a caesarean section or similar. However, most of the

participants experience that the anaesthesiologist most often arrives within 15 minutes, while a few believe it to take around 20 to 30 minutes.

Most of the midwives did not work during the night shifts. However, those who did, experienced it to take longer than during the day and evening shifts.

Anaesthesiologist running late

If the anaesthesiologist is late to an anaesthesia application, all of the interviewed midwives mentioned that they call the anaesthesiologist again. The majority of the participants call the anaesthesiologist again after 30 minutes, while a few waits for 45 minutes up to an hour. Some of the interviewees mentioned that it depends on the situation. Both considering the woman giving birth, and her condition, but also what the anaesthesiologist mentioned during the first call. If the anaesthesiologist for example had more orders in line, the midwives had a greater understanding that the anaesthesiologist might be delayed. However, most often they wait around 30 minutes.

Opinions of the current system

The majority of the midwives were pleased with the current system of ordering epidural or spinal anaesthesia. Some believed the system worked better than others, but overall, the majority were satisfied. Many of the participants mentioned the efficiency of calling the anaesthesiologist and the beneficial aspects of talking to each other. However, one midwife believed there could arise some problems when the pressure was high. When several women are in need of EDA, the anaesthesiologist has to be able to prioritize correctly. For example, if the anaesthesiologist has just applied EDA at one of the Maternity wards, and another midwife at the same ward has a patient who needs an EDA. The anaesthesiologists might prioritize the woman at the same floor even though two or three patients have been waiting longer. Further, if a woman has had a painful experience previously giving birth, maybe she should be prioritized. The midwife discussing these issues believed the aspects of prioritization and ethics were difficult.

Another of the participants mentioned that some more clarity would have been appreciated. Knowing what the anaesthesiologist is working with currently and that to expect in terms of waiting time were some aspects mentioned. The midwife believed that the information could be beneficial for the patient in order to avoid any unnecessary time spent in the preparatory position. However, it is important that the patient is ready when the anaesthesiologist arrives.

Efficiency

The majority of the midwives interviewed agreed that the system was efficient. Calling the anaesthesiologist was perceived as fast and uncomplicated. One midwife was very pleased to use the phone and get human confirmation of the order. Further, the difficulties of online orders were mentioned. Many of the participants did not see any other way of ordering epidural or spinal anaesthesia.

Communication

Overall, the midwives believed the communication with the anaesthesiologists worked well. The majority of the participants believed the communication varied between different anaesthesiologists, such as if the midwife knows the anaesthesiologist and has been working with him, or her, before. Further, some mentioned that there was not much communication. The phone calls are usually efficient where both parties know what is expected of them. Two midwives mentioned that it could happen that the anaesthesiologists could be a bit stressed. Further, it was perceived positive if the anaesthesiologist followed up how the EDA worked.

Changes of the system

Considering the ordering system of anaesthesia, the majority of the midwives believed it worked well and no changes were necessary. However, some also mentioned that they had not considered changing the system since there were no problems. Three of the participants did not want any changes, especially not a digital solution. The midwives pointed out the importance of having a conversation with the anaesthesiologist and the efficiency of calling. Further, two of the interviewees believed the application was an exciting idea and the transparency of the queue was considered beneficial.

Anaesthesiologists

In the sections below, the findings from the interviews with the anaesthesiologists of the Surgical ward 2 are presented.

Anaesthesia in relation to additional work tasks

All anaesthesiologists agreed that the time spent providing anaesthesia varied. Since the responsibility of the on-call 2 phone and pager shift during the day, the participants had difficulties estimating the distribution. However, one mentioned that approximately 20 to 40 percent of the work tasks during the day are regarding epidural and spinal anaesthesia. Further, some of the anaesthesiologists believed there are less orders of anaesthesia during the day compared to on-call hours. However, another interviewee perceived the time spent on providing anaesthesia as the same at all hours. Approximately 80 percent of the work tasks were considered to be regarding EDA. During on-call hours, one anaesthesiologist mentioned that 60 to70 percent are spent on applying anaesthesia.

Influence of anaesthesia

The majority of the anaesthesiologists believed the orders of the EDA affect their work. Two interviewees mentioned the problem when high incoming emergency cases interfere with the application of anaesthesia, or the other way around. Further discussed were the situation when being sterilized and not being able to answer the phone, during the application of EDA. Someone else in the room usually takes the order and has to write down the information given. However, in that situation information can be lost, which can cause problems.

Further, one participant believed that there is always someone to call for help if being occupied at a surgery or similar. During the in-depth interview, it was mentioned that the orders of anaesthesia also affect the recovery of the anaesthesiologists during on-call shifts. If receiving several orders of anaesthesia during on-call hours, the anaesthesiologist gets exhausted after an 18 hours long shift.

Number of anaesthesia

The number of epidural or spinal anaesthesia applied per working shift varied according to the participants. Generally, all anaesthesiologists perceived the workload of anaesthesia higher during on-call hours compared to during the day. However, that was considered to be due to the responsibility of EDA shifting between several anaesthesiologists during the day. Further, the decreased number of colleagues during on-call hours, was a contributing factor to the perceived increased anaesthesia. One anaesthesiologist mentioned that the providing of anaesthesia was considered to be the main work task, which is highly prioritized at the department.

Two of the participants estimated the amount of anaesthesia during the entire day to be between approximately ten and 13. Two other anaesthesiologists believed the number of EDA were approximately three to six during the day and between five and 15 during on-call hours. Further, all anaesthesiologists keep track of the orders using a pen and paper. The majority uses the particular EDA paper.

Information shared

All anaesthesiologists agreed considering the most important information needed from the midwife before applying anaesthesia. The most crucial information needed is if the woman is primigravida together with relevant information considering the patient's medical background. If the patient has allergies, preeclampsia or other relevant diseases or is currently on relevant medication, such as blood-thinning drugs, are important aspects. Further, two of the participants wanted to know if the patient is overweight, since this can affect the application.

From order to arrival

The time interval from the order to the arrival of the anaesthesiologist varied according to the participants, especially during the day and night. However, two of the interviewees mentioned that they apply EDA straight away if they are not occupied with anything else. Further, two anaesthesiologists estimated the time to be about 10 minutes and 15 to 20 minutes during the day. The majority believed that the waiting time can be up to an hour during on-call. However, the goal is that anaesthesia shall be applied within 30 minutes during the day and within one hour during on-call hours. One of the participants mentioned that if the anaesthesiologist estimates that application cannot be achieved within the desired timeframe, help is called.

Duration of application

All anaesthesiologists estimate the time spent applying anaesthesia to approximately 20 minutes, including all preparations before and after the application. However, the duration of the applications is varying depending on the patient and the preparations in the room.

Incoming high emergency cases

All the participants believed the incoming high emergency cases and orders of anaesthesia interfere with each other. If the anaesthesiologist is about to apply epidural anaesthesia, the application needs to be aborted due to emergency caesarean section. This also applies to if the anaesthesiologist is at a surgery and a midwife call regarding an EDA. One of the anaesthesiologists mentioned that it has occurred approximately five times during a half year that incoming high emergency cases have interfered with the application of anaesthesia. Further, two participants believed that these types of interruptions occur all the time. During the in-depth interview, the anaesthesiologist mentioned that if attending an emergency caesarean section, the surgery and applications of anaesthesia collide almost every time, resulting in delays. Further, the emergency caesarean section was estimated to occur every fourth on-call shift according to the anaesthesiologist.

If the anaesthesiologists do not have the time to apply anaesthesia, they call a colleague. During the day someone at the department and during on-call hours someone at on-call 3 or standby duty.

Opinions of the current system

The majority of the anaesthesiologists believed that the current system of ordering anaesthesia can be improved and made more efficient. The preparations of the application were seen as an area where the anaesthesiologists could save time. One participant works in Varberg as well, where the midwives prepare the EDA cart. This enables the anaesthesiologist to initiate the application faster. Further, two anaesthesiologists believed that the different wards could cooperate in order to increase efficiency. For example, try to gather the applications of anaesthesia as much as possible, so that the anaesthesiologist can apply several anaesthesia after each other.

Another anaesthesiologist discussed the flaws of the system considering the danger of orders and information getting lost due to several reasons. For example, it happens that it is not the anaesthesiologist who takes the order due to being occupied at surgery or with another anaesthesia. The interviewee also believed that the queue was not beneficial since it is only the responsible anaesthesiologist who is aware of the orders. The anaesthesiologist expressed the system to have great potential for improvement. Further mentioned was the lack of backup since the system is dependent on the human factor, which can be failing during long shifts and heavy workload. The system can fail because

of many different parties involved, the anaesthesiologist, midwife or mother in question who are all tired.

Communication

Generally, the communication with the midwives is working well according to the anaesthesiologists. However, two participants mentioned that sometimes there is a lack of information given. It is important that the midwife possesses necessary information before calling. Not being given the information needed contributes to an irritating feeling which is also something that other residents had experienced according to one anaesthesiologist. The other anaesthesiologist mentioned that the lack of information was due to another midwife calling, not the one responsible for the patient. Further, it was perceived as the midwives sometimes lack an understanding of other cases that the anaesthesiologist needs to attend. Therefore, calling several times asking where the anaesthesiologist is.

Queueing application project

One participant saw the application and its functions as a great idea. The participant further expressed that the application could increase the simplicity and accuracy of the system, as well as contribute with more information and confirmation. Another anaesthesiologist also believed the application could help the system, in particular considering the transparency of the orders of anaesthesia. If the midwives were able to monitor the queue themselves, this might increase the understanding of the delay. Further transparency and details of the anaesthesiologist's workflow was considered as beneficial, visualizing where the anaesthesiologist is currently at. Lastly, a third participant had never seen another type of ordering system for anaesthesia. However, the interviewee agreed that the application could help to increase the midwives' understanding of the anaesthesiologists' workflow. The application could contribute to beneficial aspects, although the efficiency was not perceived to be increased.

7.2.6 Likert scales

After each interview the participants got to fill in three Likert scales including statements related to the perceived efficiency, usability and usefulness of the current system. The scales included five steps, where the value on the left corresponds to "Disagree" and on the right "Agree completely". In total, eleven midwives and five anaesthesiologists participated. The mean values of the three Likert scales is presented in figure 24.

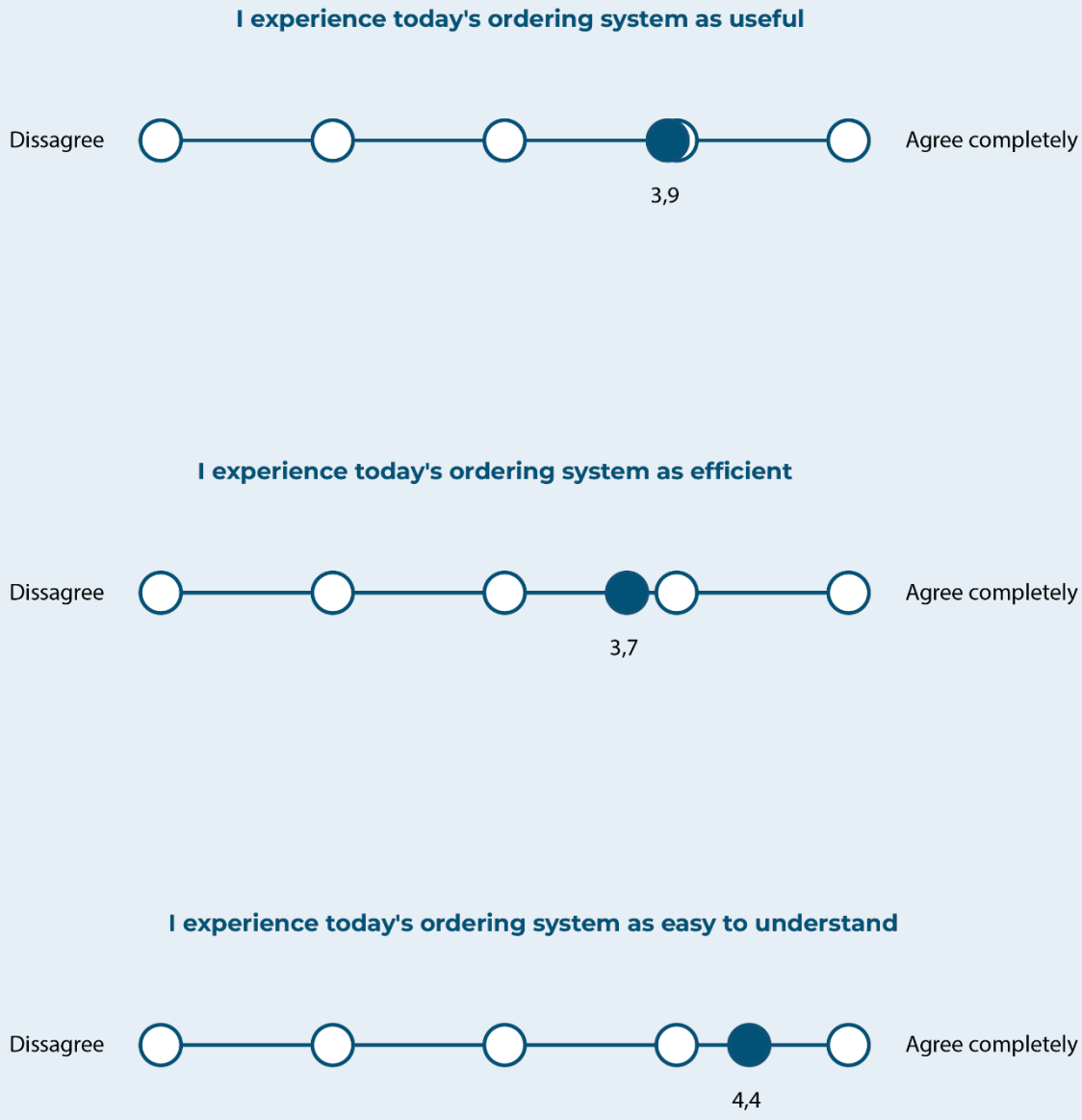

Figure 24. Mean value of the Likert scales

7.3 Personas & Scenario

Based on the findings from the user studies, two personas and one common scenario were developed for the obstetrics and gynaecology department. Presented below are the two personas Sara and Anton and a scenario of when Sara orders an anaesthesia from Anton.

Sara

Sara has been working as a midwife at the maternity ward 308 for several years now. She enjoys being a part of bringing new lives to the world. As a mother herself, she understands the pain women are experiencing when giving birth. Therefore, she values their need for pain relief highly. See figure 25.

Sara believes the order of anaesthesia is working great. She appreciates being able to talk to the anaesthesiologist regarding her patients and their needs. Further, the majority of times the anaesthesiologist arrives a few minutes after the call. However, sometimes during on-call hours she has experienced some delays. She is aware that midwives at other departments might have called the anaesthesiologist as well, or that something more urgent has occurred. But since she is not aware of what is happening outside her department, she usually calls to remind the anaesthesiologist if (s)he doesn't show up within 40 minutes. Sara does not think any changes are necessary, but is positive to the idea of trying another system with more transparency of the ordering system.

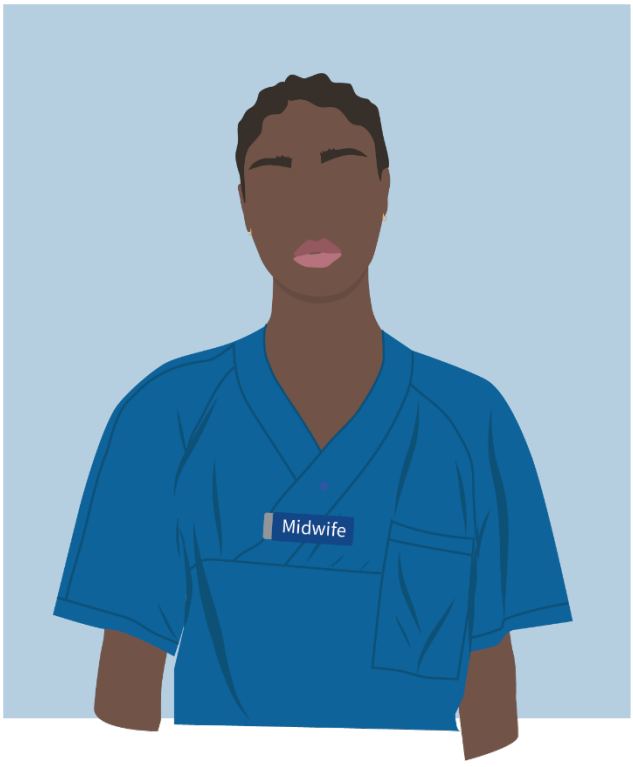

Figure 25. Sara

Anton

Anton is an experienced anaesthesiologist and has been working at the surgical ward 2 for over 10 years. He is a passionate doctor who always aims at doing his best. The providing of anaesthesia is very important when giving birth according to Anton. When receiving an order of anaesthesia, he instantly goes to the patient in question, if not being occupied with anything else. See figure 26.

Anton believes the ordering system works well most of the time, at least during the day when there are more colleagues present. However, if many patients are in need of anaesthesia at the same time, there can be complications. It can be hard to keep track of all the orders, especially during on-call hours when he has been working for 14 hours without a break. Sometimes, someone else has to take the order since he is occupied. Anton believes important information can get lost easily with the current system, since he does not always get to talk to the responsible midwife ordering an anaesthesia. Further, it would be beneficial if the midwives can get access to the queue as well, being able to see how many orders are in line and work with the mother in other ways while waiting.

Figure 26. Anton

Scenario

Anton has just sat down after a hectic afternoon when the phone rings. It is an order of anaesthesia at department 312, room 2. Anton leaves his full cup of coffee and heads

down. He did not sleep much before his on-call shift, so he really needed that coffee, but from experience he knows that the on-call shifts can be dreadful.

Anton arrives in the room just five minutes after the call. He talks to the patient and starts preparing for the application. Just when he has put on the sterile gloves, the phone rings again. The assistant nurse picks up the phone and answers.

Sara's patient is a primigravida woman, open four centimetres and wishes to get epidural anaesthesia. Further, her patient has had some difficulties during her pregnancy that Sara wishes to discuss with the anaesthesiologist. She knows from experience that there can be delays during the evening when the anaesthesiologist is alone. Therefore, Sara and her patient agree to call Anton straight away. An assistant nurse picks up the phone and Sara instantly feels concerned that she does not get to speak directly to Anton. After discussion with Anton, through the assistant nurse, Sara goes back to her patient. Since Anton was in the preparation phase of the application, Sara prepares her patient for waiting at least 20 minutes.

Anton has applied the anaesthesia at room 2, and is about to clean up when he realizes that he has forgotten the department and room number for the next EDA. Since the assistant nurse did not write this down, Anton has to ask her again. Just when he is about to leave the room, the on-call 2 pager rings. A high emergency caesarean section has to be performed and Anton runs towards the surgical ward 2. The environment in surgery is hectic since the mother and baby's life is in danger. Anton is about to apply anaesthesia when his phone rings again. One of the assistant nurses answers.

It has been almost an hour since Sara called the anaesthesiologist and her patient is in a lot of pain now. I wonder where he went? Sara thinks to herself. She knows that Anton is an experienced and efficient anaesthesiologist, so she decides to call Anton again. Another assistant nurse answers this time. Sara feels irritated that she never gets to speak to Anton. She gets informed about the emergency situation that had occurred. Sara understands that Anton had to prioritize the high emergency caesarean section. However, since women are supposed to get anaesthesia within an hour during on-call hours, Anton calls another anaesthesiologist on the on-call 3 shift. The anaesthesiologist arrives after only 5 minutes and Sara's patient finally gets her EDA.

8. Requirement Specification

The problem identification phase resulted in a requirement specification. The common requirement specification, and the specific for the Emergency ward and the Obstretics and Gynaecology department respectively, are all presented in this chapter. The result of the requirement specification was based on the findings from the user studies as well as the set requirements given by the initiators of the project. See appendix 7 for the full requirement specifications.

8.1 Common requirement specifications

In the common specification, requirements considering the need for a digital product, exclusion of patient data, amongst others were included. Further, the guidelines were constructed according to the solution's efficiency, intuitiveness, guessability and a selection of Jordan's design principles. The two most important guidelines were that the solution should enable efficient usage and provide feedback, both weighted the highest possible.

8.2 Emergency ward

The requirements and desires for the Emergency ward were structured into four different categories; general, the queue, the consultation and incoming high emergency case. The requirements included necessary functions such as providing information of the number of doctors, and their position, in the queue. Further, enabling the doctors to enter the queue, and the consultant to finish a consultation for example. Another required functionality was to enable the consultant to pause the queue due to a high incoming emergency case. The desires were related to the presentation of triage, information regarding the initiating of consultation and similar.

8.3 Obstetrics & Gynaecology department

The requirements and desires for the Obstetrics and Gynaecology department were structured into five different categories; general, the order, the queue, new samples and high incoming emergency cases. The requirements included necessary functions such as enabling the midwives to place an order and filling in necessary information regarding the department and room in question, as well as the desired type of anaesthesia, amongst others. Further, important requirements regarding the status of the application and indication that new samples were needed were included for example. Some of the desires developed were related to the status of the order such as indication of confirmation, preparation and initiating application

9. Concept development & evaluation

In this chapter the outcome of the Design process, and Evaluation with the users, is presented for both departments in question.

9.1 Emergency ward

In the sections below are the outcome of the Ideation, Concept development and Evaluation presented for the Emergency ward.

9.1.1 Ideation

The initial ideation resulted in several ideas related to a large number of categories. Features regarding the structure of the page and the presentation of the queue were investigated. For example, the queue was placed at ⅔ of the page, leaving ⅓ of the page for information. The sectioning divided the two parts both vertically and horizontally. Further, several ideas of visualizing the position in the queue were discussed. The result was a blue circle at different positions of the text, a pointing arrow, the text highlighted in blue and similar ideas. The ideation further resulted in several different buttons regarding the flow of interaction. Both text and symbols, with varying colour, size and shapes were included. Lastly, different ways of presenting when the consultant was attending an incoming high emergency case were investigated. A pop-up window and a red banner were two of the ideas. See figure 27 and 28 for some of the initial sketches of the ideation.

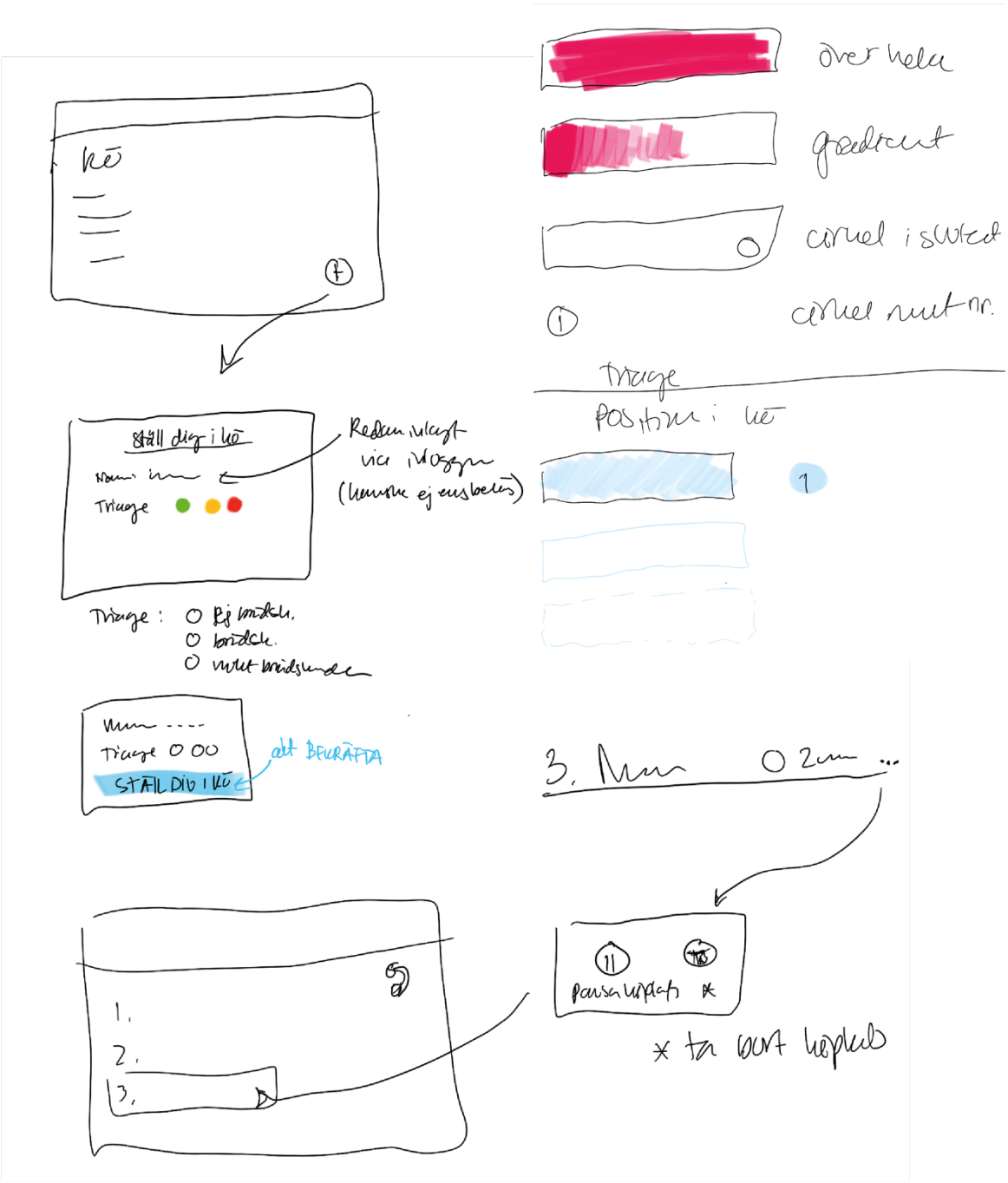

Figure 27. Initial ideation sketches I

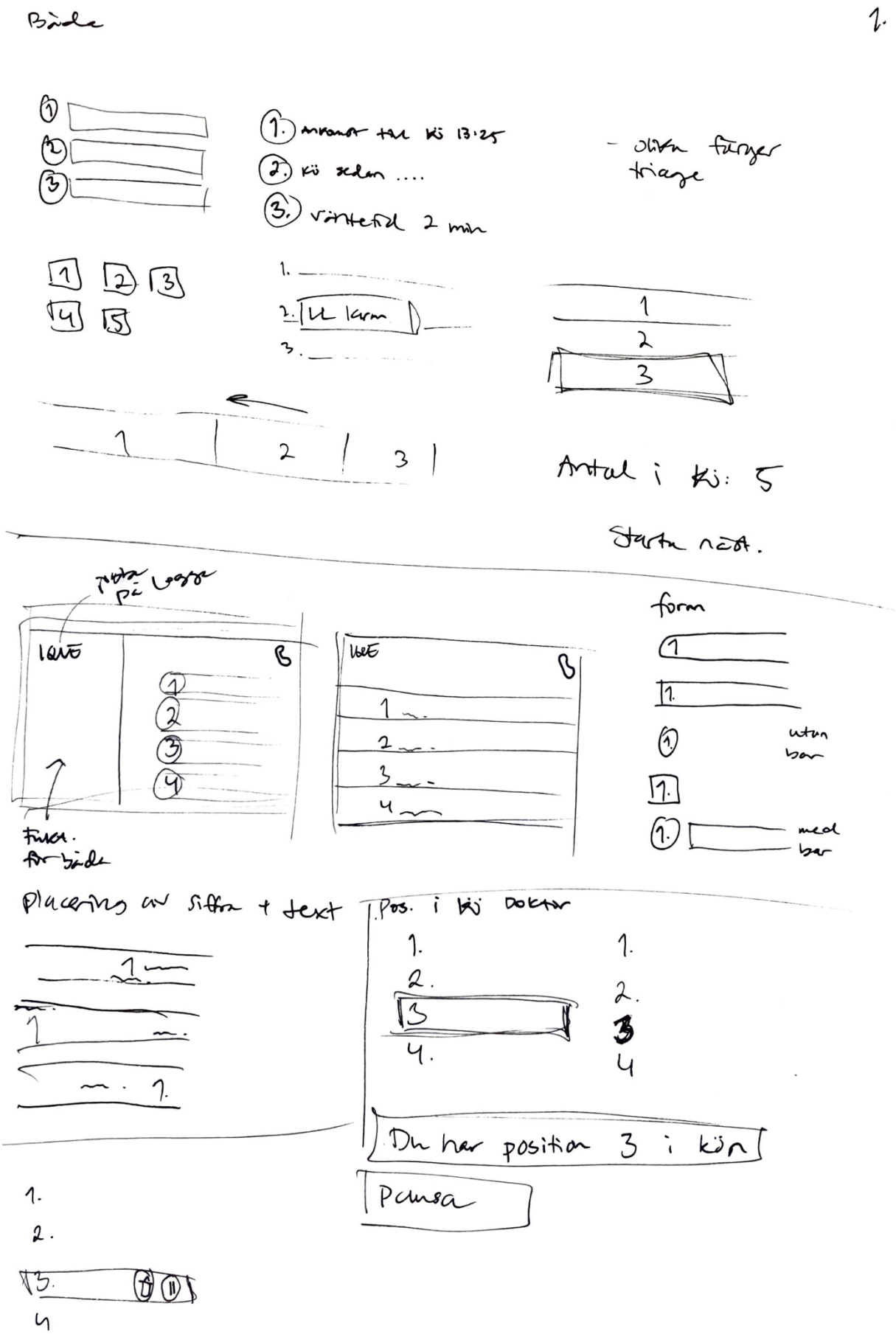

Figure 28. Initial ideation sketches II

9.1.2 Design concepts

From the morphological matrix, four concepts were developed. The concepts are presented below. See appendix 9 for the full morphological matrix for the Emergency ward.

Concept 1

In Concept 1, the queue is in focus, covering the whole page. The number is large with the name and time placed to the right, and the triage to the left. Further, the general theme of the interaction is coloured buttons with symbols designed for compatibility. The buttons are consistently placed in the same position, the bottom right corner.

Position in the queue

When being added in the queue, the position is visualized in blue. Further, the position is clarified in text, which is updated as the doctor moves forward in the queue, see figure 29. Lastly, a pop-up window appears when it is the doctor's turn, see figure 30. The doctor can also pause, or remove, the position.

Queue paused

If the consultant has paused the queue, this is visualized with a pop-up window for the doctors. Further, the doctors can close the pop-up window and interact with the pause and remove buttons, see figure 31.

Consultant

The view of the consultant is the same as for the doctor, however with other functions. The consultant can pause the queue at the start page, due to either a high incoming emergency case or a break. See figure 32. Further, the consultant can start, and finish, a consultation by clicking into a position in the queue. See figure 33.

The view of the doctor

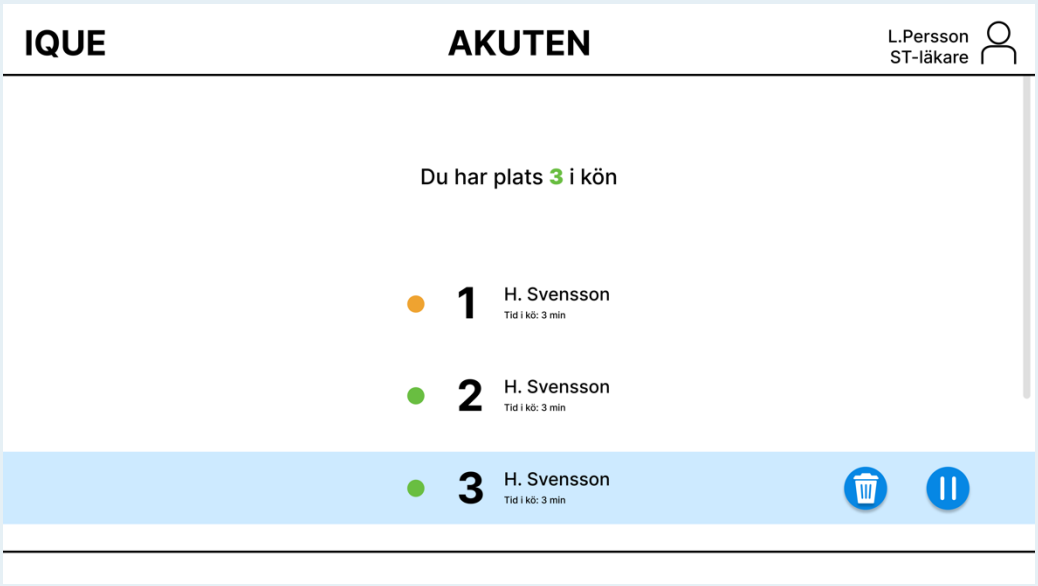

Figure 29. Position in the queue

Figure 30. Pop-up window

Figure 31. Queue paused

The view of the consultant

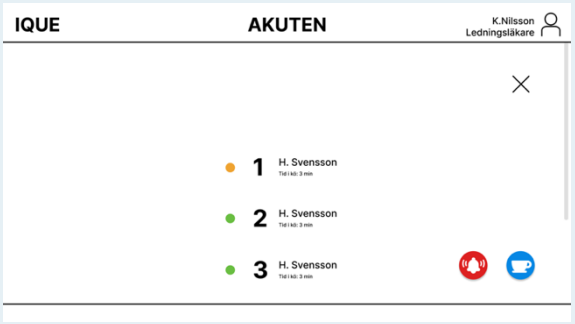

Figure 32. Start page - pause queue

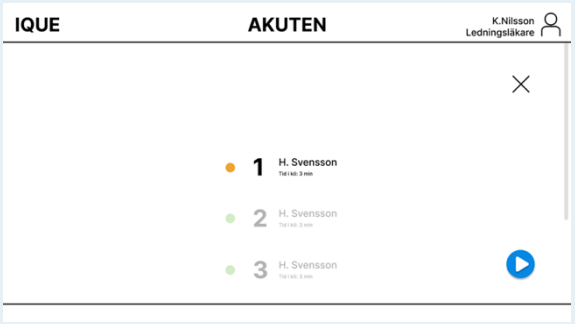

Figure 33. Initiate consultation

Concept 2

In Concept 2, the structure of the page is divided in two parts, ⅔ and ⅓. The number and text are presented horizontally, with the triage positioned to the left. Further, the same buttons with symbols are used in this concept, however at another position throughout the flow of interaction.

Position in the queue

When being added in the queue, the position is surrounded by a blue square. Further, the status is clarified and updated in the right section, as well as the pause and remove functions. See figure 34 and 35.

Queue paused

When pausing the position, the text and square are faded. If the consultant has paused the queue, this is visualized in the ⅓ of the page and with a grey blurred rectangle at the queue. See figure 36.

Consultant

The view of the consultant is the same as for the doctor, however with other functions. The consultant can pause the queue and start, and finish, a consultation in the ⅓ of the page. See figure 37. Further, the name and phone number of the doctor in question are presented as well. See figure 38.

The view of the doctor

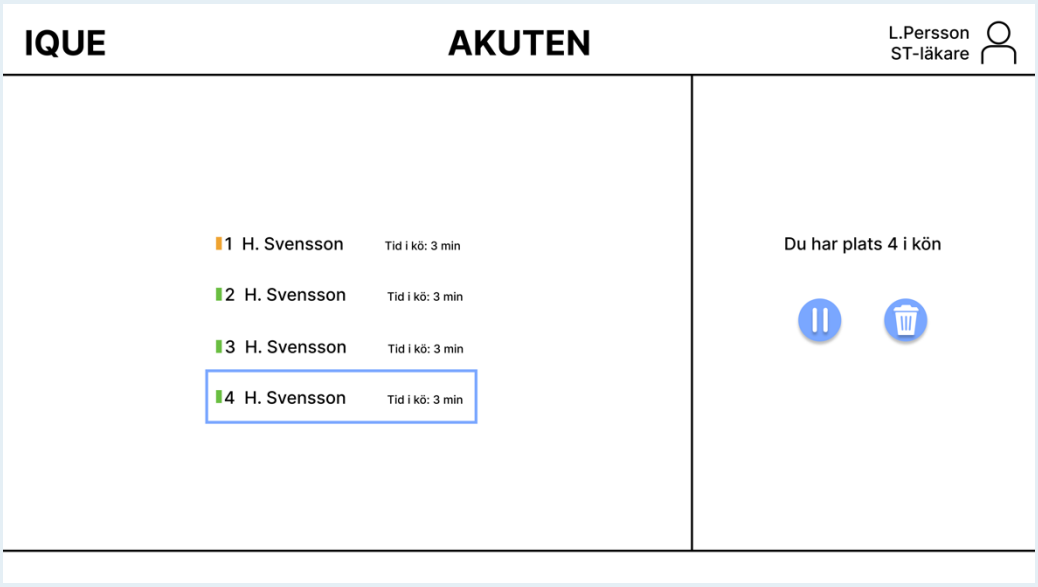

Figure 34. Position in the queue

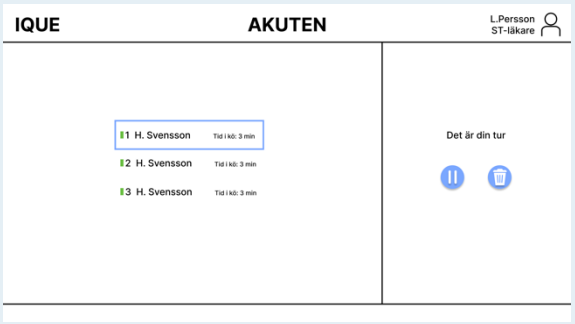

Figure 35. First in line

Figure 36. Queue paused

The view of the consultant

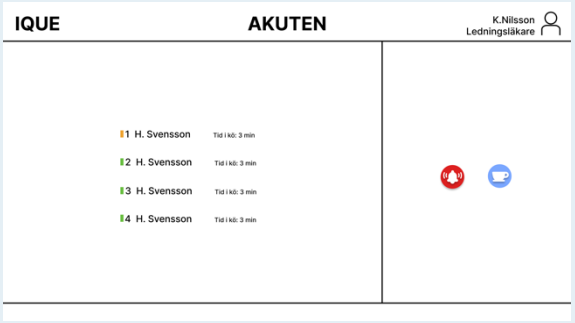

Figure 37. Start page - pause queue

Figure 38. Initiate consultation

Concept 3

Concept 3 is almost the same as Concept 2. However, the buttons used in this concept are square shaped buttons including text of interaction. See figure 38.

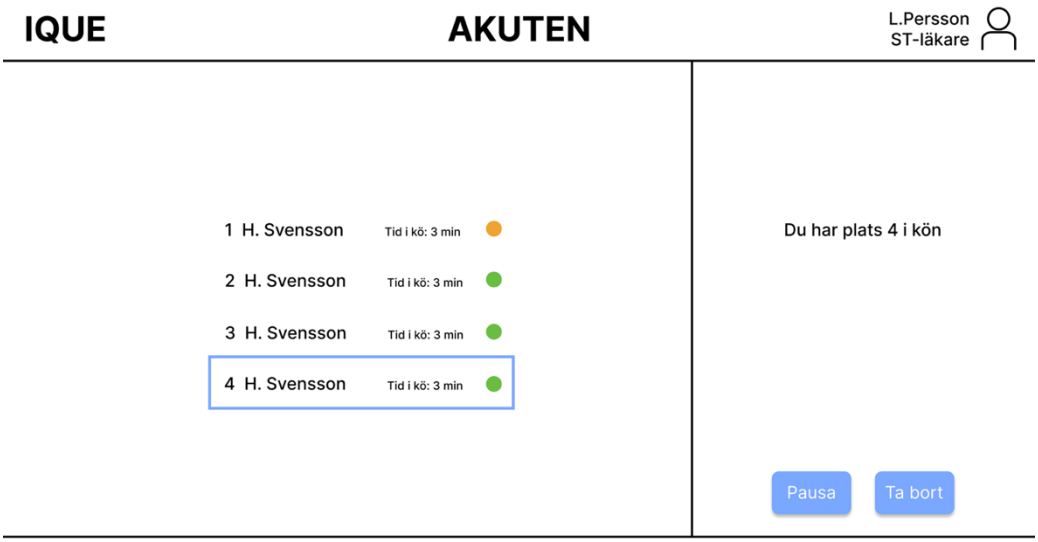

Figure 39. Position in the queue

Concept 4

In Concept 4, the structure of the page is divided in two equal parts. Concept 4 has similar characteristics as Concept 1. However, including the same buttons as in Concept 3. See figure 40. Further added is the name and phone number of the doctor seeking consultation, see figure 41.

Figure 40. Position in the queue

Figure 41. Initiate consultation

9.1.3 Evaluation

After concept development and prototyping the concepts were evaluated both theoretically and empirically. Presented below are the findings from the evaluation with the users and the concept weighting matrix of the Emergency ward.

Evaluation with the users

Considering the structure of the page the resident preferred the distribution of ⅔ parts presenting the queue and ⅓ part presenting the information. Buttons with text or symbols were not considered to matter according to the participant. However, when finishing a consultation, the button with text was most clear. The presentation of the queue was preferred with a rectangle presenting the triage and an equal size of the number and text, except for the time, as included in Concept 2.

Considering the presentation of the position in the queue the participant believed that the filled blue square, reaching all the way horizontally, was the clearest, see Concept 1 and 2. Further, information in text regarding the position in the queue was also desired. The resident also mentioned the need of being informed when someone else had paused their position in the queue, which was not included yet. The name and phone number of the doctor seeking consultation was considered to be enough information, from the consultant's point of view.

Presenting that the queue is paused, as visualized in Concept 1 and 4 including the red information section at the top, was preferred. Further, the resident mentioned that the choice of pausing the queue due to a high incoming emergency case or a break was not necessary at Östra Hospital. However, the alternative could be useful at other hospitals such as Sahlgrenska. Another function missing in this stage was the ability to enter the queue whilst the consultant had paused the queue.

Further discussed were the number of levels of triage. The resident mentioned that there exist five levels of triage, blue, green, yellow, orange and red. The participant also brought up the aspect of colour blindness as something to contemplate on.

Concept weighting matrix

The concept weighting matrix was performed based on the knowledge gained during the evaluation phase and resulted in an objective prioritization of the concepts. As shown in table 16, Concept 4 got the highest result in the matrix with a score of 105. The concept was given a 3 for all guidelines except for the "Consideration of user resources". Further, Concept 2 got the lowest result, mainly due to the lack of feedback and intuitive usage and lower guessability. To summarize, the result varied between the concepts, but not to a great extent. See appendix 10 for the full concept weighting matrix of the emergency ward.

Table 16. Concept weighting matrix, Emergency ward

Concept weighting matrix	Concept 1	Concept 2	Concept 3	Concept 4
Total value	96	85	97	105

9.2 Obstetrics & Gynaecology department

In the sections below are the outcome of the Ideation, Concept development and Evaluation presented for the Obstetrics and Gynaecology department.

9.2.1 Ideation

The initial ideation resulted in various ideas related to additional functions at the Obstetrics and Gynaecology department. Several ideas regarding the status of the order were produced, amongst others. An eye represented that the anaesthesiologists had confirmed the order and a needle represented that application had been initiated, for example. Further, different ways of adding information when placing the order were investigated. Drop down menus, scroll menus, buttons and filling in a blank space manually were some of the resulting ideas. If new samples needed to be taken, this had to be communicated between the midwife and anaesthesiologists. A pop-up window with a red text "New samples needs to be taken", in combination with a red symbol of a sample for example, was some of the results. See figure 42 and 43 for some of the sketches from the ideation phase.

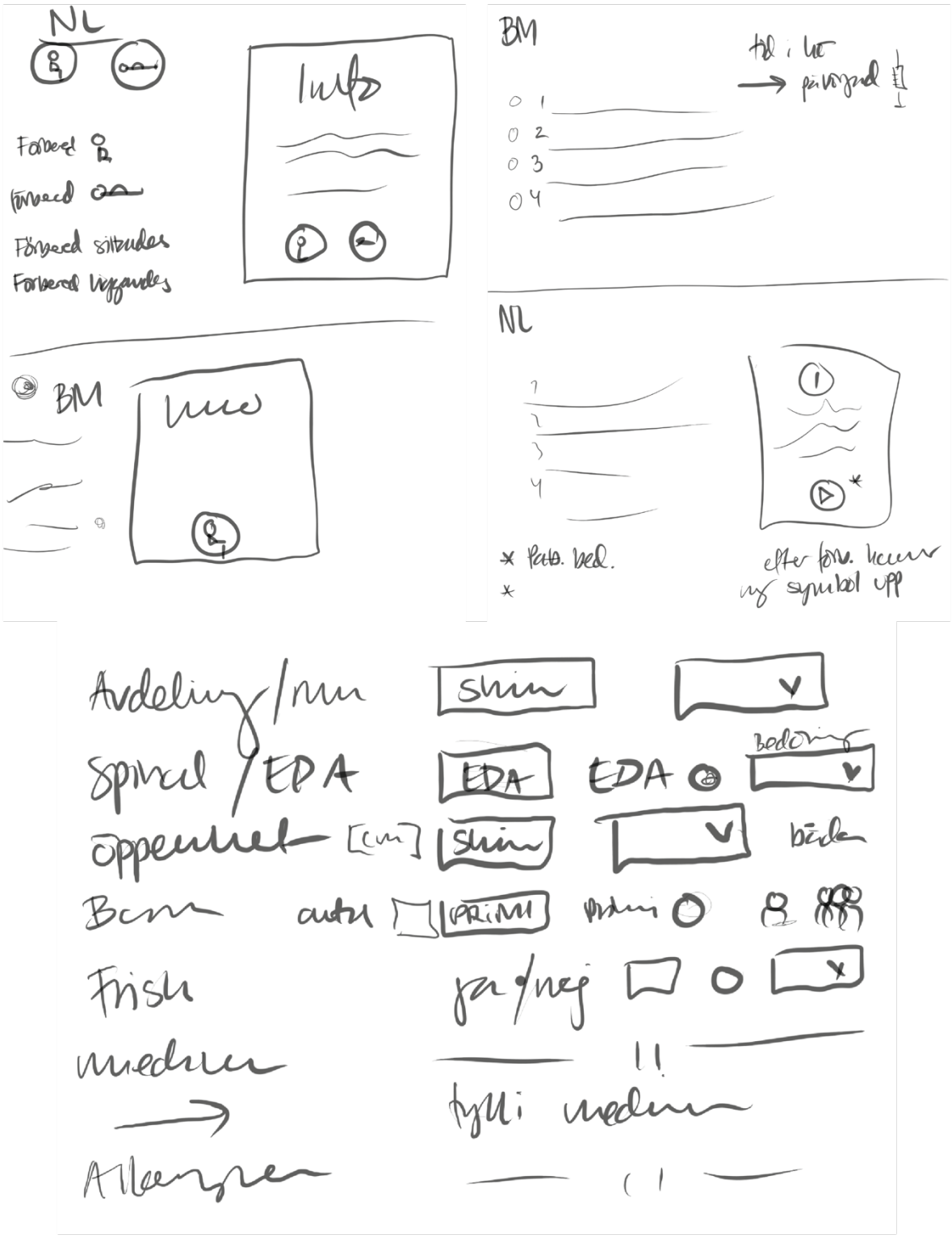

Figure 42. Initial ideation sketches I

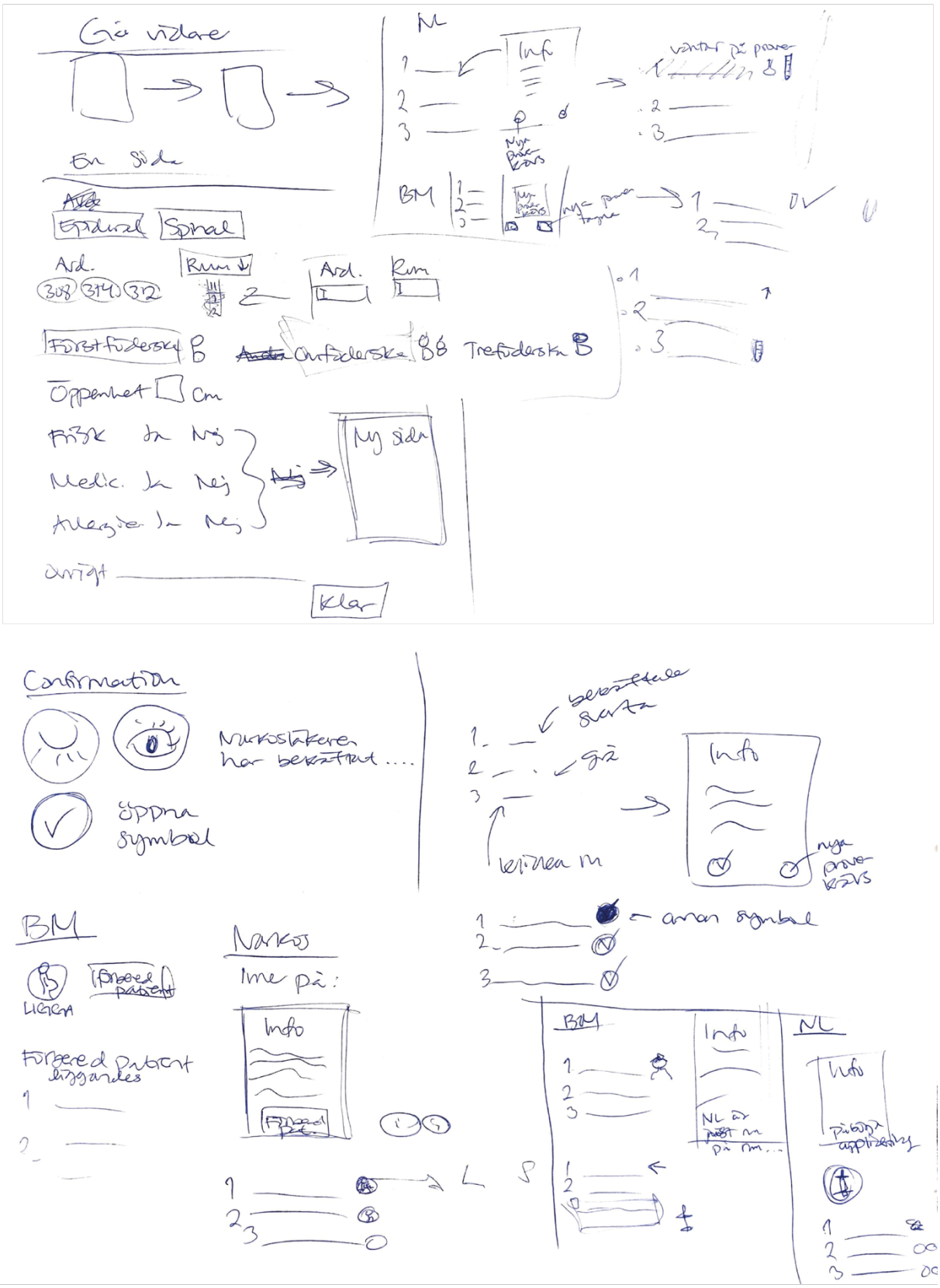

Figure 43. Initial ideation sketches II

9.2.2 Design concepts

From the morphological matrix, four concepts were developed for the Obstetrics and Gynaecology department. See appendix 9 for the full morphological matrix for the Obstetrics and Gynaecology department. The design of the structure, presentation of the queue and the general aesthetic characteristics has been re-used from the Emergency ward. Further, the functionality of pausing the queue due to an incoming high emergency case has also been re-used from the Emergency ward, see chapter 8.1.2. The focus of the design concepts of the Obstetrics and Gynaecology department has been on the additional functionality. Presented below are the four concepts.

Concept 1

In the sections below, Concept 1 is presented.

Place order

When placing an order of anaesthesia, the midwife fills in the necessary information in different steps, at individual pages, which provide consideration of user resources. The alternatives are presented mainly in terms of buttons. See figure 44.

Queue & presentation of information

When the order has been placed in the queue, the information of the order is presented at half a page. The status of all orders is visualized in terms of different symbols; an unfilled check represents that the order has been placed but not confirmed, a filled check represents that the order has been confirmed, and the blue shoot represents that the anaesthesiologists apply anaesthesia. See figure 45. The same symbols of status are also included in the bottom right corner of the information page. This symbol is updated, for example, when a sitting pregnant woman appears the anaesthesiologist wants the midwife to prepare the patient in a sitting position. See figure 46.

At the other section of the page, the information regarding the order is presented vertically. Parts of the information are marked with the colours representing the triage of the order. Further, the midwife can edit or remove the order.

New samples

If new samples are needed, a pop-up window appears and the expired time is red. See figure 47. Further, the status symbol is changed, informing the others in the queue of the status. The midwife can fill in the updated time of the new samples by clicking on the symbol of a pen. See figure 48. When new samples have been filled in, a green compatible colour has been added.

Anaesthesiologist

The view of the anaesthesiologist is almost the same as the view of the midwife. However, the symbols in the lower right corner are placed in a circle, creating a button and indicating that interaction is possible. See figure 49. Further, when clicking into one order in the queue, the other orders are faded. If the anaesthesiologist needs to attend a high incoming emergency case the anaesthesiologist can pause the queue at the start page.

The view of the midwife

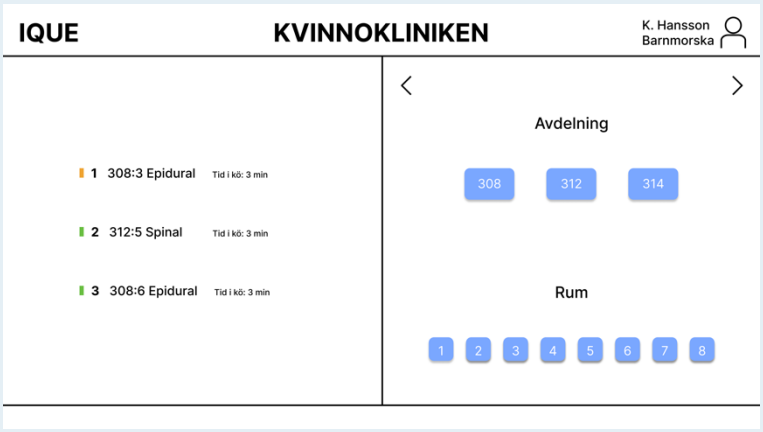

Figure 44. Place order - page: department & room

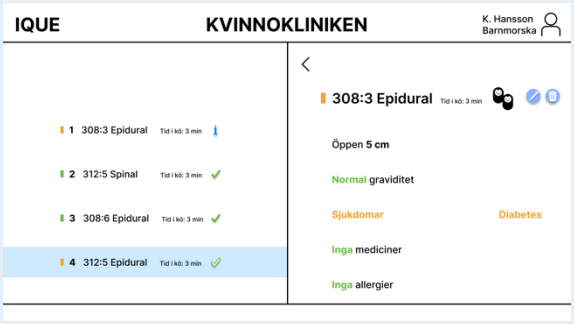

Figure 45. Diabetes patient | Status: unconfirmed

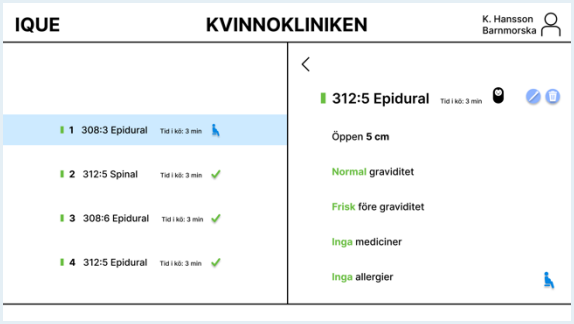

Figure 46. Healthy patient | Status: prepare position

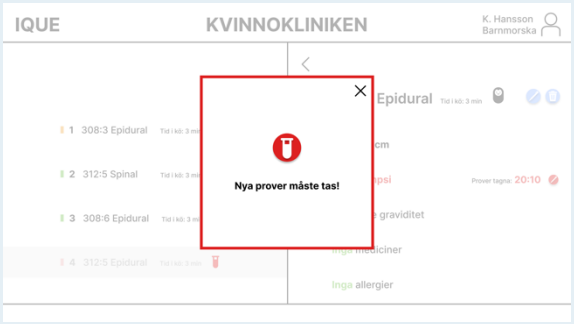

Figure 47. Pop-up: new samples

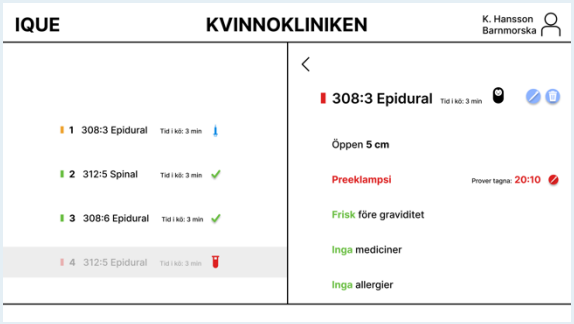

Figure 48. Add new samples

The view of the anaesthesiologist

Figure 49. Prepare patient

Concept 2

In the sections below are Concept 2 presented.

Place order

When placing an order of anaesthesia, the midwife fills in the necessary information in the same way as in Concept 1, at an individual pages. However, the choices are made through either a drop-down menu or clicking one of two circles. When interacting with the drop-down menu the other parts of the page are faded. See figure 50.

Queue & presentation of information

The structure of the page is the same as in Concept 1. However, the status of the order is visualized in a blue text, which changes according to the state of the process. See figure 51 and 52. The status of all orders is not presented in this concept, only the current status of the anaesthesiologist, informing the midwives of the ward and room where the current application takes place.

At the right section of the page, the information regarding the order is presented horizontally. A rounded square surrounds the information, some coloured according to prioritization.

New samples

If new samples are needed, a pop-up window appears in the same way as in Concept 1, see figure 53. The status and colour of the square changes, and the previous time is removed, indicating that the midwife needs to update this area. The midwife can fill in the updated time of the new samples in the information window. When new samples have been filled in, a compatible green colour has been added and the status is changed to "new samples have been added". See figure 54.

Anaesthesiologist

The view of the anaesthesiologist is almost the same as the view of the midwife. However, the status of all orders is presented to the anaesthesiologist in the queue. Further, the interaction of the change of status is done at the top of the information page. See figure 55.

The view of the midwife

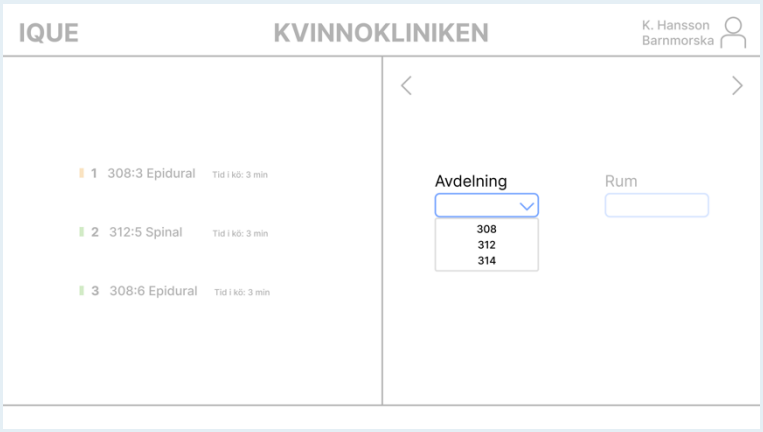

Figure 50. Place order - page: department & room

Figure 51. Diabetes patient | Status: unconfirmed

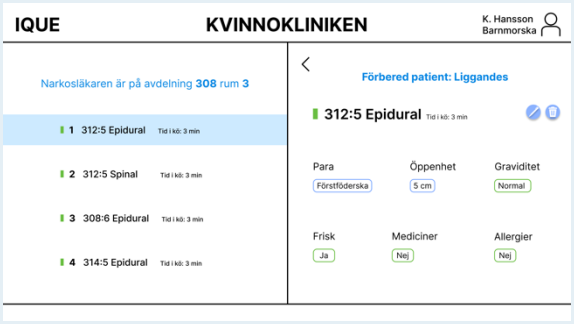

Figure 52. Healthy patient | Status: prepare position

Figure 53. Add new samples

Figure 54. New samples added

The view of the anaesthesiologist

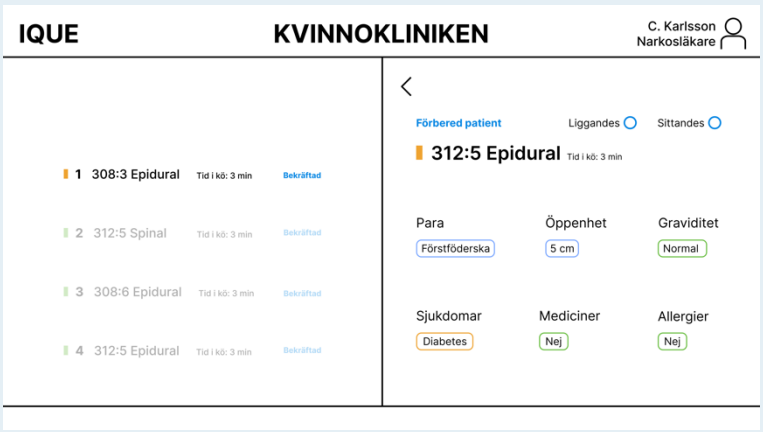

Figure 55. Prepare patient

Concept 3

In the sections below are Concept 3 presented.

Place order

When placing an order of anaesthesia, the midwife fills in all the necessary information at one page. The choices are made through either a drop-down menu or clicking a circle. When interacting with the drop-down menu the other parts of the page are faded. See figure 56.

Queue & presentation of information

When the order has been placed the queue and position is presented at ⅔ part of the page. A grey square surrounds the order placed, which then changes to blue when the anaesthesiologist has confirmed the order. See figure 57. At the other section of the page the information regarding the order is presented vertically. At the bottom of the information page the midwife can pause or remove the order. Further, all buttons are consistent throughout the whole concept regarding placement and design.

New samples

If new samples are needed an orange square appears above the pause and remove buttons. See figure 58.

Anaesthesiologist

The view of the anaesthesiologist is similar to the view of the midwife. When an order is placed a grey square covers the order and a small alarm symbol is placed to the right. See figure 59. When the order is confirmed the confirmation button is exchanged to prepare the patient and initiate application. When pressing one of the desired positions of preparation the button changes to green. See figure 60.

An arrow is added in the queue, visualizing that the application has been initiated. If new samples need to be taken a button appears to the right of the time of the samples. See figure 61. If the anaesthesiologist needs to attend a high incoming emergency case the anaesthesiologist can pause the queue at the queue page. Interaction is possible at any stage of the process.

The view of the midwife

Figure 56. Place order

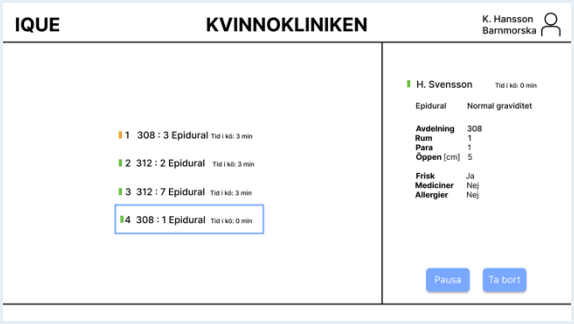

Figure 57. Healthy patient | Status: confirmed

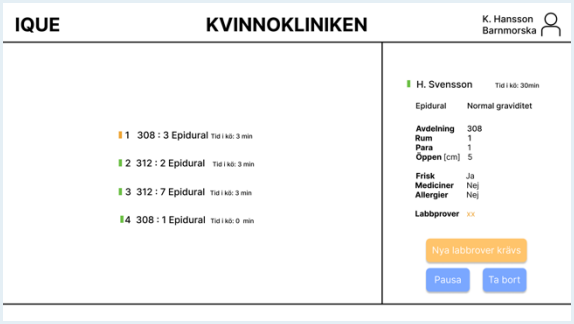

Figure 58. Add new samples

The view of the anaesthesiologist

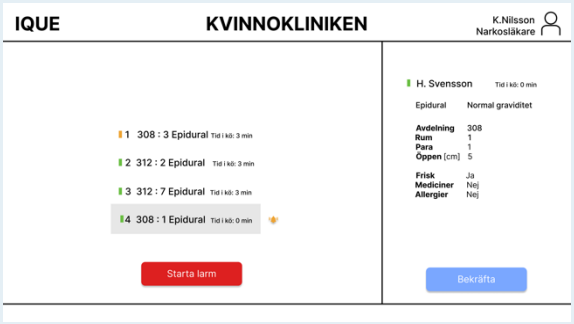

Figure 59. Confirm order

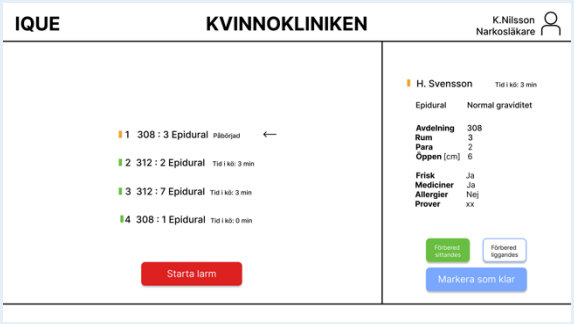

Figure 60. Application initiated

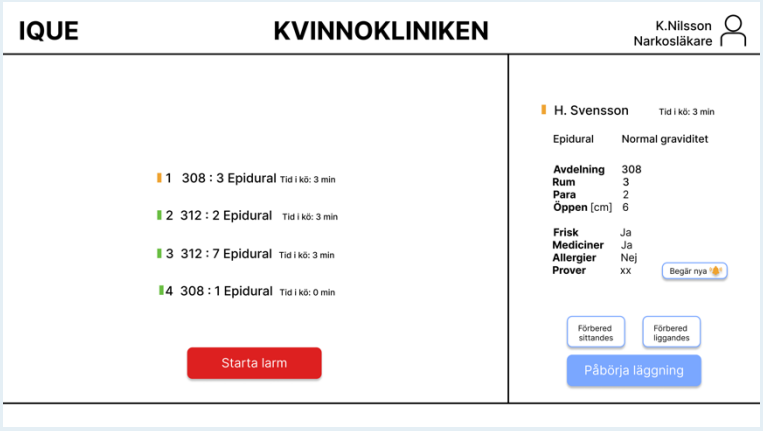

Figure 61. New samples needed

Concept 4

When placing an order of anaesthesia, the midwife fills in the necessary information in the same way as in Concept 3. However, the choices are made through either filling in text manually or clicking a circle. See figure 62. The structure and presentation of information is visualized in the same way as for Concept 3. The placement and design of the buttons are the same as in Concept 3, however with symbols instead of text. See figure 63 for the view of the anaesthesiologist.

Figure 62. Midwife | Place order

Figure 63. Anaesthesiologist

9.2.3 Evaluation

After concept development and prototyping the concepts were evaluated both theoretically and empirically read more in chapter 4.4. Presented below are the findings from the evaluation with the users and the concept weighting matrix of the Obstetrics and Gynaecology department.

Evaluation with the users

Presented in the following sections are the results from the evaluation with the users of the Maternity wards and the Surgical ward 2.

Placing an order

All midwives agreed that the best way of placing the order was made at one page. Considering filling in the information, the participants were sceptical towards the drop down menu and alternatives in terms of buttons. Typing in the information manually was considered to be the most secure way. Considering the type of pregnancy the headline was more accurate as "normal pregnancy". Further, the choices of "yes" or "no", followed by the option of filling in the information manually, was considered to be more beneficial rather than choosing between several alternatives. This was something the anaesthesiologist agreed on. The sequence of filling in the information was preferred in a different order and aspects, such as BMI and fear of giving birth, was considered to be beneficial to add according to the midwives.

Information section

Considering the presentation of information the midwives preferred Concept 2 and 3. One of the anaesthesiologists agreed with the midwives, and considered Concept 2 as clear. Further, the anaesthesiologist did not consider the surrounding coloured squares as necessary, but preferred that structure. All three participants agreed that the presentation of information in Concept 1 was not preferable. The presentation was considered a bit messy with the different colours and the bold text. However, the other anaesthesiologist believed that Concept 1 was the most clear and structured way of presenting the information. The vertical presentation and coloured text was considered to be beneficial, especially during on-call hours. Further, all participants agreed that the buttons with text were more clear.

Queue

Being able to see when the anaesthesiologist has confirmed the order, and the current location of the anaesthesiologist, was considered to be important for the midwives. The participants were neutral regarding the presenting the status of the other orders. The most important aspect was considered to be the number of orders in line and the status of the order of the midwife in question. However, the indication of preparation was not something that the midwives believed they would have time to take into consideration.

Considering the colours of prioritization, the anaesthesiologists did not agree. One of them believed it was not necessary, and the other one considered the colours to increase the visual clarity. One of the anaesthesiologists believed that the orders not confirmed should stand out from the rest, rather than the ones confirmed. Further, the other anaesthesiologist mentioned that an additional step should be included when the position of preparation is filled in. If the anaesthesiologist is left, or right, handed, both sides should be available to choose between when preparing the patient in a lying position.

New samples

If new samples need to be taken, the opinions regarding this varied. The midwives preferred that the anaesthesiologist called if new samples were needed, and that they could call the anaesthesiologist when the samples were analysed. One of the anaesthesiologists preferred to inform the midwife through the application and be notified that the midwife confirmed this. Lastly, the other anaesthesiologist believed that it was the midwives responsibility to keep track of the samples validity. However, the participant preferred if this was automatically calculated by the application, sending a notification to the midwife based on the previous time of samples. Further, both anaesthesiologists wanted to be notified when the new samples had been analysed.

Additional aspects

A discussion considering the change of personnel was carried out. The need to be able to take over someone else's order, and order for someone else, was brought up by the midwives. Further, the anaesthesiologist mentioned the need for several anaesthesiologists to access the queue at the same time if the pressure was high.

Both anaesthesiologists agreed regarding the notifications that should appear when the phone is locked. Some of these mentioned were when a new order has been placed and when new samples have been added.

Concept weighting matrix

The concept weighting matrix was performed based on the knowledge gained during the evaluation phase and resulted in an objective prioritization of the concepts. As shown in table 17, Concept 2 got the highest result in the matrix with a score of 100. The concept was given a 3 for all guidelines except considering the "visual clarity" and "efficient usage". Further, Concept 1 got the lowest result, scoring 1 in four of ten guidelines. To summarize, the result varied between the concepts, mainly due to the low score of Concept 1. See appendix 10 for the full concept weighting matrix of the Obstetrics and Gynaecology department.

Table 17. Concept weighting matrix the Obstetrics & Gynaecology department

Concept weighting matrix	Concept 1	Concept 2	Concept 3	Concept 4
Total	65	100	98	90

10. Final concept

In this chapter, the final concept is presented. It includes general functionality and design aspects considering both departments, followed by the separate concepts of the Emergency ward and the Obstetrics and Gynaecology department.

10.1 General

In this section, the general parts of the final concept are explained. This includes design solutions considering both departments in question.

Colours

The colour theme of the application follows the visual profile of Region Västra Götaland (n.d.). The main colour is blue, as for the website of Sahlgrenska University Hospital. The colours used for the application are presented in figure 64.

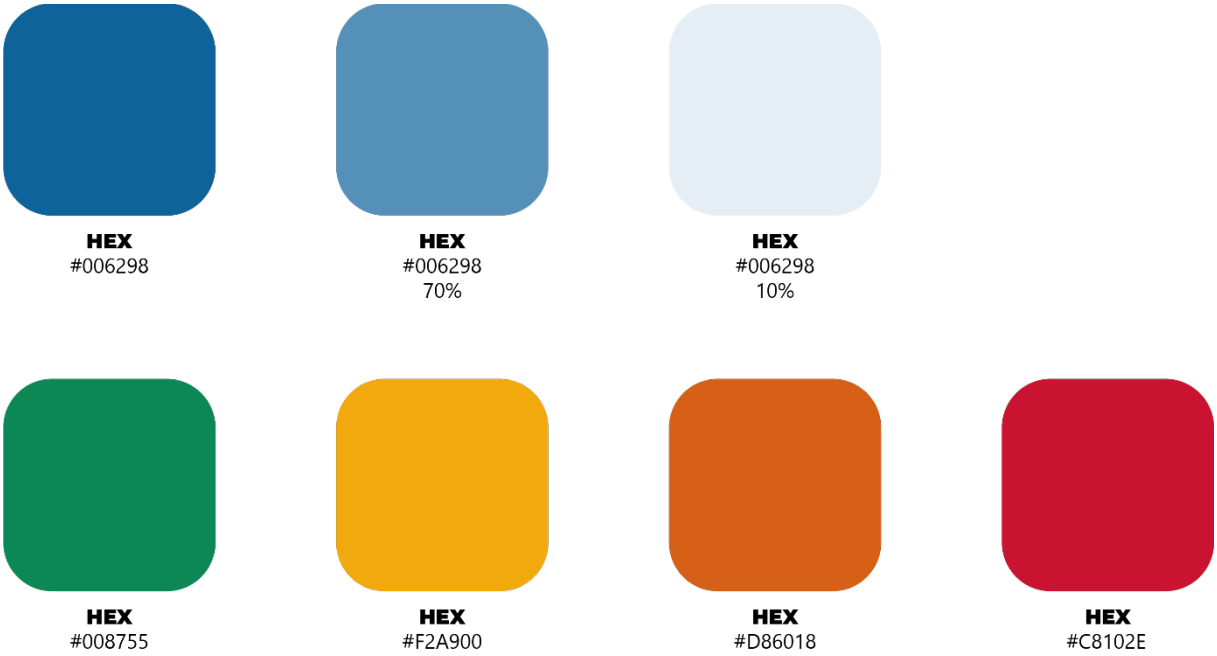

Figure 64. Colour scheme

Logo

The logotype consists of a house with a plus inside of it, together with the name of the application beneath, see figure 65. The name of the application is the same as for the prototype developed by the initiators of the project. The house is intended to symbolize a hospital, and the plus inside of it symbolizes healthcare, but also adding a position in the queue. The colours used for the logotype are in line with the remaining colours of the application.

Figure 65. The logotype

Buttons

The buttons of the application are all constructed in the same way, with a text explanation of the function placed in a rounded rectangular. The choice of buttons including text, and not icons, is based on the evaluation with the users. Using text is clearer than icons, and contributes to a higher guessability and explicitness of the application. This was further shown in the concept weighting matrix.

When not in use, the buttons have a drop shadow. This in order to clarify for the user that it is possible to interact with the button. While hovering over the button, the drop shadow is replaced with an inner shadow of the button. In addition, the text changes from regular to bold. This in order to give the user feedback, and clues, when interacting with the application. See figure 66 and 67 for the design of the buttons.

The explanation of the buttons mentioned above considers the buttons in the web-based application. For the phone-based application, the hover functionality is not included since that is not possible in a phone-based application.

Figure 66. Button default

Figure 67. Button while hovering

Icons

In addition to the buttons, some icons are used in the application. This includes an arrow, a cross and an icon representing a person, see figure 68, 69 and 70. All these icons also have a drop shadow, in order to indicate interaction. In other words, consistency is applied to the design solution.

Figure 68. The person

Figure 69. The arrow

Figure 70. The cross

The function of the arrow is to enable going backwards in the application, the cross enables the user to remove pop-up information. The icon of a person is intended to enable the user to among others log out of the application, or change the settings. All these icons possess functionalities similar to how they are used in other applications and situations, meaning compatibility is applied to this design solution.

Pop-up information

When new information is available for the user, a pop-up window appears at the centre of the application, see figure 71. The information behind the pop-up windows is faded, in order to direct the user's attention to the pop-up information.

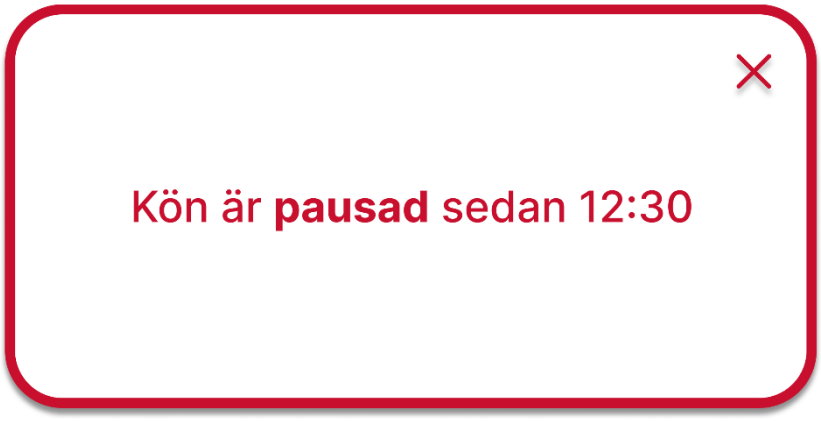

Figure 71. Pop-up window

Login

The first page of the application is the login. This is the page all users meet when starting the application. It consists of three parts where the user needs to fill in information; the department, the username and the password.

In order to fill in the department, a drop-down menu is available, where the users can choose between the Emergency ward or the Obstetrics and Gynaecology department. For the username and password, the users fill in their information in the areas by writing, see figure 72. The structure of the login page is similar to other solutions with the same function. In other words, compatibility is applied to the design solution.

After filling in the three areas, a button with the text “logga in”, log in, turns from grey to blue, which implies that all information needed is available and that it is possible to log in to the application.

Figure 72. The login page

Page structure

The start page for all users, excluding the anaesthesiologist, is structured in the same way, divided into two sections. In two thirds of the page, the queue is presented. The remaining part of the page consists of an information section. In this section, all the main interactions with the application are performed. This structure was chosen due to the results of the user evaluations.

In addition to this, a bar is placed at the top of the page. This includes the logotype of the application together with the name of the department currently staying at, both located in the left part of the bar. On the right side, the name and profession of the user is located, together with the icon of a person. Compatibility was considered for this design solution, where other applications have the same structure. See figure 73 for the page structure.

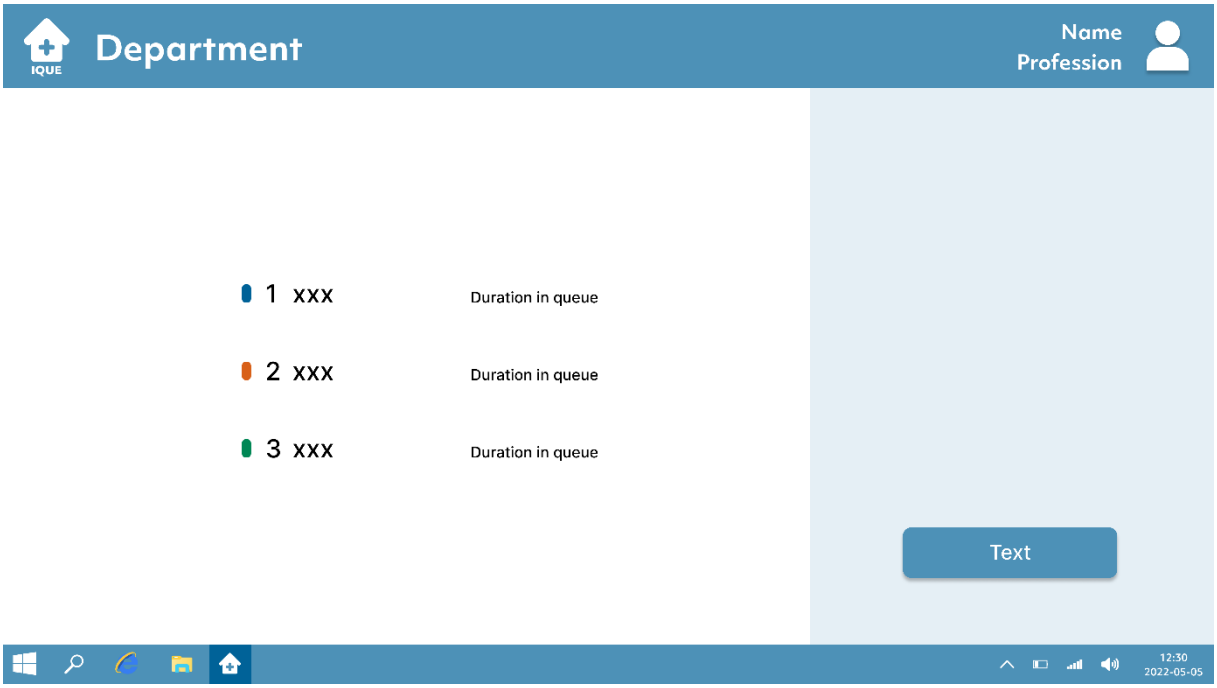

Figure 73. The page structure

The view of the anaesthesiologist differs from the system explained above. This since the application is intended for a phone. Instead, the queue and the information section are presented in two different views. Read more about this in section 6.3.2.

10.2 Emergency ward

In the sections below, the final concept of the Emergency ward is presented. See figure 74 for the interaction flow from the doctors' view and figure 75 for the consultants' views.

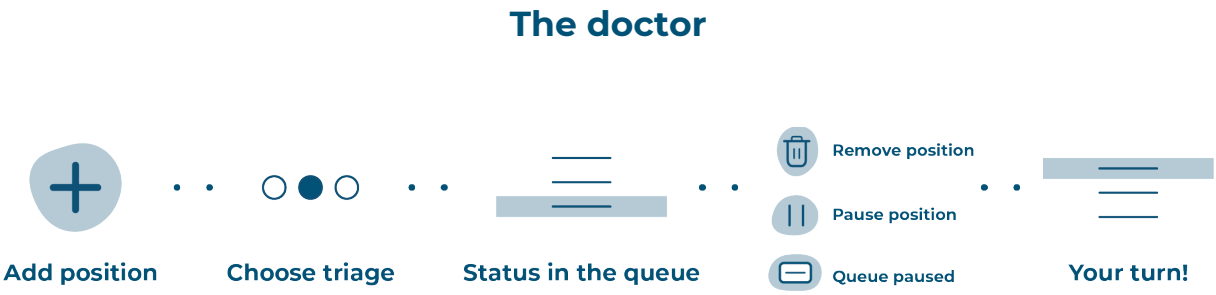

Figure 74. The interaction flow of the doctor

Figure 75. The interaction flow of the consultant

10.2.1 Doctor

Presented below are the view and interaction flow of the doctors.

Start page

The start page of the doctors consists of the current queue, presented in two thirds of the application, together with a button to get in line in the remaining section. The doctors in the queue are numbered as well as triaged. Furthermore, the time spent in the queue is presented beside the name of the doctors. See the start page of the doctors in figure 76.

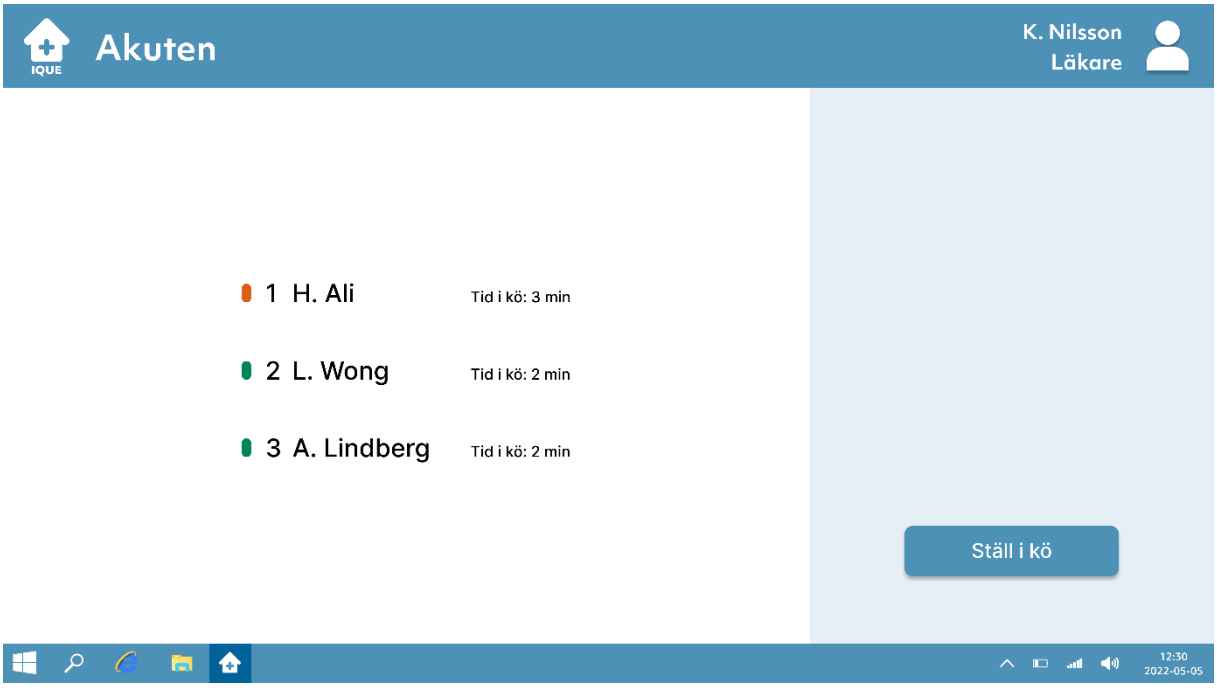

Figure 76. The start view of the doctors

Need for consultation

When a doctor is in need of consultation, the button in the right section is pressed. Before getting in line, the doctor chose the level of triage, see figure 77. While hovering over the different levels of triage, the remaining levels are faded, see figure 78. When a level is chosen, this is marked with a blue circle, see figure 79. When added to the queue, a blue banner is placed around the position of the doctor in question, see figure 80. The banner clarifies the position in the queue of the doctor. This makes it easier for the doctors to follow themselves in the queue. In addition, a clarifying text of the position in the queue is presented in the information section.

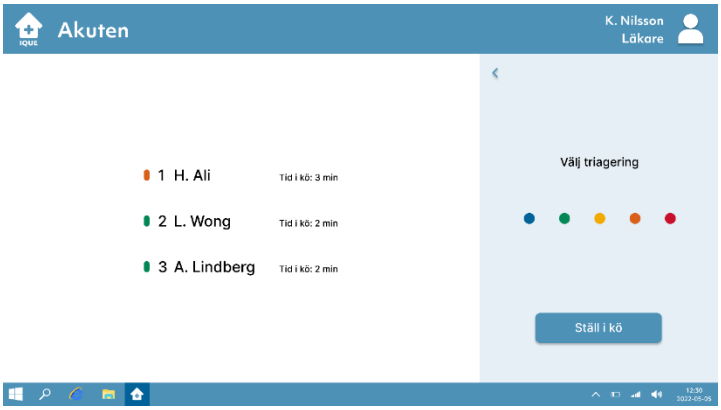

Figure 77. Levels of triage

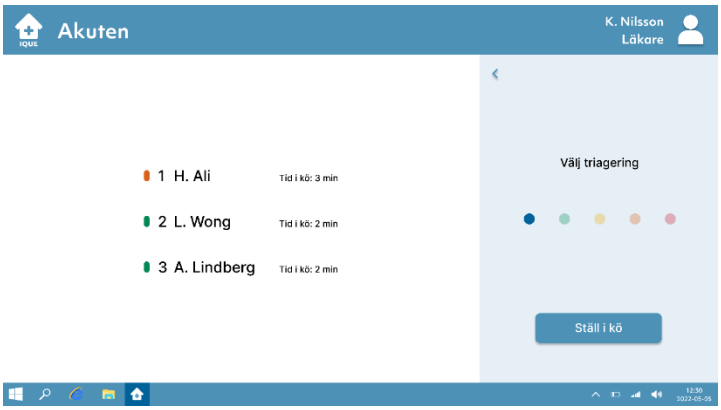

Figure 78. Hover over blue triage

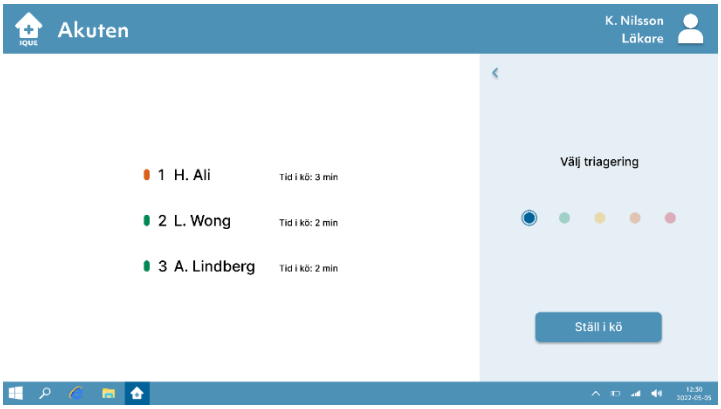

Figure 79. Blue triage chosen

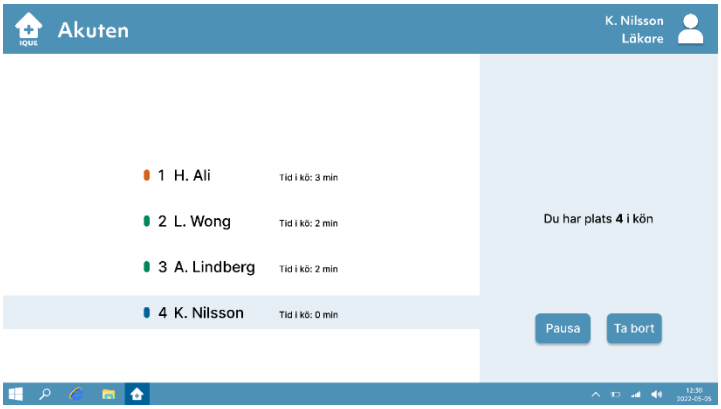

Figure 80. Added in the queue

Pause & delete

If needed, the doctors can pause or delete their positions in the queue. These functions are located in the information section, see figure 80.

When the position of a doctor is paused, this is clarified by changing the time indication from minutes spent in the queue, to the text "pausad", paused. Furthermore, the information is faded in the queue, see figure 81. To enter the queue again, the doctor can click on the button "Starta", start.

The doctors can also delete their position, if consultation is no longer needed. If so, a pop-up window appears, here the doctor can choose to delete position or not, see figure 82.

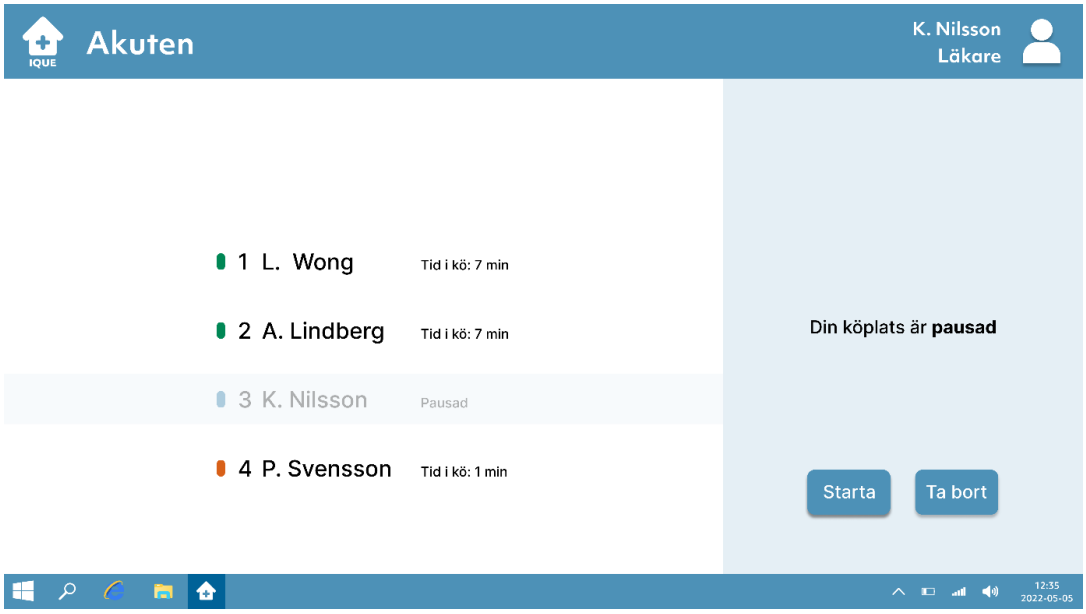

Figure 81. Position paused in the queue

Figure 82. Delete position in the queue pop-up

Consultant unavailable

If the consultant is not available, a pop-up window appears with a clarifying text of the current situation. Depending on if the consultant is not available due to an incoming high emergency case, or a break, the information is presented in red or blue, see figure 83 and 84. When the doctor removes the pop-up information, a banner located in the upper part of the queue section is replacing the pop-up. Furthermore, the queue gets faded, see figure 85 and 86. In this situation, it is still possible for the doctors to pause or delete their position in the queue. When the consultant is available again, the queue returns to what it looked like before.

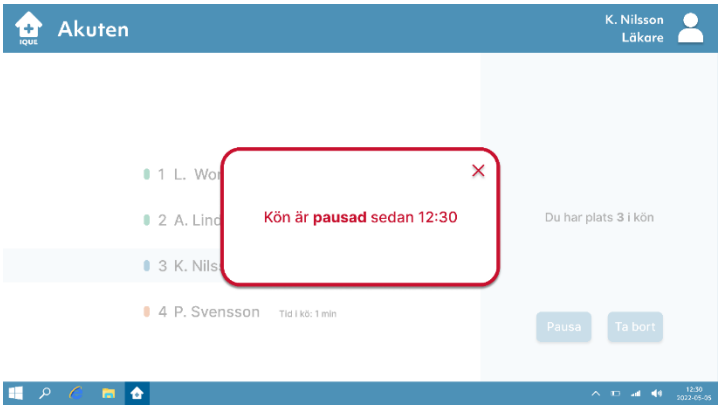

Figure 83. Consultant unavailable due to incoming high emergency case, pop-up

Figure 84. Consultant on a break, pop-up

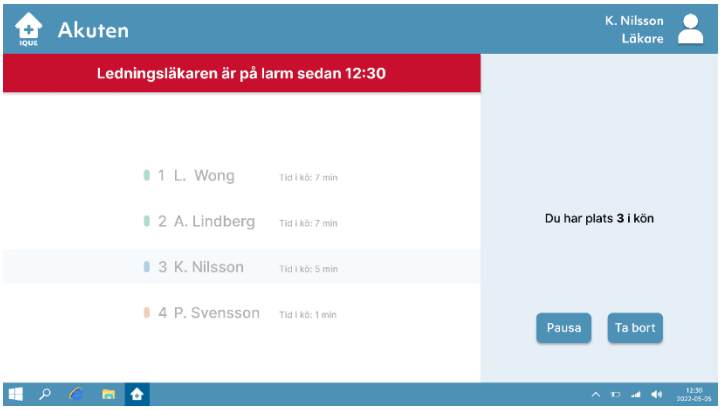

Figure 85. Consultant unavailable due to incoming high emergency case, banner

Figure 86. Consultant on a break, banner

10.2.2 Consultant

Presented below are the view and interaction flow of the consultant.

Start page

The start page of the consultant is structured in the same way as for the doctors. However, instead of being able to get in line, a button to pause the queue is placed in the right section, see figure 87.

Figure 87. The start view of the consultant

Consultation

In order to initiate consultation, the consultant clicks on one of the participants in the queue. Then, the remaining participants in the queue get faded and in the right section, information about the doctor in question is presented. This includes the triage, time spent in the queue as well as the telephone number of the doctor. In addition, the button “Starta konsultation”, start consultation, is placed in the lower part of the section, see figure 88. By clicking on this button, consultation is initiated. The time spent in the queue is changed to “pågående”, ongoing, and the start consultation button is changed to “Avsluta konsultation”, end consultation, see figure 89.

When a consultation is finished, the information about the doctor next in line is presented instead. If the consultant needs to pause the entire queue from this position, it is possible by clicking on the back arrow, which leads to the start page, followed by the break button.

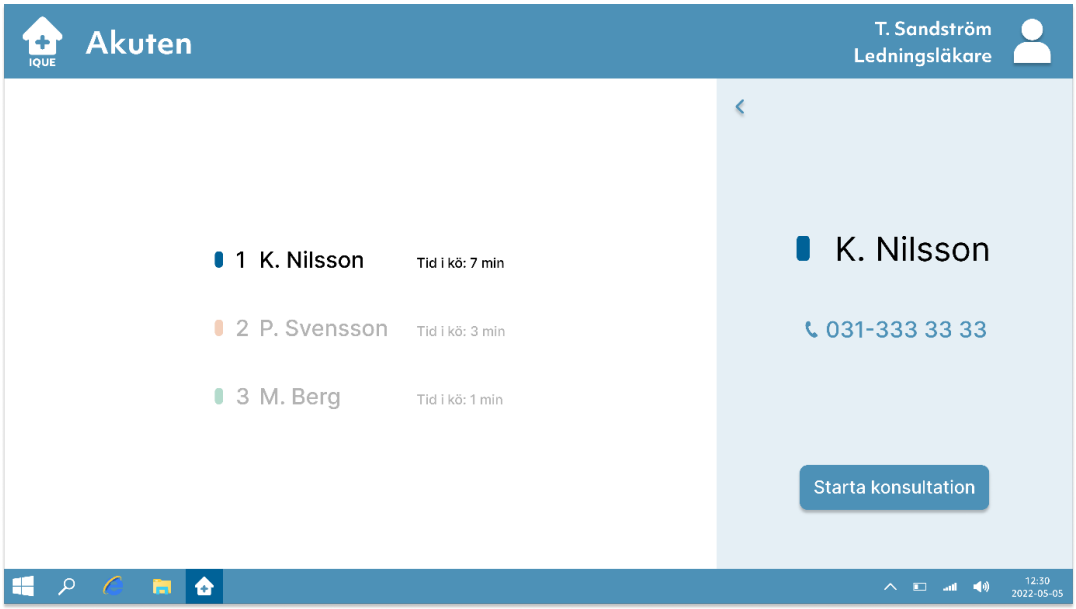

Figure 88. Start consultation

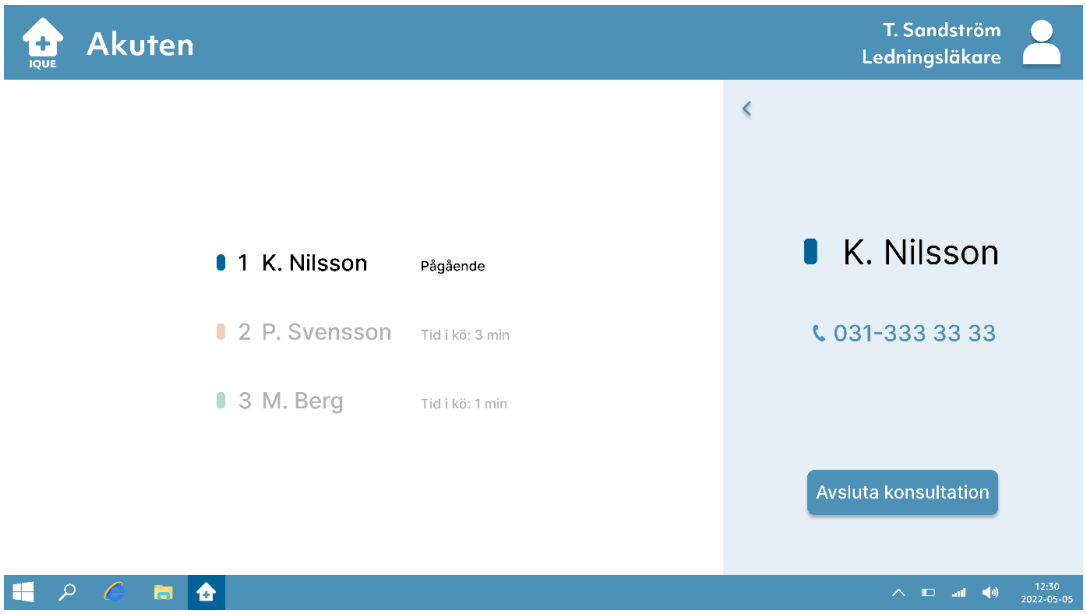

Figure 89. Finish consultation

Pause of queue

If the consultant needs to pause the queue, due to an incoming high emergency case or a break, this is possible by pressing the button “pausa kö”. This leads the consultant to a second page, where incoming high emergency case or break can be chosen, see figure 90. After choosing the type of pause, a banner appears over the queue and the queue gets faded, as for the doctors, see figure 91. The banner is coloured according to the type of pause. In the right section, it is possible for the consultant to start the queue again when the break is over.

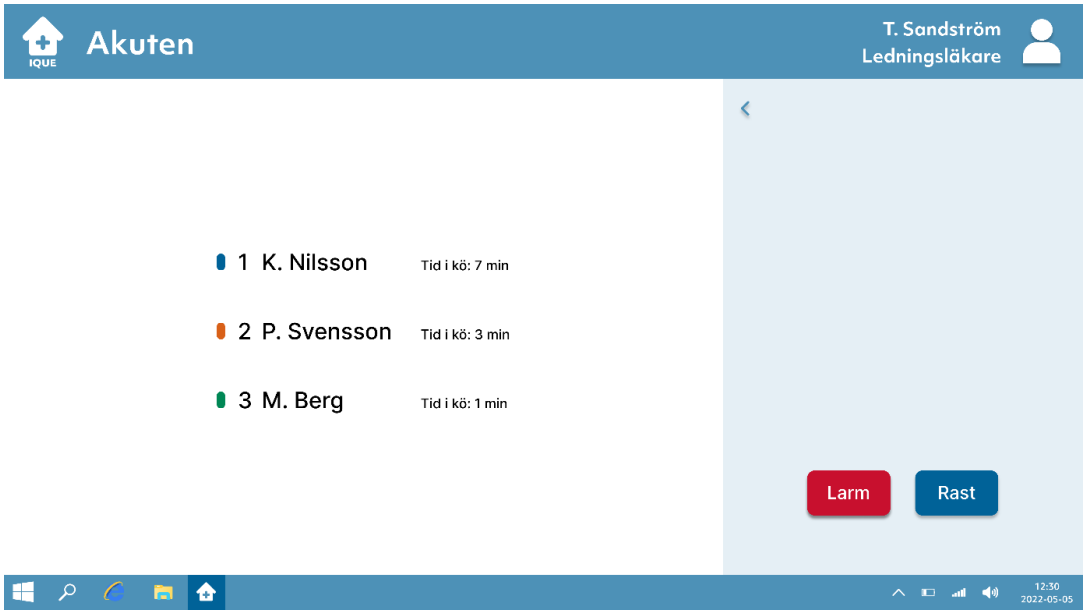

Figure 90. Choice of pause

Figure 91. Queue paused due to incoming high emergency case

10.3 Obstetrics & Gynaecology department

In the sections below, the final concept of the Obstetrics and Gynaecology department is presented. See figure 92 for the interaction flow from the midwifes' view and figure 93 for the anaesthesiologists' views.

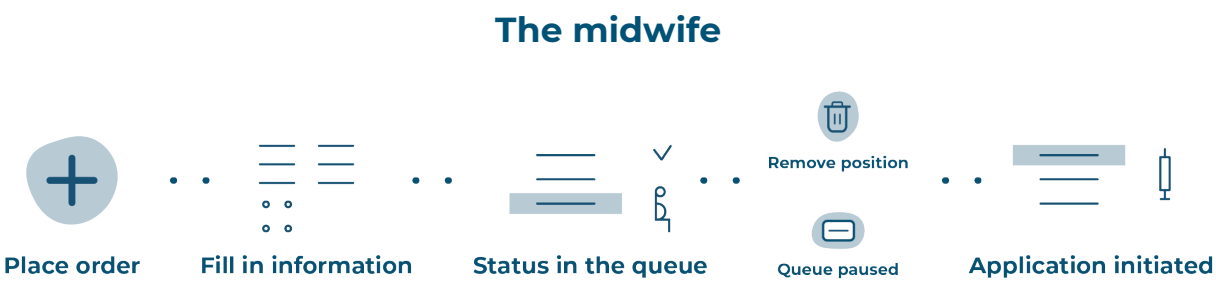

Figure 92. The interaction flow of the midwife

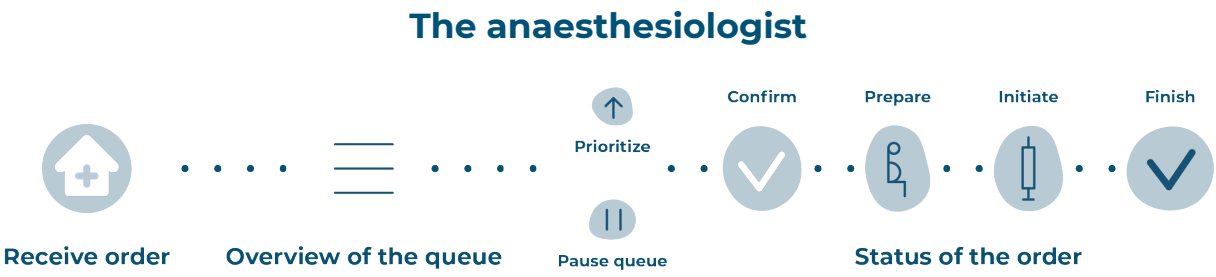

Figure 93. The interaction flow of the anaesthesiologist

10.3.1 Midwife

Presented below are the view and interaction flow of the midwife.

Start page

The start page of the midwives consists of the current queue, presented in two thirds of the application, together with a button to place an order located in the remaining section. The orders in the queue are presented with the department and room of the orders, together with the type of anaesthesia. The orders are numbered as well as prioritized. Furthermore, the time spent in the queue is presented, and it is possible to see if the anaesthesiologist has started an application. In other words, the start page of the midwives is designed in a similar way as for the doctors at the emergency ward, contributing with consistency of the application. See the start page of the midwives in figure 94.

Figure 94. Start page of the midwives

Place order

To make an order, the midwife clicks on the button in the right section. A list of information to fill in, in order to place an order of anaesthesia, is presented, see figure 95. The list consists of both optional as well as mandatory fields. The mandatory fields are marked with a red *. This solution was designed with compatibility in mind.

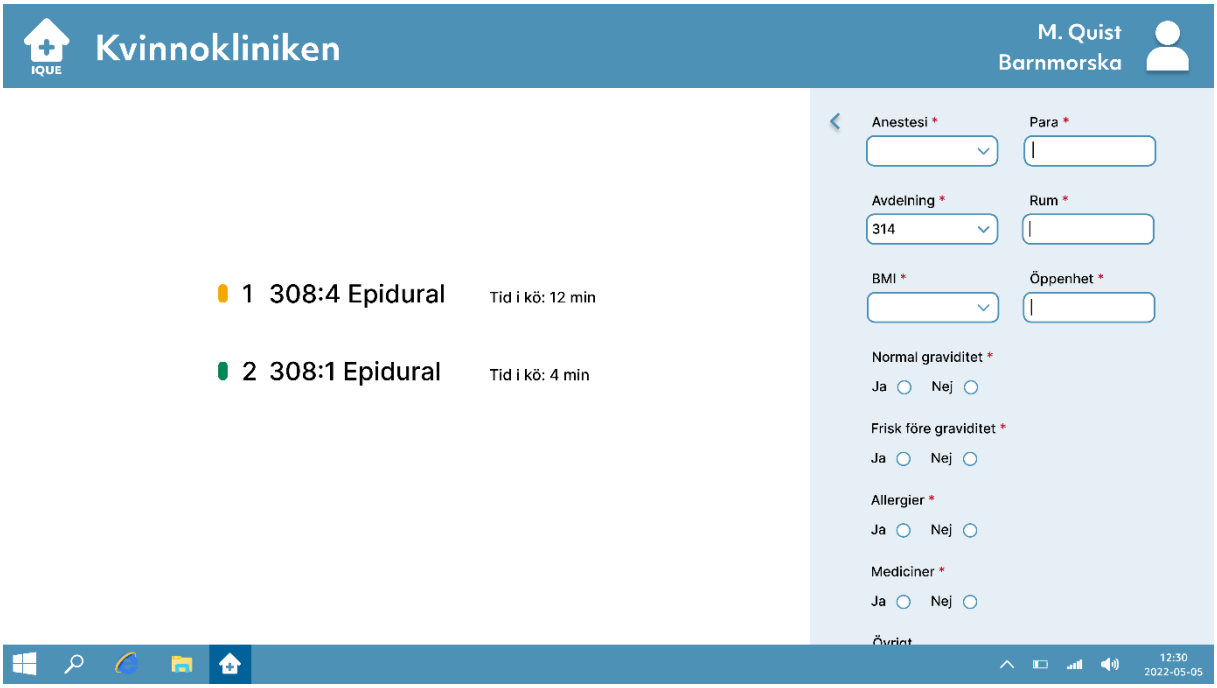

Figure 95. Order application page

In some of the sections to fill in, an arrow pointing downwards is placed in the right corner. This enables the midwives to choose between already existing alternatives, see table 18.

Table 18. Alternatives of the order

Section	Alternatives
Anaesthesia	Epidural Spinal
Department	308 312 314
BMI	Under 40 Over 40

For the department section, a department is already filled in as default. This is based on where the midwife logged in is based. However, it is possible to change department if needed.

The remaining sections to fill in consist of areas where the midwives write words or numbers themselves. Furthermore, the last part of the order consists of options where the midwives choose between yes or no in questions regarding the health of the mother giving birth. This includes; if the mother had a normal pregnancy, if the mother was healthy before the pregnancy, if the mother has any allergies or if the mother is taking any medicines. A section of additional comments appears if the answer is no to the first two questions mentioned, or yes regarding allergies or medicines. However, these areas are

not mandatory to fill in. See figure 96 for the entire order application, excluding the additional comment areas.

For example, if the mother has not had a normal pregnancy, but has preeclampsia, the answer to normal pregnancy is no and preeclampsia is added in the comment section. Furthermore, if the mother is not healthy before the pregnancy, an additional question appears regarding if samples are needed. If so, additional comments about what time the last samples were taken pop-up. See figure 97 any 98 for this example.

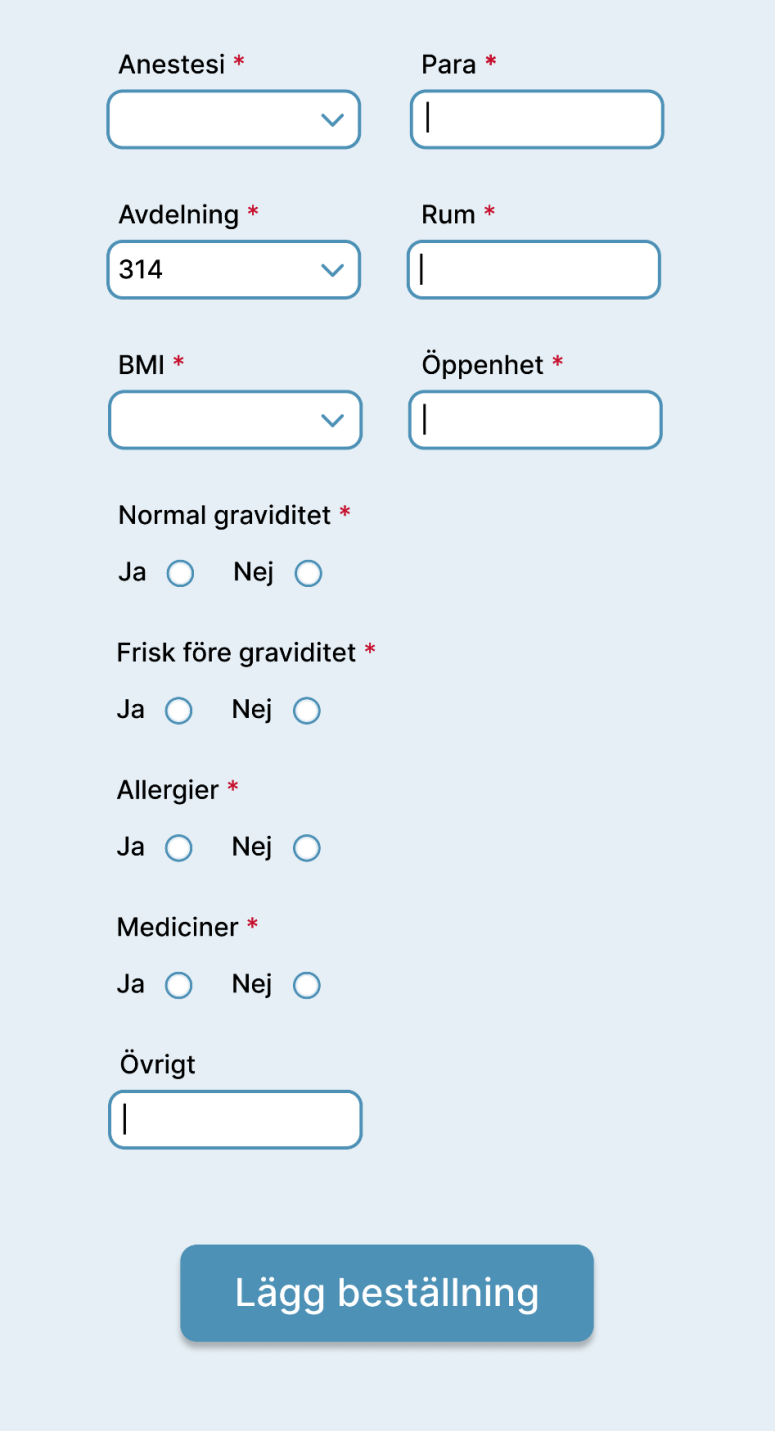

Figure 96. The order application fields

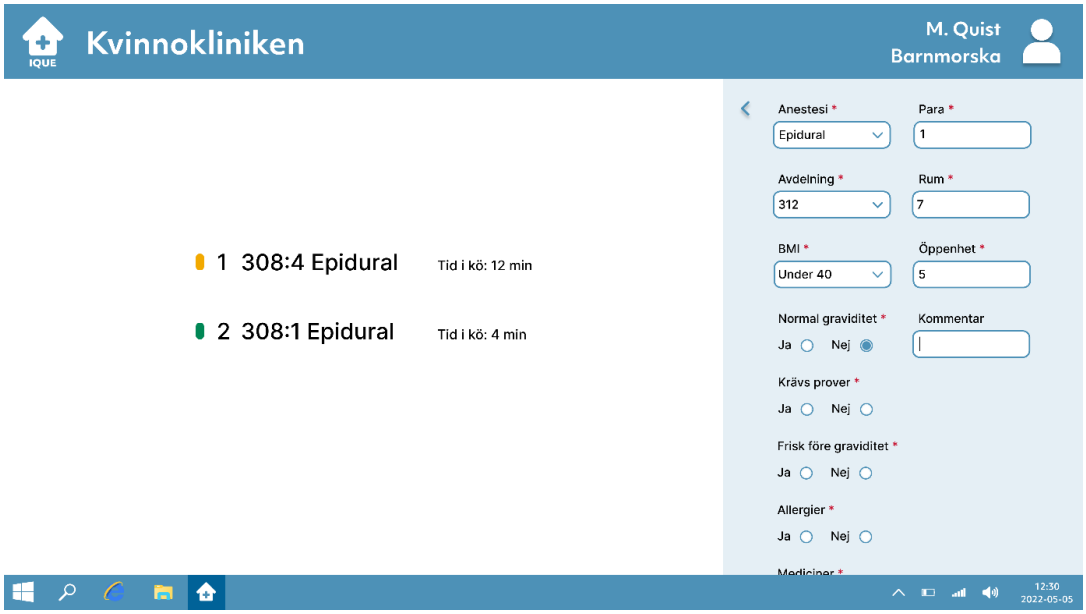

Figure 97. Order application including addition comment area

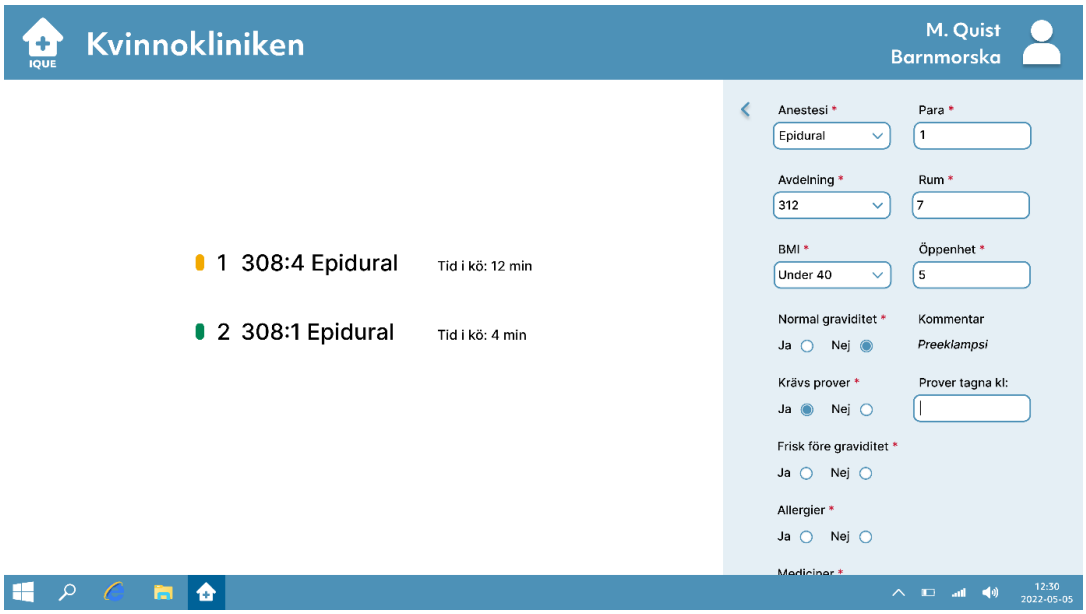

Figure 98. Order application when samples are needed

Status in the queue

When an order is placed and added to the queue, a banner is placed around the position of the order in question, as for the doctors of the emergency ward. However, the banner is coloured in grey until the order is confirmed by the anaesthesiologist, see figure 99. When the anaesthesiologist has seen and confirmed the order, a pop-up appears with a confirmation text, see figure 100. After this, the banner turns from grey to blue. Furthermore, another confirmation text is placed above the queue, see figure 101. This gives the midwife feedback that the order is approved by the anaesthesiologist. The banner also contributes with visual clarity of the position in the queue of the midwives.

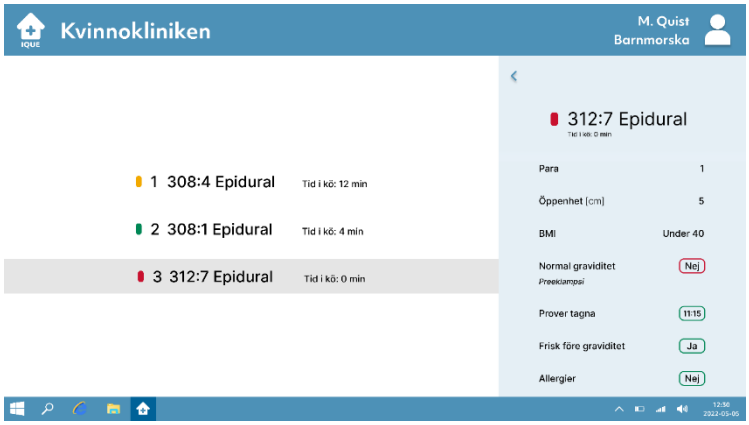

Figure 99. Unconfirmed order

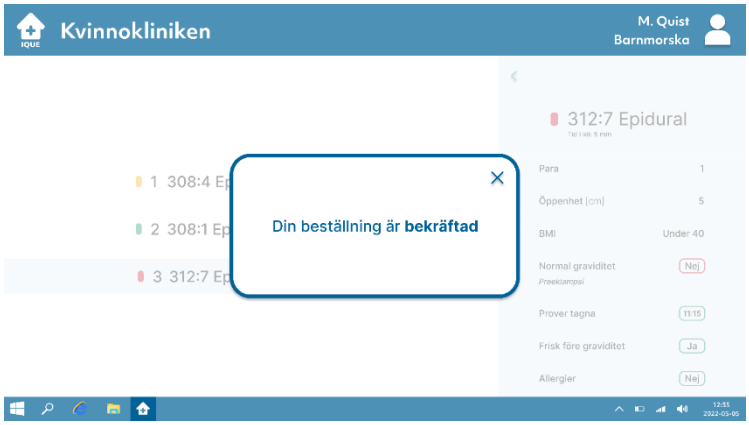

Figure 100. Order confirmation

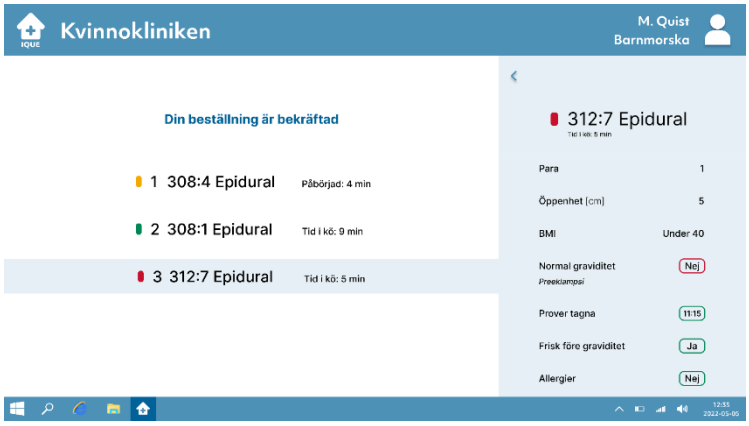

Figure 101. Order confirmed

Before the anaesthesiologist arrives, the mother should be prepared in a sitting or lying position. When it is time for this, a pop-up appears with an explanation text of how the mother should be positioned, see figure 102. When the pop-up is removed, it is replaced with a text located above the queue, as for the order confirmation, see figure 103.

Figure 102. Prepare patient, pop-up

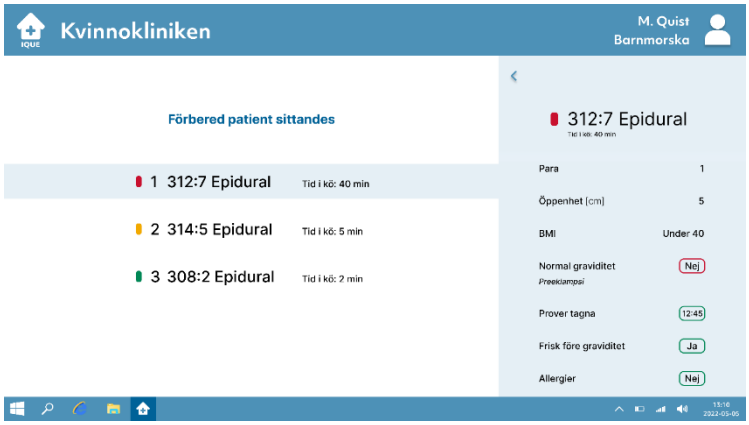

Figure 103. Prepare patient

Depending on the answers in the order placement, the orders are triaged and marked in either green, yellow or red. Furthermore, the answers regarding the health of the mother are circled in a frame coloured either in green, yellow or red. This contributes with visual clarity of what areas might be critical in order to apply an anaesthesia. See figure 104, 105 and 106 for three different examples of orders.

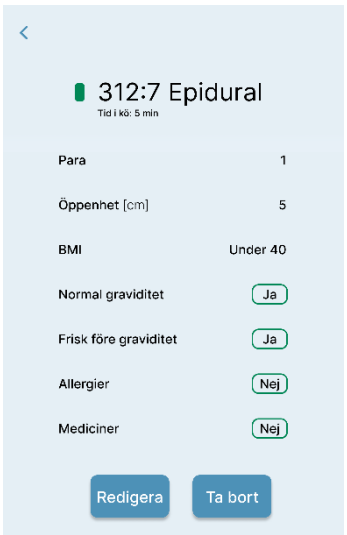

Figure 104. Healthy patient

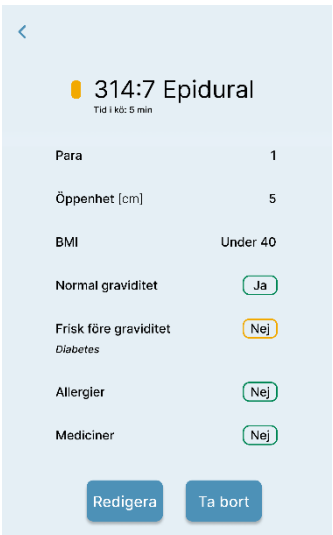

Figure 105. Diabetes patient

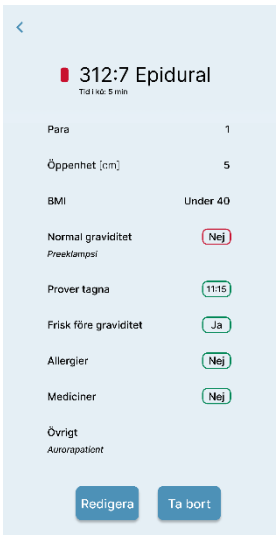

Figure 106. Preeclampsia patient

New samples

If the mother is not healthy, and new samples are needed before an anaesthesia is possible to apply, this is presented with a pop-up reminder, see figure 107, followed by an explanation text located over the queue. In addition, the frame around the time of the samples taken turns from green to red when the samples expire, see figure 108. In order to update the samples, the midwife clicks on the sample time in the information section. Then, a pop-up window appears, where the hour can be adjusted, see figure 109. After changing the hour, the frame around the time turns back to green.

The notification of when new samples are needed is an automated function of the application, in which the system of the application calculates the maximum duration of the samples taken, and sends a notification to the midwife when they are about to expire. This solution was developed as the midwives expressed the request of a reminder.

The solution of the situation regarding new samples was discussed during the user evaluation session, where this was the end result.

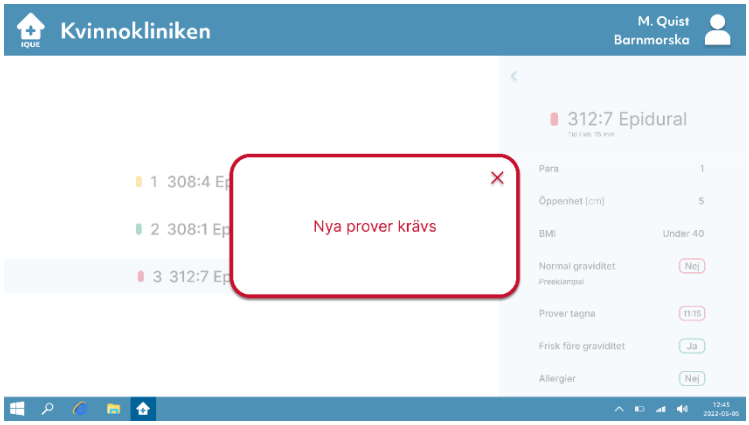

Figure 107. New samples needed, pop-up

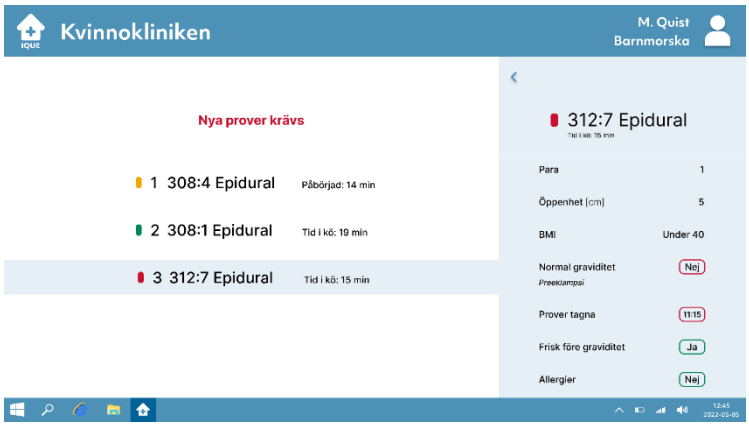

Figure 108. New samples needed

Figure 109. New sample time, pop-up

Edit & delete

If needed, the orders can be edited. This is possible through the button “Redigera”, edit, placed in the information section, as shown in figure 104, 105 and 106. By clicking on the button, it is possible to change the information presented. When the new information is added, the midwife can update the order by clicking on a button named “Uppdatera”, update, see figure 110. It is also possible to delete an order if anaesthesia no longer is needed. In this case, a pop-up window appears, as for the doctor at the Emergency ward, see figure 111.

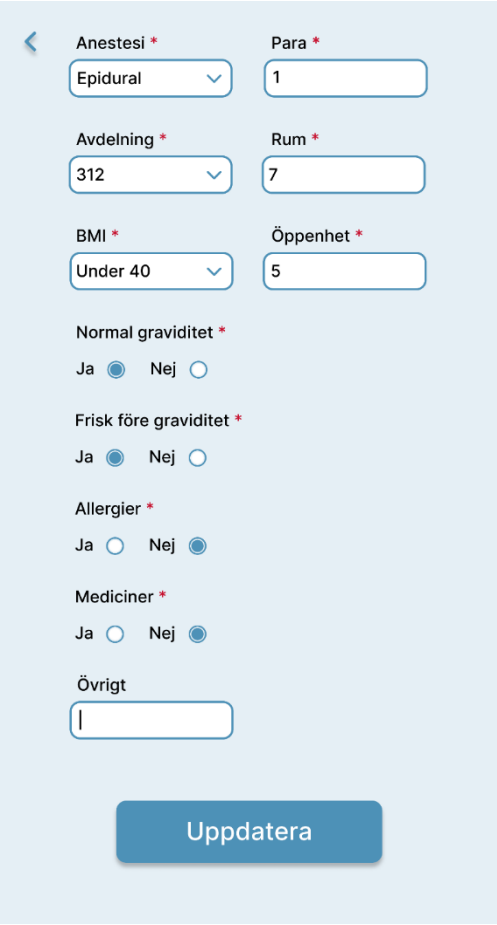

Figure 110. Update order

Figure 111. Delete order

Anaesthesiologist unavailable

Finally, if the anaesthesiologist is not available, a pop-up window appears with a clarifying text of the current situation, see figure 112. A banner located in the upper part of the queue section is replacing the pop-up when removed, see figure 113. Furthermore, the queue gets faded. In this situation, it is still possible for the midwives to edit or delete their orders. When the anaesthesiologist is available again, the queue returns to what it looked like before. In other words, this structure is similar to how it works for the doctors at the emergency ward.

Figure 112. Queue paused, pop-up

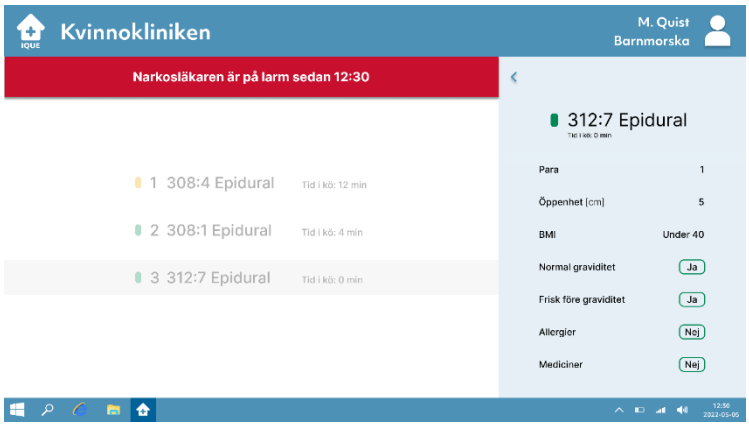

Figure 113. Queue paused, banner

Change of work shift

Furthermore, a midwife can take over another midwife's order. This might be needed when an order is placed close to the change of work shifts. This is possible through the icon of a person in the top bar. By clicking on the icon, a drop-down menu appears. From this view, the midwife can choose the alternative "Ta över beställning", take over order, followed by choosing which order to take over, see figure 114 and 115.

When an order is chosen, a question considering confirmation pop-up, see figure 116. When the order is confirmed, the pop-up is replaced with another pop-up informing the midwife that the task is accomplished, see figure 117.

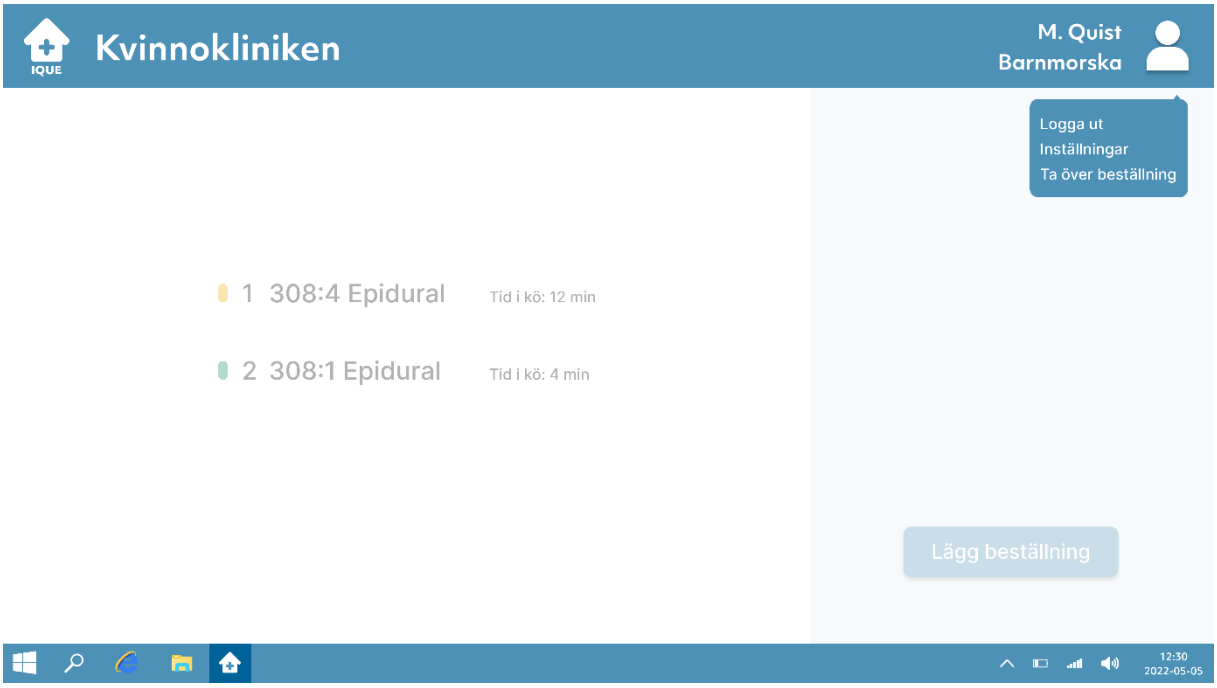

Figure 114. Drop-down menu

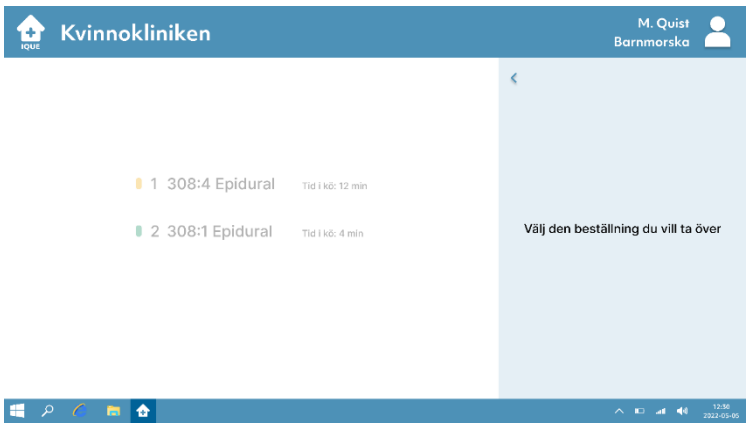

Figure 115. Choice of order

Figure 116. Confirmation request

Figure 117. Order confirmation

10.3.2 Anaesthesiologist

The application of the anaesthesiologist is intended for a phone. This results in that the structure of the pages of the anaesthesiologist varies from the remaining user groups. However, the information presented in the application is similar, or the same. Presented below are the view and interaction flow of the anaesthesiologist.

Start page

The start page of the anaesthesiologist consists of the queue of orders presented, see figure 118. From this view, the anaesthesiologist can accomplish various tasks. If needed, the anaesthesiologist can prioritize the different orders in the queue, and switch their places. This is possible through the switcher located in the upper right corner of the page. When the switch is activated, the anaesthesiologist can change places of the orders by pressing the three stripes bedside an order, and move it to the position desired, see figure 119. When finished, the switch is turned off again.

Further, when the anaesthesiologist is not active in the application, notifications from the app pop-up in the same way as for other applications, see figure 120.

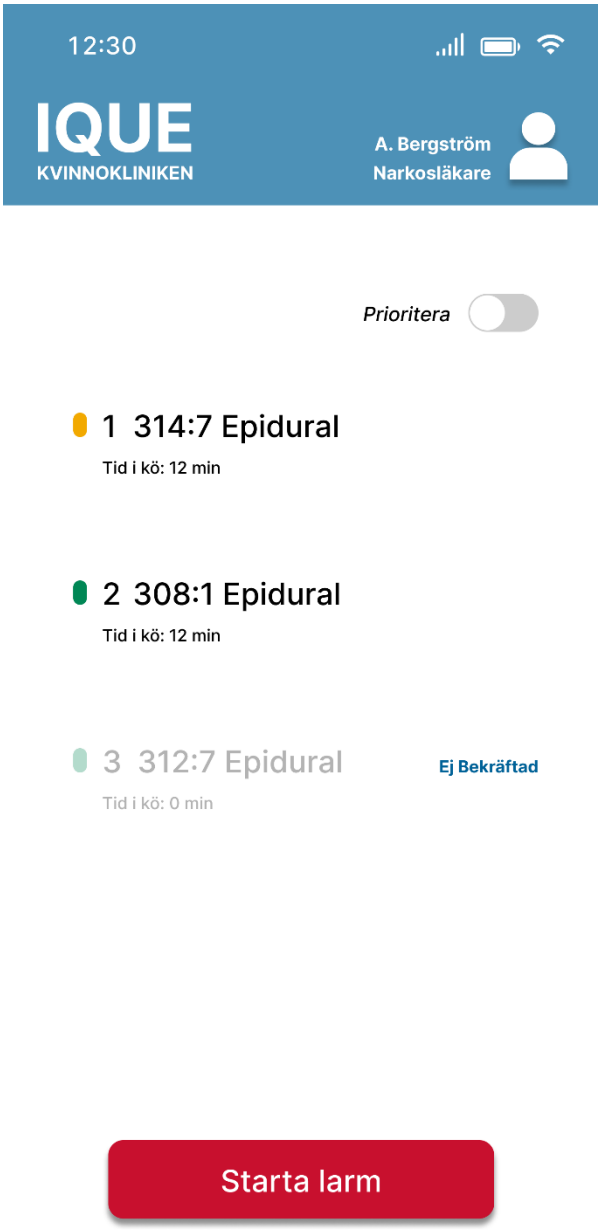

Figure 118. Start page of the anaesthesiologist

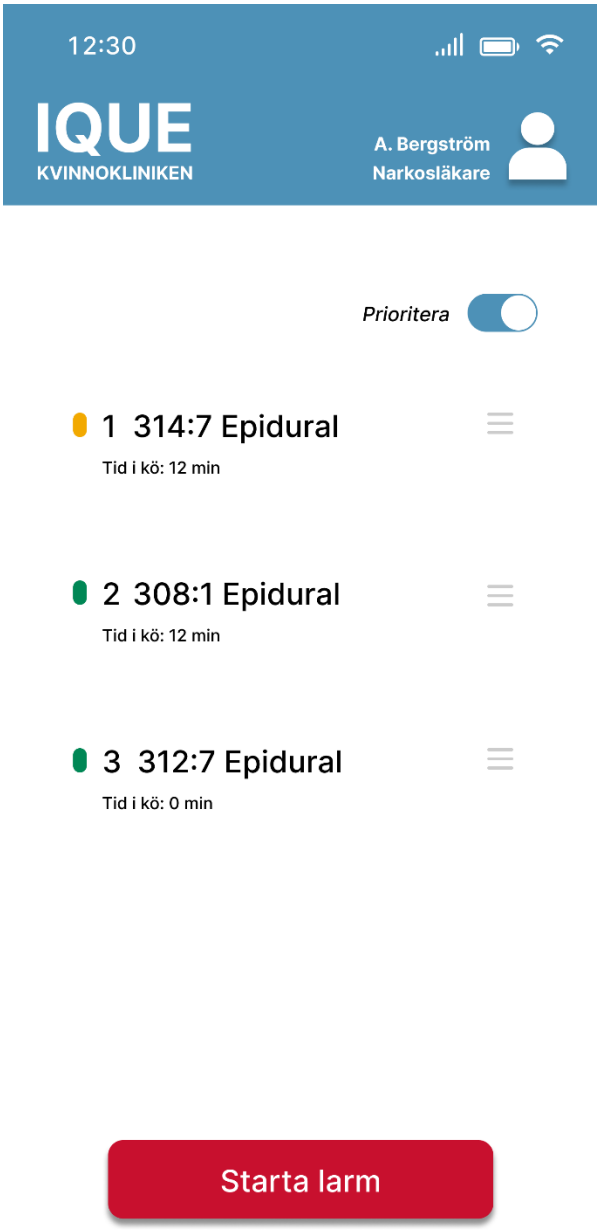

Figure 119. Prioritising mode on

Figure 120. Notification from the IQUE application

Confirmation of order

Further, the anaesthesiologist can confirm orders not confirmed. These orders are faded, and the text “Ej bekräftad”, not confirmed, is placed beside the order. By clicking on the order in question, a new view consisting of the information of the order is presented, see figure 121. If the information is approved, the anaesthesiologist confirms the order by pressing on the button at the bottom of the page. After this, the anaesthesiologist can go backwards to the queue.

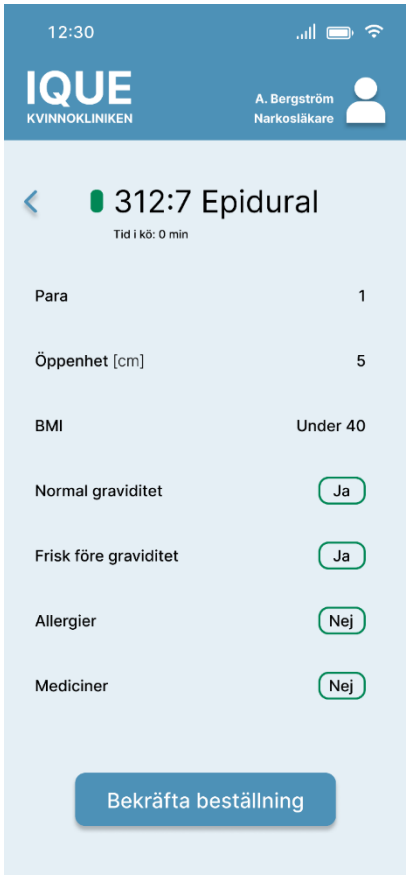

Figure 121. Unconfirmed order

Prepare patient

By pressing on one of the orders confirmed in the start page, an information page of the order appears. In this view, the anaesthesiologist can inform the midwife to prepare the patient either in a sitting position or lying position, see figure 122. If the anaesthesiologist chooses a lying position, the alternatives left or right also need to be chosen, see figure 123.

In the start page, an explanation text of how the patient should be prepared is placed beside the order after choosing the type of position, see figure 124.

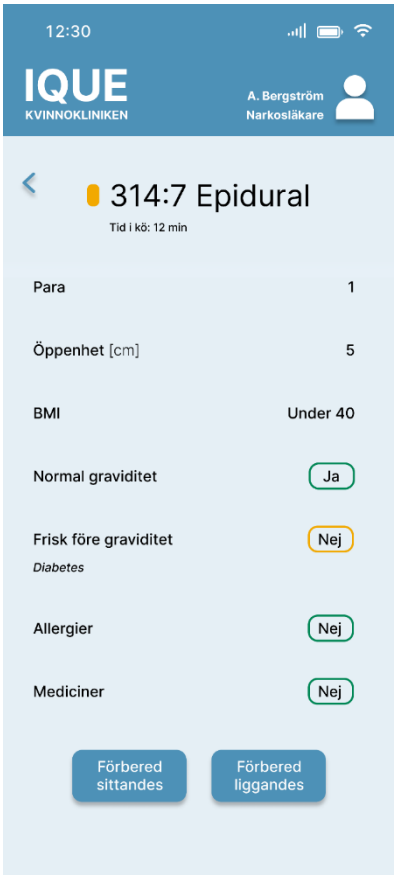

Figure 122. Choice of positioning

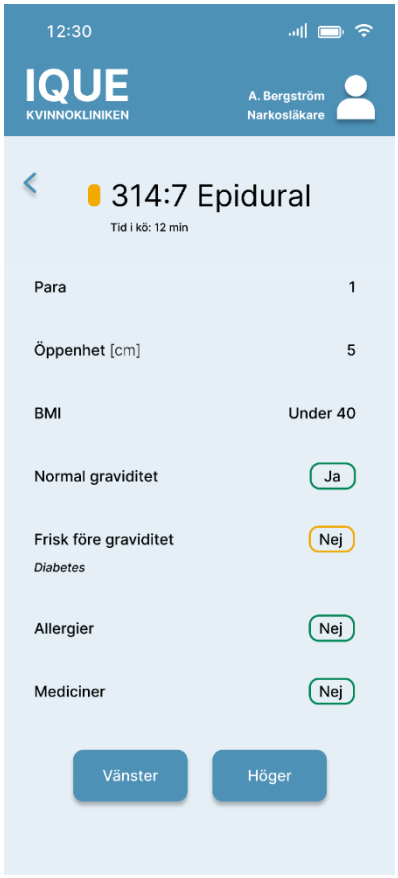

Figure 123. Choice of side

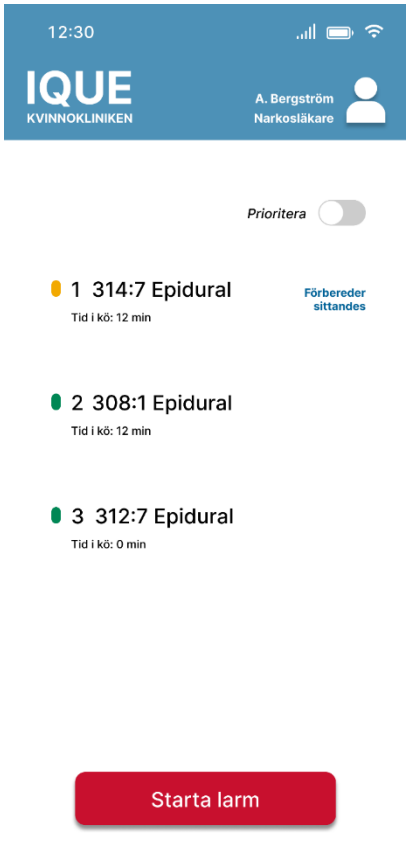

Figure 124. Start page, prepare patient

Initiate application

When an application is initiated, the anaesthesiologist presses the button “Påbörja läggning”, initiates application, located in the information page of an order, see figure 125. The order is updated in the queue as initiated, including time since initiation, see figure 126. The button to initiate application in the information page is replaced by a button to finish application. When an application is finished, the button is pressed, leading the anaesthesiologist to the start page again. In this view, the application performed is out of the queue.

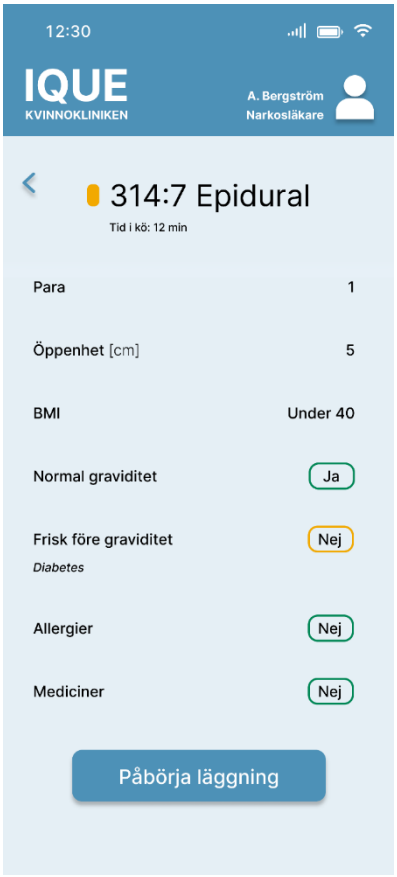

Figure 125. Start application

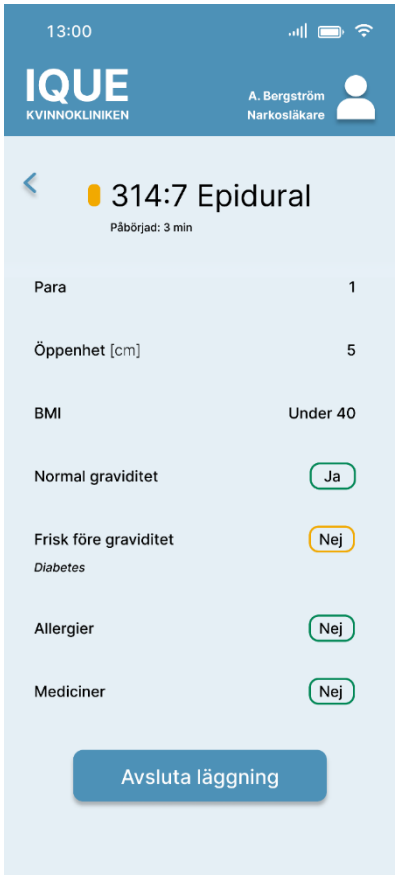

Figure 126. End application

Pause of queue

The anaesthesiologist can pause the queue from the start page. This is possible by pressing the button “Starta larm” located at the bottom of the page. A pop-up window appears where the anaesthesiologist confirms whether or not the queue should be paused, see figure 127. If the queue is paused, a red banner appears in the upper part of the page, and the queue gets faded, as the view of the midwives, see figure 128. In order to start the queue again, the anaesthesiologist press the button “Starta kö”.

Figure 127. Confirmation of pausing queue, pop-up

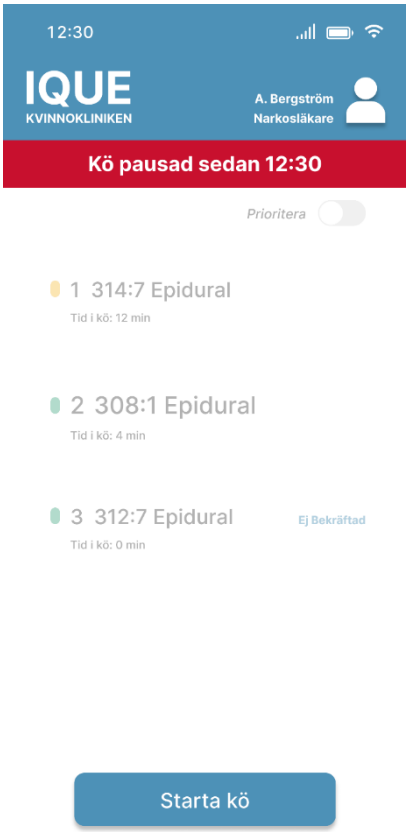

Figure 128. Queue paused

New samples

If new samples are needed in order to apply an anaesthesia, this is both presented in the start page, as well as information page. In the start page, a red text “Nya prover krävs”, new samples needed, is presented besides the order, see figure 129. In the information page, a banner is located in the upper part of the page, including an explanation text. Furthermore, the frame around the hour of the samples is marked in red, see figure 130.

If new samples are needed, it is not possible for the anaesthesiologist to press any button in the information page. Therefore, these are marked in grey. When new samples are taken, the red text, banner and frame is replaced in a green colour together with a confirmation text. Furthermore, the buttons turn blue again, see figure 131 and 132. The colour frames in the information window contribute to clarity for the anaesthesiologist of critical areas. It also contributes to consideration of user resources, and enables the anaesthesiologist to focus on the marked areas. This is useful not least when the anaesthesiologist works late hours on duty.

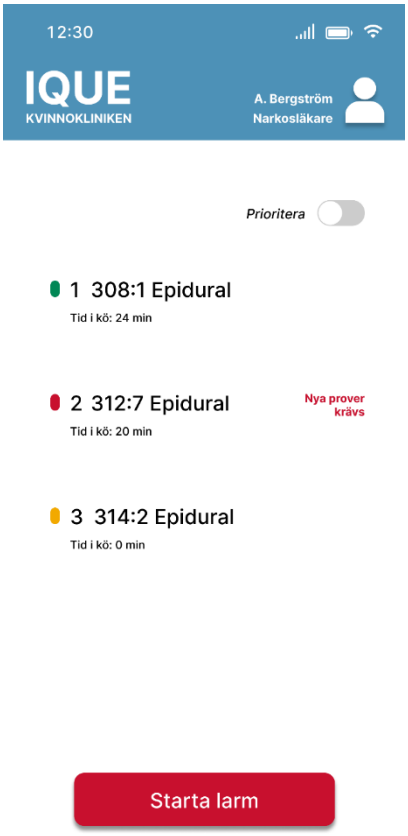

Figure 129. New samples needed, start page

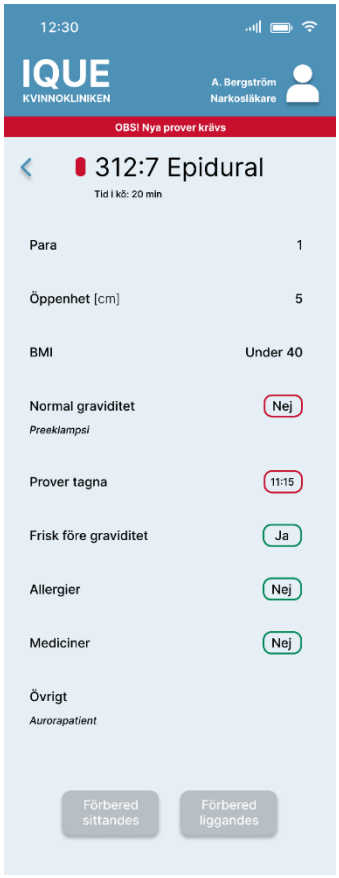

Figure 130. New samples needed, information page

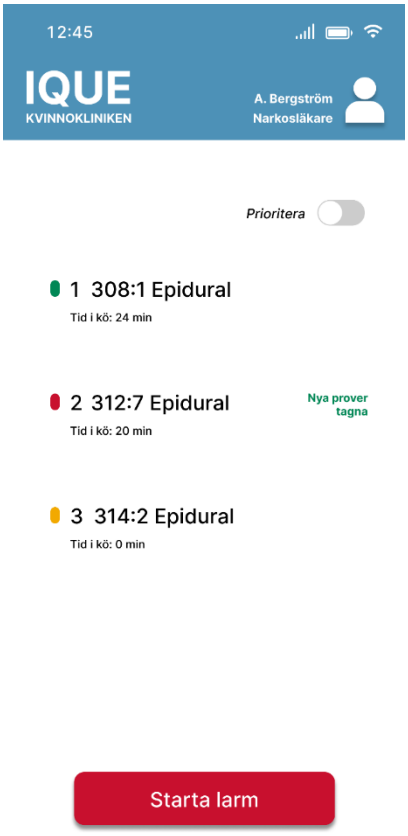

Figure 131. Samples updated, start page

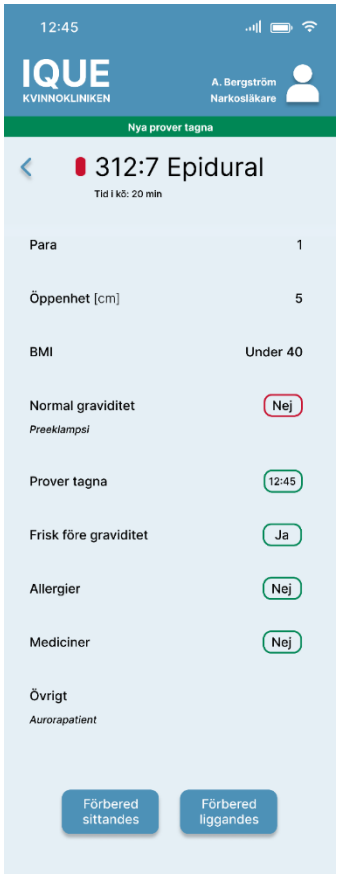

Figure 132. Samples updated, information page

10.4 Scenario with the IQUE

Presented in this chapter are the two scenarios of the Emergency ward and the Obstetrics and Gynaecology department, including the final concept. See chapter 5.3 and 6.3 for the original scenarios including the current system of today.

10.4.1 Emergency ward

Kate had just finished her lunch and now needs to discuss one of her patients with the consultant. As always, the consultant receives more questions during the coming hours after lunch. Kate sits down at her desk in team 4 and opens the IQUE app at her desktop. As expected, two doctors have already gotten in line. She chooses triage and enters the queue as well. Since it is so easy to keep track of the flow in the queue, she starts working with another case while she is waiting. From time to time, she checks her position in the IQUE application. After a while, she is first in line and starts to get ready. Just a minute later it is her turn, so she brings her notebook and walks to the consultant.

This time, the time spent in the queue was as long as it usually is. However, Kate did not have to interrupt her work all the time, going to check the queue. This since she did not have to stand physically in the line, but could work with another case meanwhile. Compared with the system they had before, Kate enjoys being able to work while waiting for consultation, efficiency and productivity is important.

10.4.2 Obstetrics & Gynaecology department

Anton has just sat down after a hectic afternoon when he gets a notification on his phone. It is an order of anaesthesia at department 312, room 2. He confirms the order and heads down, arriving just five minutes after. He talks to the patient and starts preparing for the application. Just when he has put on the sterile gloves, the phone buzzes again. However, Anton can finish the sterile part of the application and look at the phone afterwards. He enjoys not being interrupted while applying the anaesthesia, further not having to keep track of all the orders himself. The job is stressful as it is during on-call hours.

Sara's patient is a primigravida woman, open four centimetres and wishes to get epidural anaesthesia. Further, her patient has had some difficulties during her pregnancy that Sara wishes to inform the anaesthesiologist about. She opens the IQUE app to see how many anaesthesia that are in line currently. Although it is only one order in line, Sara and her patient agree to place the order straight away. She fills in the information at the computer in the patient room, being able to monitor her patient at the same time. In the section "other" Sara fills in the patient's difficulties that she wanted to communicate to Anton. Before placing the order, Sara noticed that Anton just initiated the application of the order before, so she prepares her patient for waiting at least 20 minutes.

Anton has applied the anaesthesia and can now check his phone. He confirms Sara's order and starts to clean up. Just when he is about to leave the room, the on-call 2 pager rings. A high emergency caesarean section has to be performed and Anton runs towards the surgical ward 2. The environment in surgery is hectic since the mother and baby's life is in danger. However, he had time to start the incoming high emergency status in the application.

Sara got her order confirmed just ten minutes after placing it. However, there has been no update since the confirmation almost 40 minutes ago. She goes to the computer to check the status of the queue and notices that Anton had to attend an incoming high emergency case, which explains the wait. Sara explains the situation to her patient while working with other ways to ease her pain. Being able to check the status of the anaesthesiologist via the app keeps her updated and informed of important matters affecting her order. Sara believes the transparency of the flow of anaesthesia and the anaesthesiologist contributes to her feeling more confident in her work.

Suddenly a pop-up window appears on the computer indicating Sara to prepare her patient. Anton must have called another anaesthesiologist on the on-call 3 shift since it has almost been an hour, Sara thinks to herself. The anaesthesiologist arrives after only 5 minutes and Sara's patient finally gets her EDA.

11. Discussion

In this chapter, a discussion of the project is presented. This includes different aspects which might have affected the methodology implemented, findings and outcome of the project. The outcome of this Master's Thesis is the queueing application IQUE, which have two different functionalities adjusted for the Emergency ward and the Obstetrics and Gynaecology department.

11.1 Digitalization acceptance

When visiting the Emergency ward, the workload and patient flow was unusually low, as previously mentioned. Further, the majority of the doctors participating in the user studies believed the current system of today worked well and is efficient. Therefore, the need for a digital solution of the queueing system was not believed to be necessary in order to facilitate the queuing. However, at the same time, most of the interviewees were positive towards trying something new.

When visiting the maternity wards, the same comments were noted. The majority of the midwives were pleased with the current ordering system, and several of them mentioned the value of speaking with the anaesthesiologist over phone. Further, during the in-depth focus group as well as the evaluation, it was perceived that the midwives were sceptical towards a digital solution. It could be argued that there is no need for change according to the midwives, and that their sceptical attitude might have an effect during a potential implementation.

Although, when observing and interviewing the anaesthesiologists, clear evidence of the need for support was found. As presented in chapter 6.2.5, the anaesthesiologists stated that they were in need of a tool to help them keep track of the different orders. This was further confirmed during the observations.

As stated in Chapter 2.2, *Innovation and Digitalization*, the implementation of digital health information services can be considered slow within the healthcare sector compared to other industries. This might be the reason behind the sceptical attitude to a change into digital systems as well as the usage of additional digital tools within the healthcare organization, both for the midwives at the maternity wards, as well as the doctors at the emergency ward of Östra Hospital. Furthermore, since healthcare is under constant pressure, there is a possibility that the personnel working at the hospitals do not want to take the risk of trying a new system that might be less efficient than the current solution. This is important to take in consideration when testing and implementing new systems and solutions into the healthcare organization.

11.2 Interviews

Due to the lack of time and resources within the healthcare organization, only two in-depth interviews were conducted. These were performed with the initiators of the project. The additional interviews were performed during lunches and breaks, which did not allow the interviews to get in-depth. In order to reach a deeper level of understanding of the current situation, it would have been beneficial to perform more in-depth interviews with all the user groups. Especially, with further interviewees than the initiators of the project, in order to avoid potential bias. However, a large number of shorter interviews were performed with all the user groups, which made the result saturated.

Another issue of the interviews was related to the environment of where most of the interviews were conducted. Since the majority of the users did not have time to sit down for a longer period of time, and the interviews were conducted spontaneously in the lunchrooms, several factors might have affected the outcome. First, the users might have felt stressed or disturbed during the conversation, resulting in shorter and less developed answers than needed. This, even though the users were asked if they were willing to participate in the studies. Secondly, the environment and volume were not beneficial, due to the number of people eating lunch and staying in the room. Lastly, the aspect of honesty. The interviewees might have experienced it difficult to express their opinions related to someone sitting across the room, such as their supervisor.

11.3 Observations

Considering the observations of the Emergency ward, the exclusion of auditory feedback might have affected the result. Since the observations were conducted from the hallway, the conversations within the enclosed office area between the consultant and doctors were not possible to observe. This made it difficult to determine whether the conversations were work related or not. As a result, data might have been collected as consultation, although it was only normal conversations between the doctor and consultant, or vice versa.

Further, during the observations of the Emergency ward, the overall patient flow was considered as unusually low. This was also confirmed by the doctors participating in the interviews. The low flow of patients of the ward affected the data collected from the observations, where a decreased workload contributed to a lower rate of consultations. Due to this, the data collected did not show much evidence of the problem area, since there was not much waiting time for the doctors to the consultant. A normal number of patients per day might have resulted in a more truthful overview of the problem area.

During the observations at the Obstetrics and Gynaecology department, the conversations regarding orders of anaesthesia, between the midwives and anaesthesiologists, were not observed during several occasions. Instead, the conversation was related after the phone call was performed. Even though an update was given afterwards, valuable insights and information might have been lost. This might have contributed to a loss of depth, considering the understanding of the communication when ordering anaesthesia, including the information shared. Not being present during the conversations might also have been affecting the data of time parameters, since the exact time of order was not observed. This may have led to a slight shift of the result of the data related to the time parameters.

However, during several occasions, observation of the conversation was possible, where valuable information was collected. In combination with the related conversations, the

conversations observed are believed to have contributed to an understanding of the current situation.

11.4 Evaluation

Since the healthcare personnel often have a full schedule, the user evaluation was difficult to perform. Since the evaluation required additional time to explain the concepts, in comparison to the interviews, the evaluation could not be performed with all user groups at the Emergency ward. Only an in-depth evaluation with the initiator of the project was carried out. However, the resident participating is at the end of her residential training, soon becoming a consultant. Therefore, it could be argued that both user groups were almost included. Further, the functionality of the application of the Emergency ward is not that complex. Therefore, it could be argued that evaluation might not be needed to the same extent as for the Obstetrics and Gynaecology department. However, the points of view of several users, from all user groups, are indeed valuable.

Considering the Obstetrics and Gynaecology department, evaluation was performed with all user groups, although with three midwives and two anaesthesiologists in total. In order to gain more insights, and a deeper understanding of all the users' opinions in regards to the different concepts, further developed user studies would be beneficial.

As a complement to the user evaluations, an objective evaluation was performed considering the concepts of the two departments. These evaluations supported as well as confirmed the evaluation gathered from the users.

11.5 Ethical considerations

In order to gather insights about the current situation of the Emergency ward, as well as the Obstetrics and Gynaecology department of Östra Hospital, both interviews as well as observations were conducted at the hospital.

Conducting user studies in a hospital means that there are ethical considerations to take into account. The ethical considerations regard both the patients staying at the hospital, but also the healthcare personnel. Since the hospital environment can be considered sensitive and private, it is important that both of these groups feel comfortable during the observations of the work at the hospital. It is also important to clarify the reason behind the visits and that the observations are not of the specific individuals.

At the maternity wards of Östra Hospital, some observations were performed in the patient rooms, in order to gather greater insights about the process when applying an anaesthesia, including the communication between the midwives and anaesthesiologist as well as situations that might occur during an application, resulting in delays or similar.

Furthermore, observations at the rooms were performed in order to note when the anaesthesiologist got phone calls during an application. In these situations, the patient was always asked if they allowed observation of the application. Furthermore, the personnel working also gave their approval, before an observation in the patient room was performed. Therefore, ethics were taken into consideration.

No private patient data was collected either at the maternity wards, or the Emergency ward during the observations and interviews. However, information connected to the child delivery of women were collected at the maternity wards, but were not possible to connect to the individual.

11.6 Final concept & future steps

Considering the order and application of anaesthesia at the Obstetrics and Gynaecology department, there were some disagreements between the user groups considering some of the functionalities of the application. When new samples are needed, the midwives wanted the anaesthesiologist to call to inform about this, whilst the anaesthesiologist initiating the project believed this was the responsibility of the midwives. This resulted in an automated solution, where the system of the application calculates the maximum duration of the samples taken, and sends a notification to the midwife when they are about to expire. However, the exact time span of a sample is not yet decided for the application, and must be further investigated. During the visits at the hospital, no situations where the samples needed to be updated were observed. Since the application is mainly focused on facilitating more standard cases, the situations including samples were not further developed but this is something that needs to be investigated, iterated, evaluated, tested in future processes.

Further, during the evaluation session, the midwives expressed the need for an additional section considering the fear of giving birth, when filling in the necessary information of the order. This was something not prioritized in the final concept, since it was not classified as necessary information according to the anaesthesiologists, who are the ones performing the application of anaesthesia. Further, the anaesthesiologists mentioned during several occasions that they preferred talking about this kind of matter when being present with the patient instead. However, a field for additional comments is added in the final concept, enabling the midwives to include this kind of information if preferred.

During the interviews at the Emergency ward some participants mentioned the need of consultation with other doctors than the consultant, and hence a possibility for more experienced doctors to sign up as an additional consultant. However, this was not included in the final concept. The reason for this was to not make the application too complicated to use initially, but to focus on the main functionalities. However, this aspect is possible to develop in future developments of the application.

In order to implement the final concepts, the applications need to be tested in the real user environment by the user groups. Therefore, the next step of this project would have been to programme the final solution for both departments. The first step after this would be to let the user groups in question test the application and the interaction flow together, however not in the real user environment with the patients. Further, the concepts need to be iterated and tweaked accordingly. After this, additional features, such as adding further consultation possibilities at the Emergency ward, could be implemented if requested and needed.

12. Conclusion

In this chapter, the conclusion of the project is presented.

The aim of this Master's Thesis has been to improve the workflow, increase efficiency, free up resources and improve cooperation within the Emergency ward and Obstetrics and Gynaecology department at Östra Hospital. The project also aimed at answering the following research question:

Can a digitalization of the current queueing systems facilitate the workflow in order to increase efficiency?

Further, the goal was to develop a digital application using design methodology to facilitate the personnel in question.

From the user studies at the Emergency ward, it was shown that the healthcare personnel were satisfied overall with the system of today, and believed it would be difficult to make the system more efficient through digitalization. At the same time, many of the interviewees mentioned that they could consider trying out new methods.

At the Obstetrics and Gynaecology department, the midwives were satisfied with the system of today, and believed that the phone communication between the midwives and anaesthesiologists was crucial. Since many of the midwives interviewed were satisfied with the current system, they did not believe that digitalization of the system was necessary, rather that it would result in inefficiency. However, this was not the opinion of the anaesthesiologists, where the majority of the personnel believed a digitalized system would make the process more efficient as well as patient safe since the information needed for the orders of anaesthesia would be gathered for both parties in the application.

A conclusion that can be made after carrying out this project, is that healthcare is much more complex than one imagines. After conducting over 25 interviews and over 63 hours of observations, it can be concluded that there are several aspects affecting the internal systems. When taking care of a patient, the outcome of a situation cannot be predicted or generalized due to the high number of factors that need to be taken into consideration. Therefore, user testing in its real context is vital when it comes to digital tools within healthcare.

The deliverable of this project is an internal queueing application called IQUE, intended to improve the workflow of the two departments mentioned. It can be stated that the goal of the project has been reached. However, the final concept developed has not yet been tested. In order to answer the research question for this Master's thesis, further evaluation and user testing is needed, with the users in question, in their real working environment.

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Appendices

Appendix I
Survey templates

Emergency ward

Junior doctors, interns & residents

Vilket sjukhus arbetar du på?

Vad är din arbetsroll?
- Underläkare
- AT-läkare
- ST-läkare
- Specialistläkare
- Överläkare

Vad är dina huvudsakliga arbetsuppgifter på akuten?

Har du möjlighet att rådfråga en ledningsläkare vid behov?
- Ja
- Nej

Beskriv kort hur konsultationen sker.

Hur många gånger under ett arbetspass behöver du i snitt rådfråga en ledningsläkare?
- < 5 gånger
- 5 - 10 gånger
- 10 - 15 gånger
- >15 gånger
- Övrigt:

Hur länge behöver du i snitt vänta på att få hjälp, per konsultation?

- Ingen väntetid
- < 5 min
- 5 - 15 min
-
- 15 - 25 min
- >25 min
- Övrigt:

Vilka förbättringsområden ser du med dagens konsultation? (Du kan kryssa i flera alternativ)

- Effektiviteten av konsultation
- Kommunikationen mellan läkarna
- Kösystemet av konsultation
- Inga, det fungerar bra
- Övrigt:

Har du några övriga tankar kring dagens upplägg av konsultationen?

Specialists and senior physicians

Vilket sjukhus arbetar du på?

Vad är din arbetsroll?

- Underläkare
- AT-läkare
- ST-läkare
- Specialistläkare
- Överläkare

Vad är dina huvudsakliga arbetsuppgifter på akuten?

Ingår det i dina arbetsuppgifter att stötta mindre erfarna läkare vid konsultation?

- Ja
- Nej

Beskriv kort hur konsultationen sker.

Hur mycket tid lägger du i snitt på att svara på frågor i förhållande till dina övriga arbetsuppgifter?

- < 20%
- 20% - 40%
- 40% - 60%
- 60% - 80%
- > 80%

Hur mycket tid lägger du i snitt på att svara på frågor i förhållande till dina övriga arbetsuppgifter?

- < 20%
- 20% - 40%
- 40% - 60%
- 60% - 80%
- > 80%

Hur lång tid tar det i snitt att hjälpa en kollega?

- < 5 min
- 5 - 10 min
- 10 - 15 min
- 15 - 20 min
- > 20 min

Vilka förbättringsområden ser du med dagens konsultation? (Du kan kryssa i flera alternativ)

- Effektiviteten av konsultation
- Kommunikationen mellan läkarna
- Kösystemet av konsultation
- Inga, det fungerar bra
- Övrigt:

Har du några övriga tankar kring dagens upplägg av konsultationen?

Obstetrics and Gynaecology department

Midwives

Vilket sjukhus arbetar du på?

Vad är din arbetsroll?
- Narkosläkare
- Barnmorska

Beskriv kort hur det går till när du lägger en beställning på en epiduralbedövning.

Hur lång tid tar det i snitt från beställning tills narkosläkaren lägger den?
- < 20 min
- 20 - 40 min
- 40 - 60 min
- >60 min
- Övrigt:

Vilka förberedelser krävs inför epiduralbedövning?

Vilka förbättringsområden ser du med dagens epiduralbeställningar? (Du kan kryssa i flera alternativ)
- Effektiviteten av beställningen
- Kommunikationen med narkosläkaren generellt
- Utbytet av patientinformation med narkosläkaren
- Kösystemet av beställningarna
- Inga, det fungerar bra
- Övrigt:

Har du några övriga tankar kring dagens upplägg av epiduralbeställningar?

Anaesthesiologists

Vilket sjukhus arbetar du på?

Vad är din arbetsroll?

- Narkosläkare
- Barnmorska

Hur många epiduralbedövningar lägger du i snitt per arbetspass?

- < 5 st
- 5-10 st
- 10-15 st
- 15-20 st
- > 20 st

Hur mycket tid lägger du i snitt på epiduralbedövningar i förhållande till dina övriga arbetsuppgifter?

- < 20%
- 20% - 40%
- 40% - 60%
- 60% - 80%
- > 80%
- Övrigt:

Beskriv kort hur det går till när du får en beställning på en epiduralbedövning.

Hur lång tid tar det i snitt från beställning tills du lägger den?

- < 20 min
- 20 - 40 min
- 40 - 60 min
- > 60 min
- Övrigt:

Hur lång tid tar det i snitt att lägga en epiduralbedövning?

- < 20 min
- 20 - 40 min
- 40 - 60 min
- > 60 min
- Övrigt:

Vilka förbättringsområden ser du med dagens epiduralbeställningar? (Du kan kryssa i flera alternativ)

- Effektiviteten av beställningen
- Kommunikationen med barnmorskorna generellt
- Utbytet av patientinformation med barnmorskorna
- Kösystemet av beställningarna
- Inga, det fungerar bra
- Övrigt:

Har du några övriga tankar kring dagens upplägg av epiduralbeställningar?

Appendix II
Participants

Emergency ward

Interview	Participant	Type of interview	Duration of interview
1	Resident	Individual interview	10 minutes
2	Resident	Individual interview	8 minutes
3	Resident	Individual interview	3 minutes
4	Resident	Individual interview	4 minutes
5	Consultant	Individual interview	8 minutes
6	Consultant	Individual interview	11 minutes
7	2 Residents	Focus group 1	7 minutes
8	Resident Basic Service (BT) 2 Junior Doctors	Focus group 2	13,5 minutes
9	2 Junior Doctors	Focus group 3	17 minutes
10	Resident	In-depth interview	1 hour

Obstetrics and Gynaecology department

Interview	Employment	Ward	Type of interview	Duration of interview
1	Midwife	Maternity ward 312	Individual interview	6 minutes

2	Midwife	Maternity ward 312	Individual interview	6 minutes
3	Midwife	Maternity ward 312	Individual interview	11 minutes
4	Midwife	Maternity ward 308	Individual interview	5 minutes
5	Midwife	Maternity ward 308	Individual interview	5 minutes
6	Midwife	Maternity ward 308	Individual interview	7 minutes
7	Midwife	Maternity ward 308	Individual interview	16 minutes
8	Midwife	Maternity ward 314	Individual interview	10 minutes
9	Midwife	Maternity ward 314	Individual interview	10 minutes
10	Anaesthesiologist	Surgical ward 2	Individual interview	18 minutes
11	Anaesthesiologist	Surgical ward 2	Individual interview	10 minutes
12	Anaesthesiologist	Surgical ward 2	Individual interview	12 minutes
13	Anaesthesiologist	Surgical ward 2	Individual interview	16 minutes
14	2 Midwives	Maternity ward 308 & 314	In-depth focus group	26 minutes
15	Anaesthesiologist	Surgical ward 2	In-depth interview	46 minutes

Appendix III
Interview templates

Emergency ward

Doctor

- Vad har du för tjänst?
  Underläkare/AT/ST/Specialist/Överläkare
- Vad ingår i dina arbetsuppgifter?
  - Hur många patienter tar du hand om samtidigt i snitt?
- Hur många gånger per pass behöver du rådfråga ledningsläkare i snitt?
- Hur lång tid brukar du stå i kö per gång i snitt?
- Ungefär hur lång tid brukar det ta att få hjälp per gång?
- Händer det att lledningsläkaren brukar vara otillgänglig för att svara på frågor? (larm mm)

Tankar kring dagens system

- Vad är dina tankar kring dagens upplägg av kön?
- Hur upplever du att det fungerar?
- Hur upplever du effektiviteten?
- Vad hade du velat se för förändringar?

- Har du några övriga synpunkt eller tankar?

Consultant

- Vad har du för tjänst?
  - Specialist/Överläkare
- Vad har du för övriga arbetsuppgifter mer än att svara på frågor?
  - Hur är fördelningen mellan dina arbetsuppgifter ungefär?
- Hur många frågor i snitt brukar du få per pass?
- Hur lång tid uppskattar du att det tar att hjälpa en kollega?
- Brukar det bli köbildning ofta/inte alls?
  - Hur påverkar det dig i dina arbetsuppgifter?
- Ungefär hur ofta behöver du springa på larm?
  - Hur länge brukar du i snitt bli borta?

Tankar kring dagens system

- Vad är dina tankar kring dagens upplägg av kön?
- Hur upplever du att det fungerar?
- Hur upplever du effektiviteten?
- Vad hade du velat se för förändringar?

- Har du några övriga synpunkt eller tankar?

In depth interview

Jobbrelaterade frågor

- Vad har du för tjänst?
- Hur ser en vanlig arbetsdag ut?
    - Hur många patienter tar du hand om samtidigt?
- Hur många gånger per pass behöver du rådfråga ledningsläkare?
- Upplever du att det brukar bli köbildning?
    - Hur lång tid brukar du stå i kö per gång i snitt?
- Upplever du att det tar lång tid att få svar på dina frågor?
- Hur ofta brukar ledningsläkaren vara otillgänglig för att svara på frågor?

Tankar

- Vad är dina tankar kring dagens upplägg av kön?
    - Hur upplever du att det fungerar?
- Hur upplever du kommunikationen mellan dig och ledningsläkaren?
- Hur upplever du effektiviteten?

Larm

- Vilka typer av larm kan ledningsläkaren behöva gå på?
    - Ambulanslarm?
    - Annan avdelning?

Team & personal

- Kan du beskriva de olika teamen?
    - Respektive teams huvudansvarsområde
    - Hur många jobbar per team (USK/SSK/L/OL)
- Hur ser schemat ut för personal på akuten; dagtid, kvällstid, nattetid?
    - Vad finns det för olika pass att arbeta?
    - Hur ser detta ut för respektive tjänst?
- Vem ringer nattpersonalen för att rådfråga när de behöver hjälp?
- Vad gör ledningsansvarig?

Övrigt

- Vad kallas ert Triage-system?
    - Använder ni er endast av GÖTT eller även RETTS?
    - Gäller detta hela sjukhuset (ex KK) eller endast akuten?

- Finns det statistik på hur många patienter som kommer in till akuten?
- Har ert arbetssätt ändrats under corona?
    - Ambulansflödet (Främst covidrelaterat)
    - Har "vanliga" akutpatienter minskat under denna period?

Struktur på avdelningen

- Vem sitter i båset bredvid LL?

Obstetrics & Gynaecology department

The midwife

EDA

- Berätta hur det går till när du beställer en EDA.
    - Vad för information ger du till narkosläkaren?
- Hur lång tid i snitt brukar det tar det från beställning tills narkosläkaren kommer?
    - Jobbar du natt?
    - Är det någon skillnad på dag/natt?
- Vad gör du om narkosläkaren dröjer länge?
    - Händer det ofta?

Tankar

- Vad är dina tankar kring dagens upplägg av beställningen av EDA:n?
    - Hur upplever du effektiviteten?
- Hur upplever du kommunikationen mellan dig och narkosläkaren?
- Hade du velat se några förändringar kring beställningen?

The anaesthesiologist

- Ungefär hur mycket tid lägger du på att lägga EDOR i förhållandet till dina andra arbetsuppgifter?
- Ungefär hur många EDOr lägger du per pass?
    - Dagpass
    - Jourpass
- Hur upplever du att EDOrna påverkar dina övriga arbetsuppgifter?

Larm

- Hur ofta påverkar larm EDOrna?
- Vad gör du om du inte har möjlighet att lägga en EDA? (Om nån ringer på dig, men du inte har tid)

EDA

- Vilken information behöver du av barnmorskan inför en EDAläggning?
- Hur lång tid brukar det ta från beställning tills du anländer till rummet?
- Hur lång tid tar det att lägga en EDA ungefär?
- Hur håller du redan på de olika beställningarna?

Tankar

- Vad är dina tankar kring dagens upplägg av beställningen av eda:n?
- Hur upplever du att kommunikationen mellan dig och barnmorskan fungerar?
- Hade du velat se några förändringar kring beställningen?

In depth interviews

The midwife

- Vad har ni för roll på respektive avdelning?
- Vad skiljer avdelningarna åt?
    - Hur många förlossningssalar finns det på respektive avdelning?
- Vad innebär det att vara med i KPO-teamet?
    - Hur tar ni vidare ert arbete in på era kliniker?
- Hur ser en vanlig arbetsdag ut för er?

EDA

- Berätta hur det går till när ni beställer en EDA?
    - Vilken information behöver narkosläkaren?
- Hur lång tid i snitt brukar det tar det från beställning tills narkosläkaren anländer till rummet?
    - Dag/Natt
- Vad gör du om narkosläkaren dröjer länge?
    - Händer det ofta?
- Vilka förberedelser krävs inför EDAn?
    - Patient
    - Görs samtliga steg före samtal till narkosläkaren?
- Vilka komplikationer kan uppstå med patienten vid förberedelserna?
    - Vid läggningen
- Hur lång tid ungefär brukar det ta att lägga EDAn?

Tankar

- Vad är era tankar kring dagens upplägg för beställning av eda?
- Hur upplever ni kommunikationen mellan er och narkosläkaren?
- Hade du velat se några förändringar kring beställningen?
    - App

The anaesthesiologist

- Vad har narkosläkare för övriga arbetsuppgifter mer än att lägga EDOr?
    - Om man ej har eda telefon mm vad har man på sitt schema då?

    - Ungefär hur är fördelningen mellan dina arbetsuppgifter?
- Hur många EDOr lägger du i snitt per pass?
    - Dagpass
    - Jourpass
- Hur ofta påverkar larm epiduralbeställningar?
- Vad gör du om du inte har möjlighet att lägga en EDA? (Om nån ringer på dig, men du inte har tid)

EDA

- Berätta hur det går till när du får en beställning på en eda?
- Hur lång tid i snitt brukar det tar det från beställning tills du lägger den?
- Hur lång tid tar det i snitt att lägga en EDA?
- Vad för förberedelser krävs inför EDAn?
    - Vilken information behöver du gällande patienten innan en EDA kan läggas?
- Vilka komplikationer kan uppstå när EDAn ska läggas?
- Hur upplever du att edorna påverkar dina övriga arbetsuppgifter?

Tankar

- Vad är dina tankar kring dagens upplägg för beställning av eda?
    - Hur upplever du att det fungerar?
- Hur upplever du kommunikationen mellan dig och barnmorskan?
- Hur upplever du effektiviteten?
- Vad hade du velat se för förändringar?

Övrigt

- Vilka jobbar på Op 2? Sjuksköterskor, undersköterskor, narkosläkare och kirurger?
- Finns det en obstetriker på varje förlossningsavdelning?

Likert scales

The Emergency ward

Jag upplever att dagens kösystem är användbart

Jag upplever att dagens kösystem är effektivt

Jag upplever att dagens kösystem är lättförståeligt

The Obstetrics and Gynaecology department

Jag upplever att dagens beställningssystem är användbart

Jag upplever att dagens beställningssystem är effektivt

Jag upplever att dagens beställningssystem är lättförståeligt

Appendix IV
Observation templates

Emergency ward

The consultation

Datum:
Tid:

Person	**Ankomst till kö**	**Konsultation påbörjas**	**Konsultation avslutad**	**Kommentarer** (Diskussion/Till patient)

The consultant

Datum:
Tid:

Går på larm	Ankomst tillbaka	Kommentarer

Obstetrics and Gynaecology department

The midwife

Avdelning:
Datum:
Tid:

Person	Beställer	NL ankommer	NL lämnar	Kommentarer

The anaesthesiologist

Avdelning:
Datum:
Tid:

NL får beställning	NL går mot BM	Avdelning för EDA	NL ankommer	NL lämnar	Kommentarer

Appendix V
Evaluation templates

Emergency ward

Köns uppbyggnad

Visa:
Kön/sidans uppbyggnad
Lägg till
Ta bort
Starta Larm
LL är på larm

Frågor:

Generellt sett fråga ang knappar, placering, funktioner mm

- Föredrar ni ikoner eller text? eller kombinerat?
- (tvingande/icke tvingande fält)

- Hur hade ni föredragit att **se kön**? (olika text, placering, sid uppbyggnad)

- Hur hade ni föredragit att se när LL är på **larm**?

- Hur hade ni föredragit att starta/avsluta ett **larm**?

Avslutande frågor

- Vad är dina generella tankar kring beställningssystemet?
- Är det något/någon information som känns överflödig?
- Är det något/någon information du saknar?
- Är det något du vill förändra?
- Hur många nivåer av triagering krävs? 3? 5?

Obstetrics & Gynaecology department

Introduktion: uppbyggnad & funktionalitet

The midwife

Flöde: Lägga till beställning

Visa:
Beställa EDA
Alla steg

Frågor:

- Hur hade ni föredragit att **lägga till en beställning**?
- Vad tycker ni om de olika **fälten man ska fylla i**?
    - Något som saknas? något som känns överflödigt?

Flöde: Köns status

Visa:
Bekräftad, Förbered patient, Läggning pågår
Ta bort beställning/(pausa)

Frågor:

- Hade ni velat se **status på de andras beställningar**?
- Hur hade ni föredragit att **se NLs status i flödet**?
    - Om NL bekräftat andra beställningar eller fyllt i förbered patient mm
    - Ser ni behov av att se när **NL lägger EDA**? eller endast kunna markera som klar?

Flöde: Nya prover krävs

Visa:
Nya prover krävs, lägga in nya prover, nya prover har lagts in

Frågor:

- Hur hade ni föredragit att det skulle meddelas att **nya prover krävs**?
- Hur hade ni föredragit att **lägga in nya prover**?

The anaesthesiologist

Flöde: Info kring beställning

Visa:
Infosidan av beställningen

Frågor:

- Hur hade ni föredragit att **informationen** gällande patienten hade **presenterats**?
- Måste ni veta vilka mediciner/allergier, om patient har det?
    - Skriva i i app?
    - Ringas ang det?
    - Ta det på rummet när NL kommer om ej prover krävs?
- Vill ni att beställningarna är **markerade med olika färger** beroende på om det är en "lätt" patient eller någon med preeklampsi?
    - Vad klassas som **rött/orange/grön**?

Flöde: Status på beställningar

Visa:
Bekräfta beställning, Förbered patient, Läggning pågår, Läggning avslutad

Frågor:

- Hur hade ni föredragit att **uppdatera status** på beställningen?
    - Bekräfta, förbered patient, läggning påbörjad, läggning avklarad

Flöde: Nya prover krävs

Visa:
Prover gått ut, meddela BM, nya prover är tagna

Frågor:
1. Hur hade ni föredragit att **meddela BM** att nya prover krävs?
1.1 Hur hade ni föredragit att **bli meddelad** när proverna var uppdaterade?

Allmänt om notiser

- NL: Vilka notiser hade ni velat kom på telefonen när ni ej var inne i appen? (som en pling)
    - Ny beställning har gjorts
    - Bm önskar att bli uppringd
    - Prover uppdaterade

Köns uppbyggnad mm
Alla gemensamt

Visa:
Kön/sidans uppbyggnad
Lägg till (BM)

Ta bort (BM)
Starta Larm (NL)
NL är på larm (BM)

Frågor:

Generellt sett fråga ang knappar, placering, funktioner mm

- Föredrar ni ikoner eller text? eller kombinerat?
- (tvingande/icke tvingande fält)

Båda

- Hur hade ni föredragit att **se kön**? (olika text, placering, sid uppbyggnad)

Barnmorskorna

- Hur hade ni föredragit att **ta bort/pausa er beställning** (om patient hunnit gå för långt och eda ej kan läggas)?
    - Nödvändigt?
- Hur hade ni föredragit att se när NL är på **larm**?

Narkosläkare

- Hur hade ni föredragit att starta/avsluta ett **larm**?

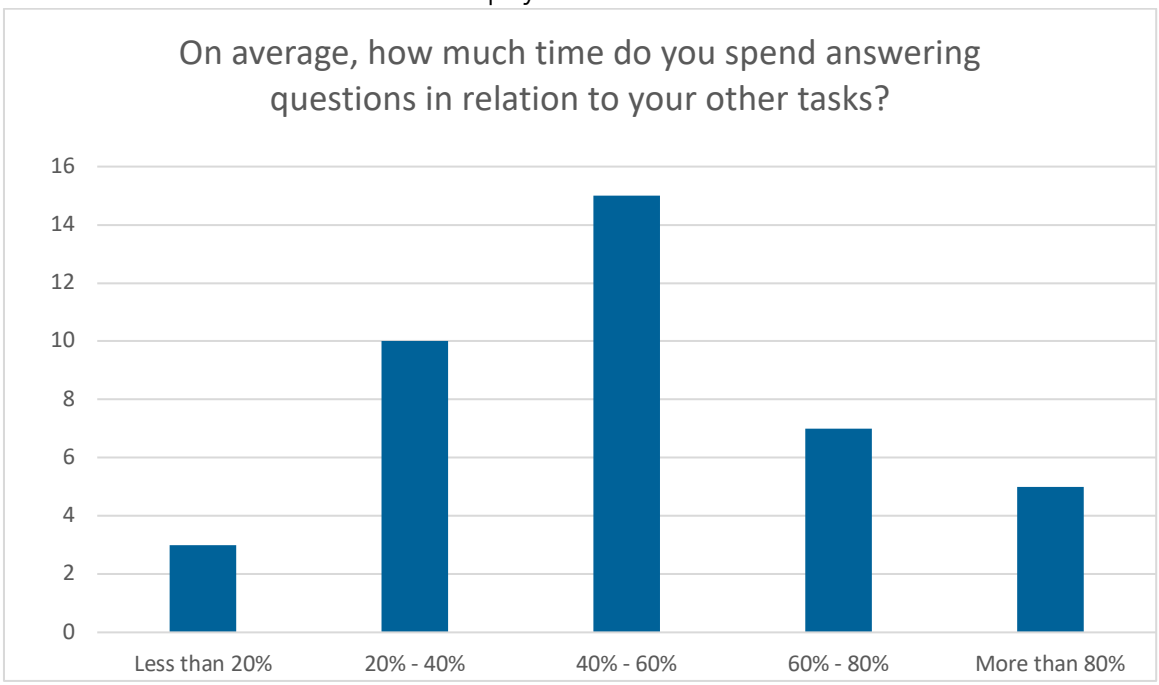
Gemensam diskussion

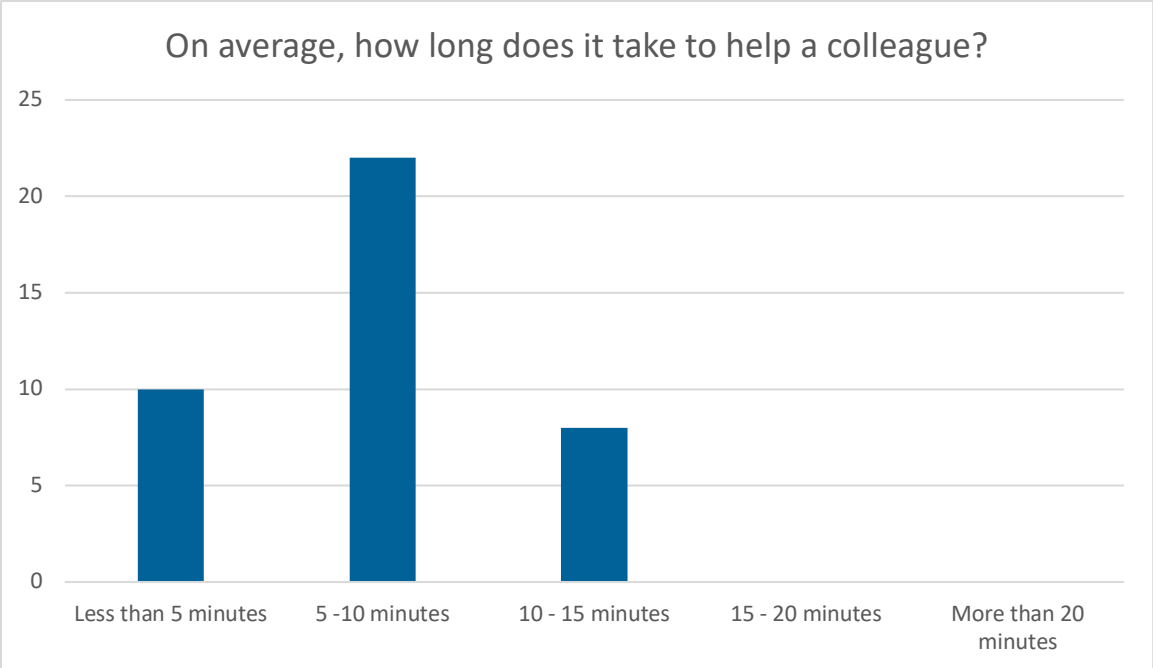
- Vad är era generella tankar kring beställningssystemet?
- Är det något/någon information som känns överflödig?
- Är det något/någon information du saknar?
    - Info: BMI
        - Ja. Ha med BMI över 40 (ja/nej)
- Är det något ni vill förändra?
- Finns behovet att pausa en specifik beställning? Från NL? Från BM?
    - (funktionen finns i den POC som gjorts)

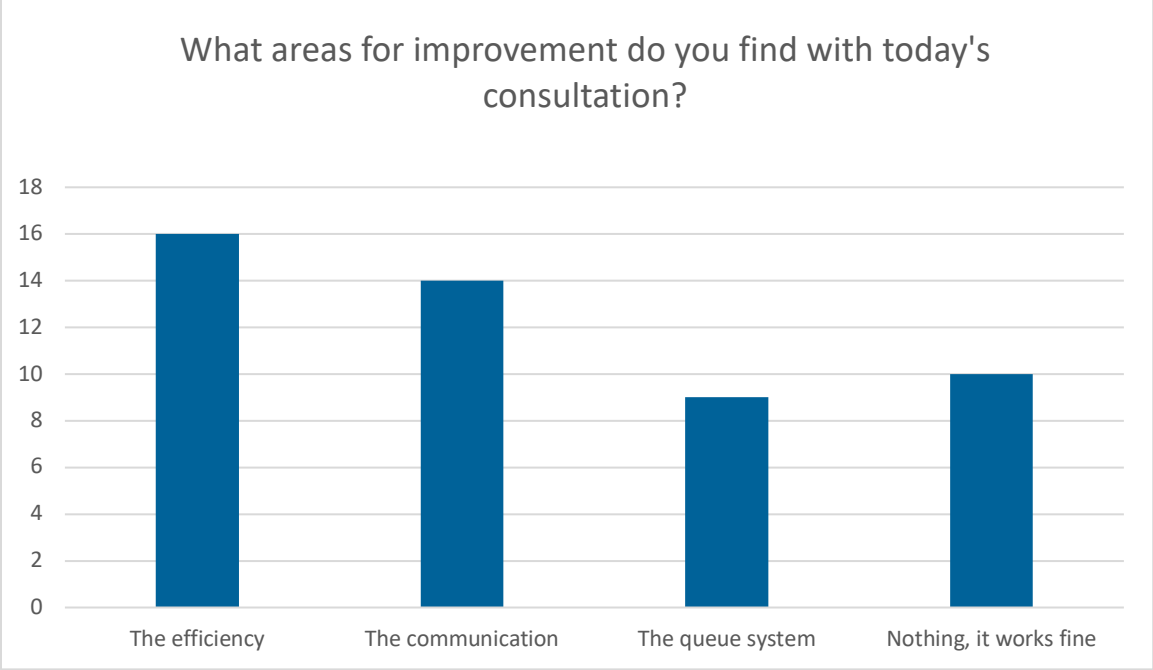
Appendix VI
Benchmarking results

Emergency ward

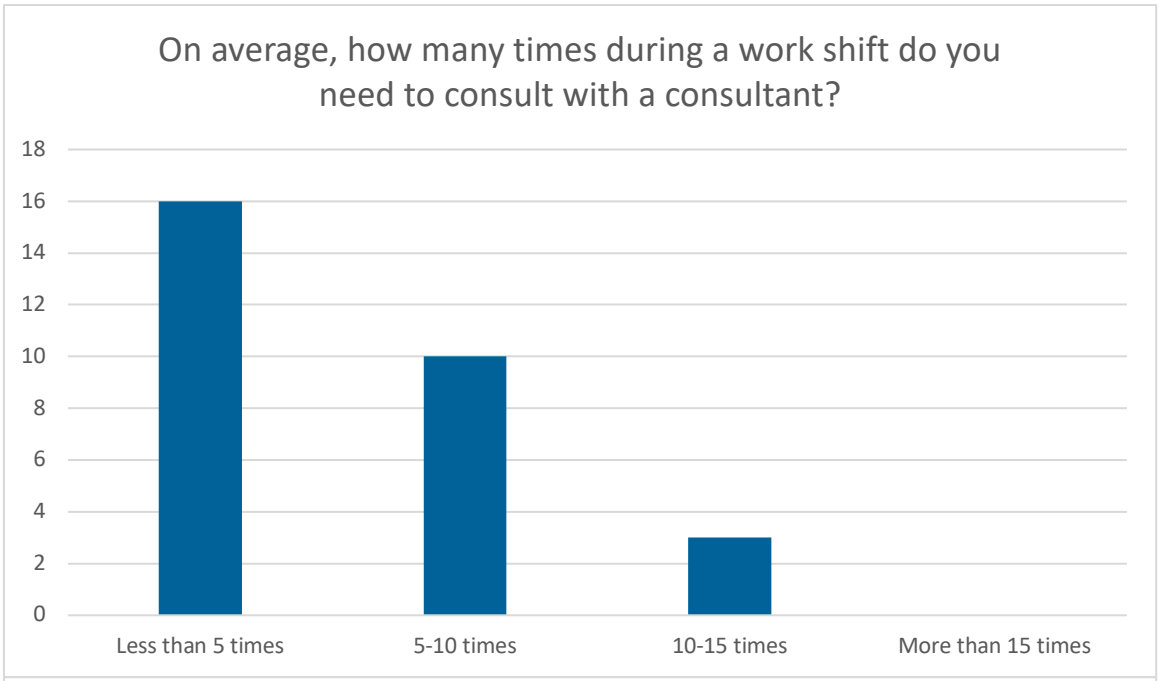
Answers of the residents and senior physicians

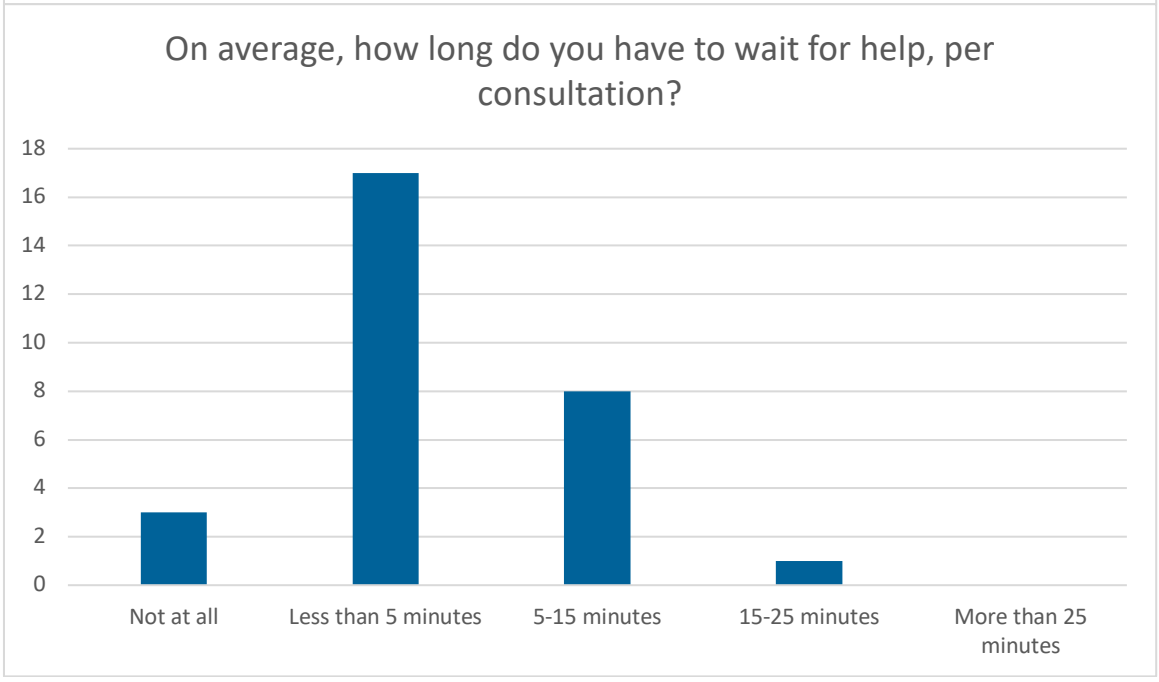


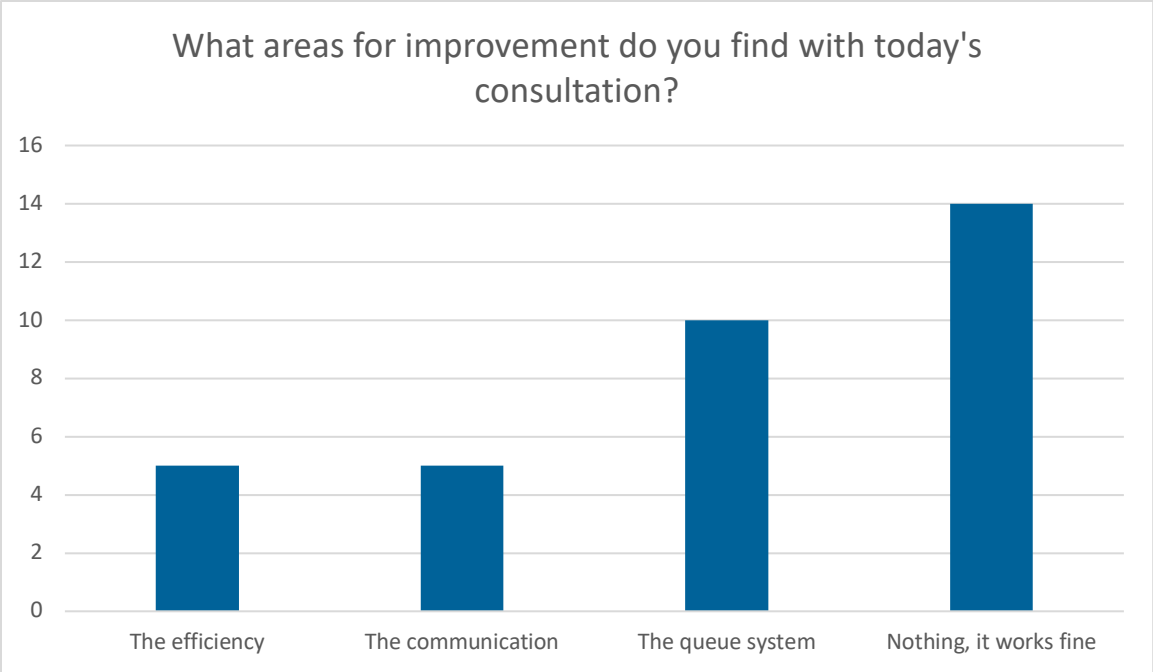




Answers of the junior doctors and interns

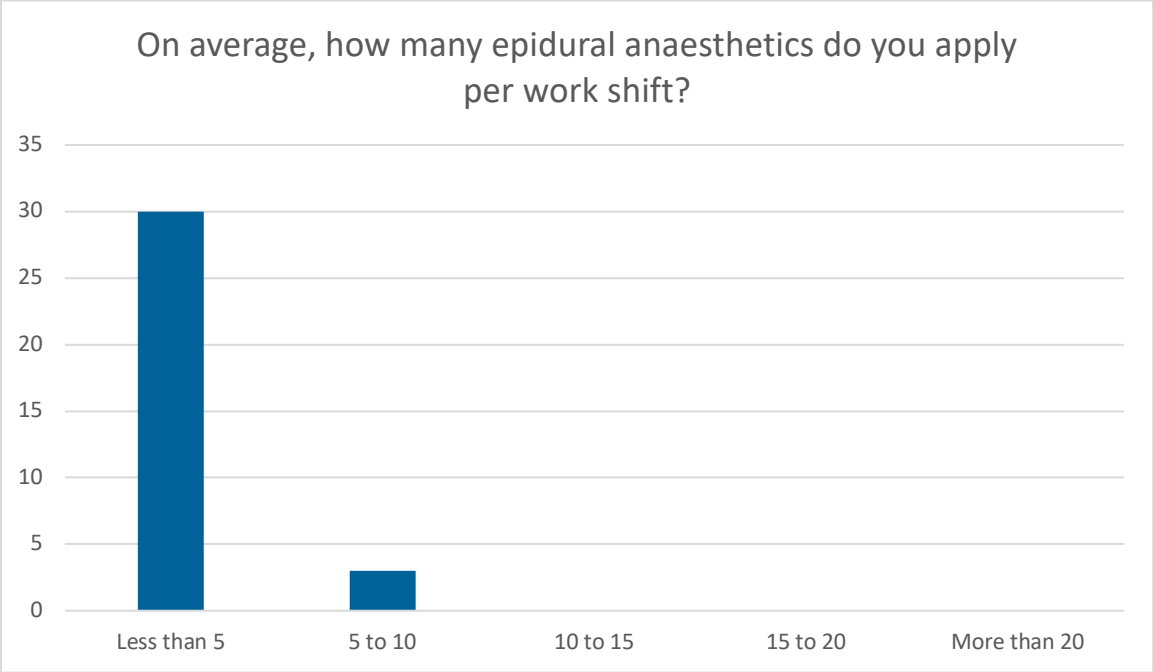

On average, how many times during a work shift do you need to consult with a consultant?
18
16
14
12
10
8
6
4
2
0
Less than 5 times
5-10 times
10-15 times
More than 15 times

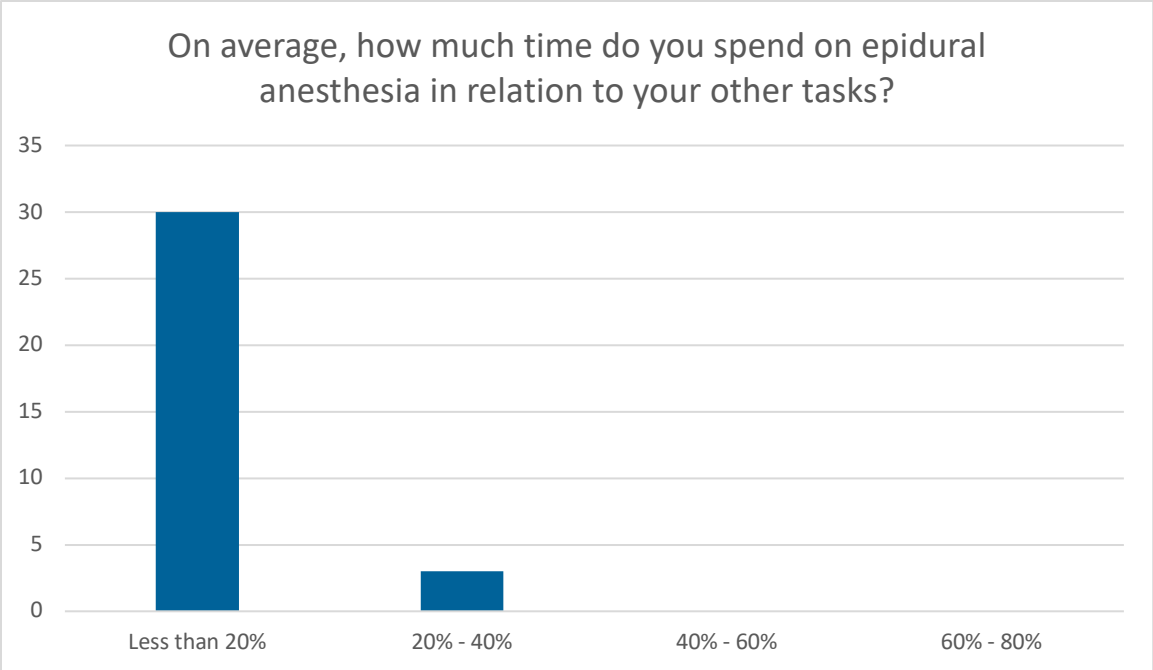

On average, how long do you have to wait for help, per consultation?
18
16
14
12
10
8
6
4
2
0
Not at all
Less than 5 minutes
5-15 minutes
15-25 minutes
More than 25 minutes

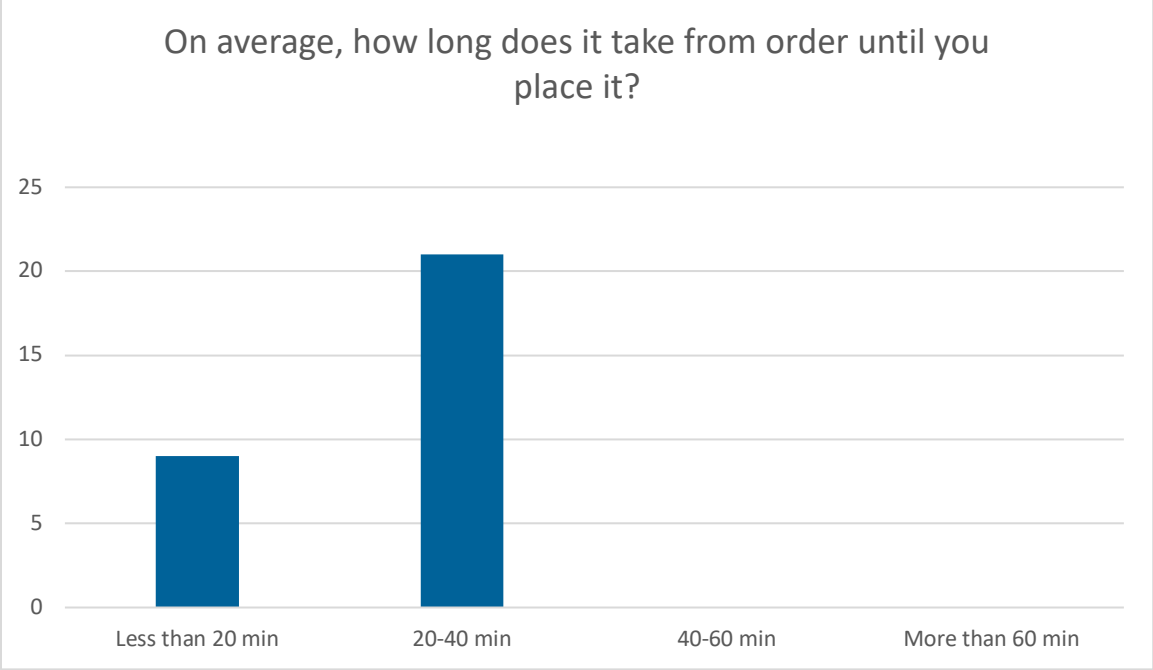


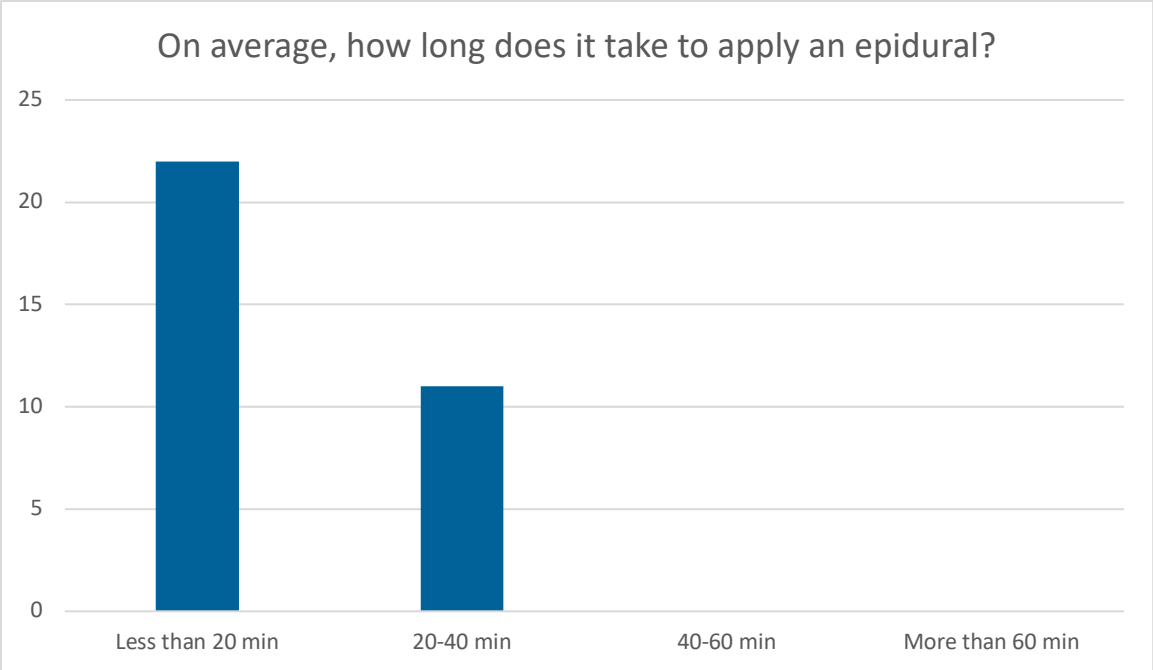
Obstetrics and gynaecology department

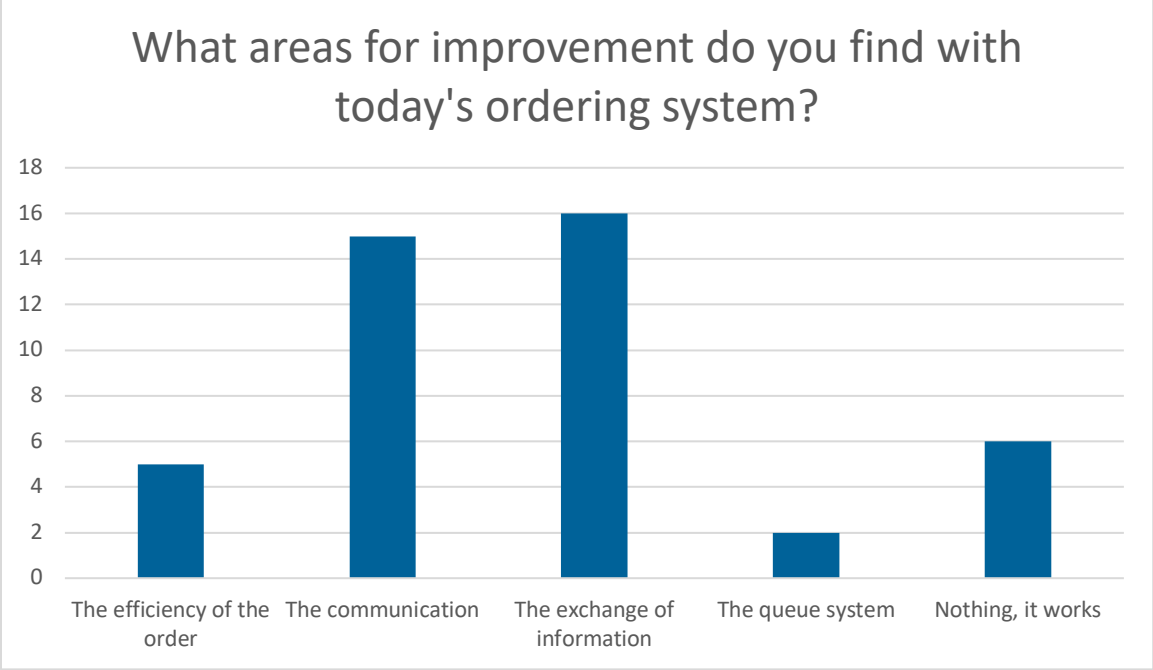
Answers of the anaesthesiologists



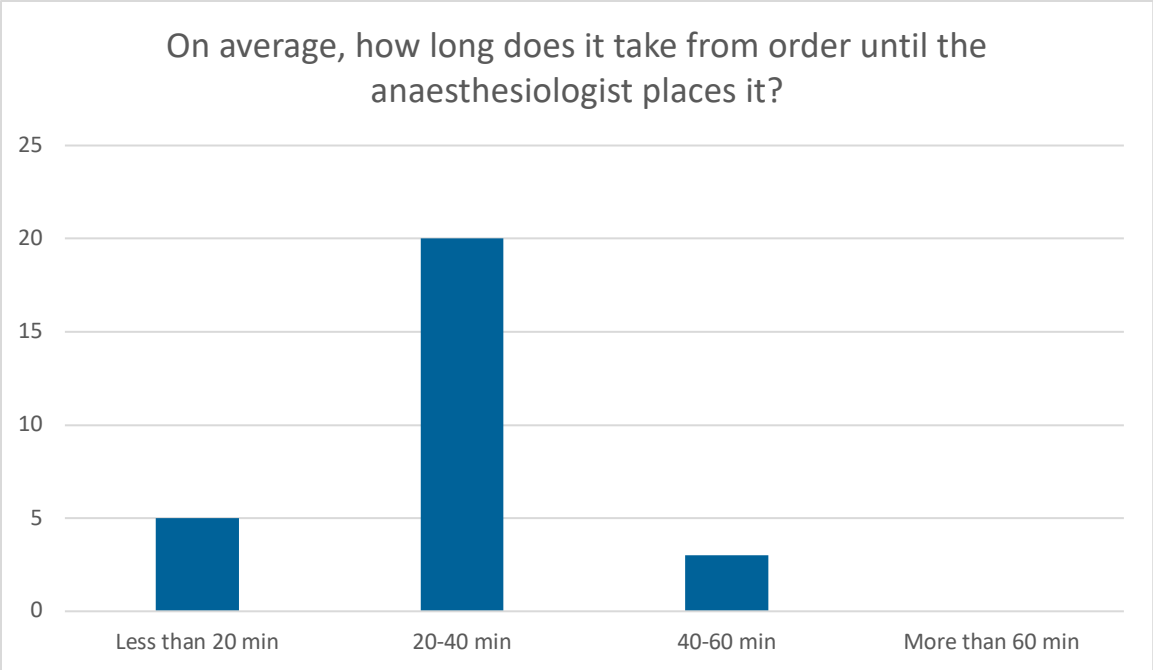

On average, how much time do you spend on epidural anesthesia in relation to your other tasks?
35
30
25
20
15
10
5
0
Less than 20%
20% - 40%
40% - 60%
60% - 80%

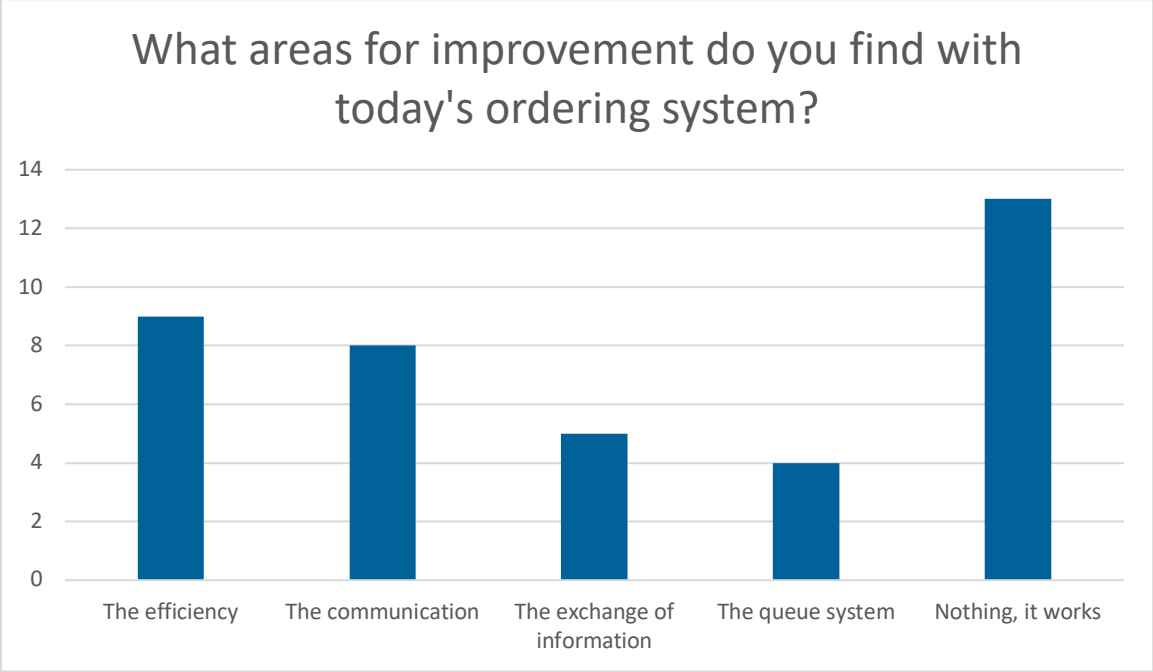

On average, how long does it take from order until you place it?
25
20
15
10
5
0
Less than 20 min
20-40 min
40-60 min
More than 60 min





Answers of the midwives


On average, how long does it take from order until the anaesthesiologist places it?
25
20
15
10
5
0
Less than 20 min
20-40 min
40-60 min
More than 60 min


What areas for improvement do you find with today's ordering system?
14
12
10
8
6
4
2
0
The efficiency
The communication
The exchange of information
The queue system
Nothing, it works

Appendix VII
Requirement specifications

Common

Requirements & desires	R/D	Weighting (1-5)
The solution should be digital	R	
The solution requires a digital product	R	
The solution should not include any personal patient data	R	
The solution should enable personal login	R	
The solution should provide information of the ward stationed at	D	2

Guidelines	Weighting (1-5)
The solution should enable efficient usage	5
The solution should be enable intuitive usage	4
The solution should provide a high guessability	4
The solution should follow the design principles of Jordan, presented below	
Consistency Compatibility Consideration of user resources Feedback Error of prevention & recovery Visual clarity Explicitness	2 4 3 5 2 3 4

Emergency ward

B: Both
D: Doctor
C: Consultant

Requirements & desires	R/D	B/D/C	Weighting (1-5)
The solution should present triage in the queueing system	D	B	4
The solution should enable triage of question	D	D	4
The queue			
The solution should enable doctors to enter the queue	R	D	
The solution should provide information of the time when a doctor enters the queue	D	B	2
The solution should provide information of the position in the queue	R	D	
The solution should provide information of the number of doctors seeking consultation	D	B	4
The solution should provide information of when a doctor is next in line	D	D	3
The solution should provide information of when the senior physician is available for the doctor first in line	R	D	
The solution should enable the doctor to pause their position in the queue	D	D	5
The solution should enable removal of position in the queue	R	D	
The consultation			
The solution should enable initiation of consultation	D	C	1

The solution should provide information of when consultation is initiated	D	B	1
The solution should enable finishing of consultation	R	C	
The solution should provide contact information of the doctor seeking consultation	D	C	2
Incoming high emergency case			
The solution should enable the senior physician to pause and start the queue due to: • Break • Incoming high emergency case	 D R	C	2
The solution should provide information of when the senior physician is not available: • Break • Incoming high emergency case	 D R	B	2
The solution should provide information of the duration of absence of the senior physician	D	B	2

Obstetrics and Gynaecology department

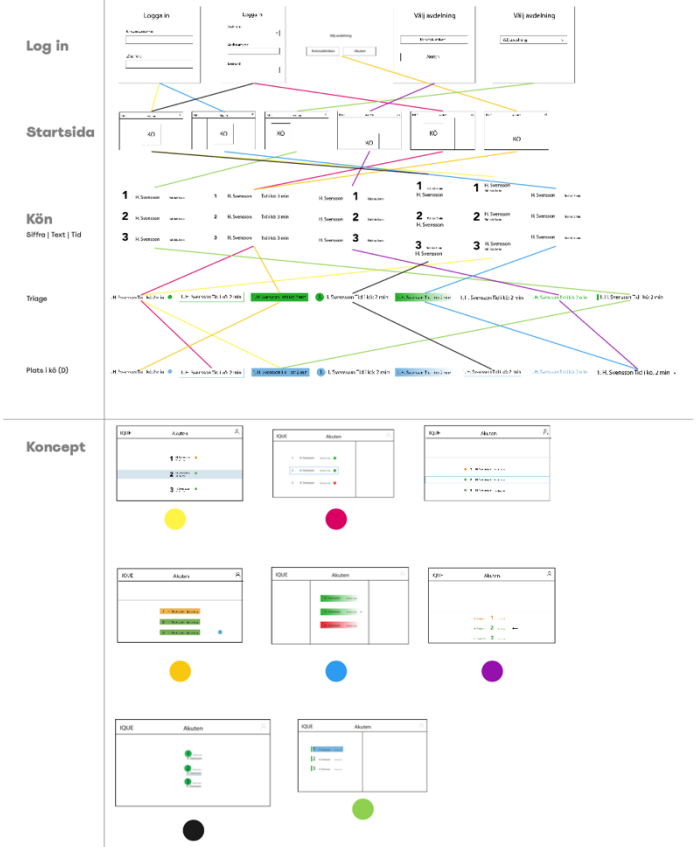
B: Both
M: Midwife
A: Anaesthesiologist

Requirements & desires	R/D	B/M/A	Weighting (1-5)
The solution should enable prioritization in the ordering system	D	A	4
The solution should enable several anaesthesiologists to handle the orders simultaneously	D	A	3
The order			
The solution should enable input of necessary information	R	B	
The solution should enable input of desired type of anaesthesia	R	B	
The solution should enable input of the department and delivery room	R	B	
The solution should enable input of necessary patient data: • Primigravida or multipara • Degree of opening • Course of pregnancy • Current health • Medicines • Allergies	R	B	
The solution should enable input of additional information	D	B	3
The queue			
The solution should provide the number of orders placed	R	B	

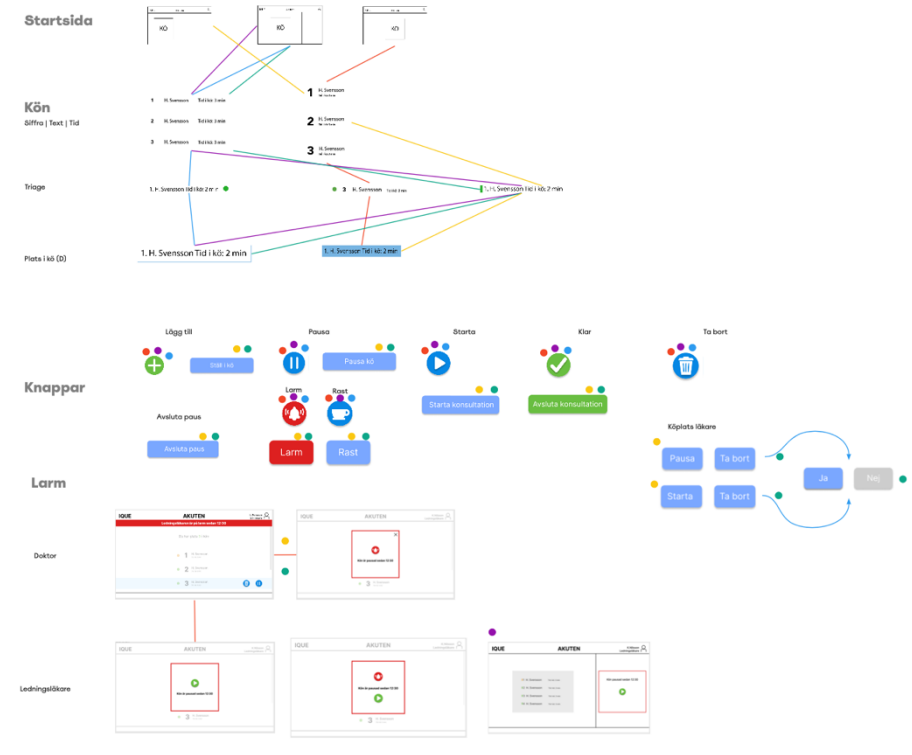
The solution should provide information of the position in the queue	R	M	
The solution should provide information of the time when an order is placed	R	B	
The solution should provide order confirmation from the anaesthesiologist	D	B	3
The solution should provide information of when to prepare the patient	D	B	3
The solution should provide information of when application is initiated	D	B	2
The solution should provide information of when application is completed	R	B	
The solution should enable removal of order	R	M	
New samples			
The solution should enable automatic requirement of new samples	R	B	
The solution should enable confirmation of new samples	R	M	
Incoming high emergency case			
The solution should provide information of when the anaesthesiologist is attending a high incoming emergency case	R	B	
The solution should provide information of the duration of absence of the anaesthesiologist	D	B	3

Appendix VIII
Morphological matrix

Morfologisk matris kön



Favoriter

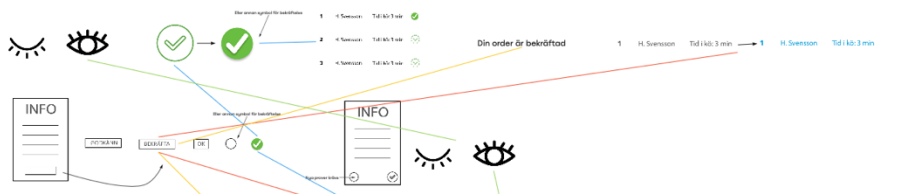


Morfologisk matris Kvinnokliniken

Bekräftelse av order

BM

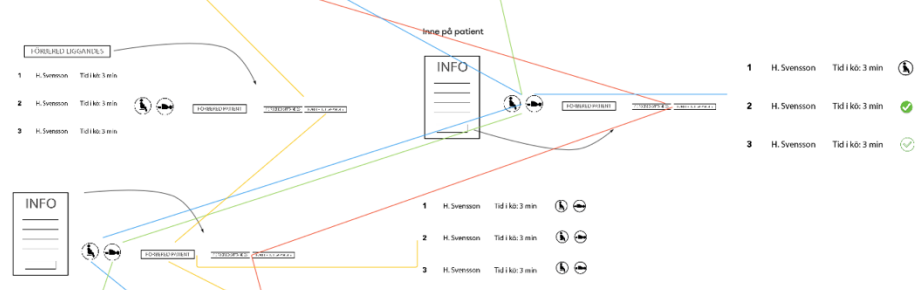
NL



Förbered patient

BM

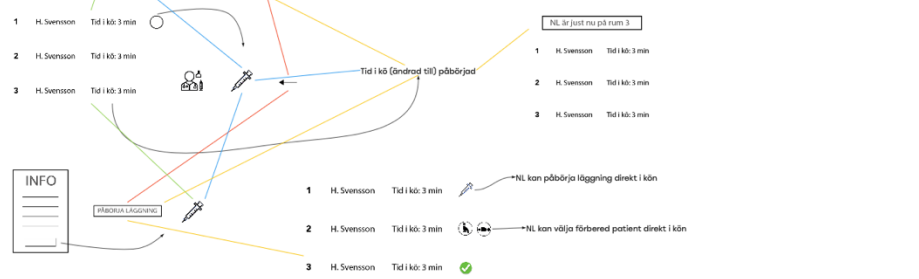
NL



Påbörja läggning

BM

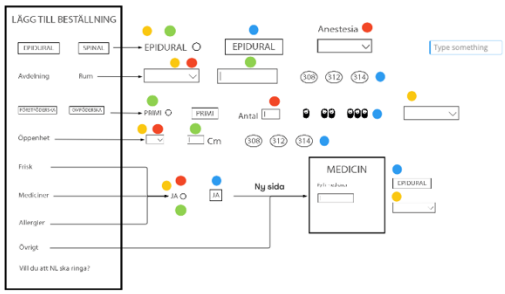
NL



Lägga in beställning

Struktur BM

Lägg beställning

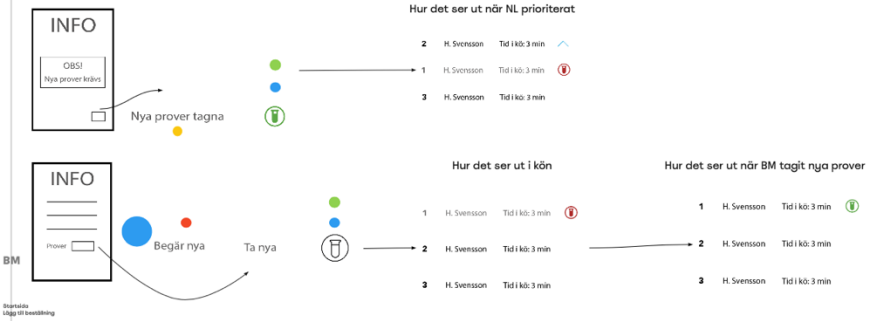


Nya prover krävs

BM

NL

BM



Snartaida
Lägg till beställning

Appendix IX
Concept weighting matrix

Emergency ward

Guidelines	Weighting	Concept 1	Concept 2	Concept 3	Concept 4
The solution should enable efficient usage	5	3	3	3	3
The solution should be enable intuitive usage	4	2	2	3	3
The solution should provide a high guessability	4	2	2	3	3
The solution should follow the design principles of Jordan presented below					
Consistency	2	3	3	3	3
Compatibility	4	3	3	3	3
Consideration of user resources	3	3	2	2	2
Feedback	5	3	2	2	3
Error of prevention & recovery	2	3	3	3	3
Visual clarity	3	3	2	2	3
Explicitness	4	2	2	3	3
Total		**96**	**85**	**97**	**105**

Obstetrics and Gynaecology department

Guidelines	Weighting	Concept 1	Concept 2	Concept 3	Concept 4
The solution should enable efficient usage	5	2	2	3	3
The solution should be enable intuitive usage	4	1	3	2	2
The solution should provide a high guessability	4	1	3	3	2
The solution should follow the design principles of Jordan presented below					
Consistency	2	3	3	3	3
Compatibility	4	1	3	3	3
Consideration of user resources	3	3	3	2	2
Feedback	5	1	3	3	3
Error of prevention & recovery	2	3	3	3	3
Visual clarity	3	3	2	2	2
Explicitness	4	2	3	3	2
Total		**65**	**100**	**98**	**90**

DEPARTMENT OF INDUSTRIAL AND
MATERIAL SCIENCE
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