Developing a mobile application supporting parents' activities during pregnancy

Master Thesis in Software Engineering

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ABSTRACT

A particular case when many, often healthy patients need to meet different health institutions is the case of the future parents. Obstetrics, examining this period incorporates activities beginning approximately six months before and ending approximately one year after the childbirth in the Scandinavian countries. This study presents the design and early stage of development of a possible mobile application supporting future parents' necessary activities to better plan and organize the new challenges due to the pregnancy in their life. While there are several applications on the market supporting women in her pregnancy, these applications are mainly aimed for single activities, e.g., weight control, sports, or information about the fetus.

One of the main challenges behind this thesis is identifying and supporting communication between the possible stakeholders. These are not only groups of family and friends and other parents in similar situations, but also different health institutions following policies, regulations, and laws. Discussing appointments, tests, and possibilities with healthcare institutions are difficult today as it involves data sharing. Currently, in health institutions, clinical data is often stored in different ways. Using free text and several formats can make it impossible to share information between the different involved health care institutions and the patients. Therefore, communication and planning activities meet not only social but also technical challenges.

The primary goal is to design and develop a prototype of the mobile application based on data from major stakeholders: the future users, the practitioners involved in healthcare (midwives, nurses, and clinicians) and technicians involved in designing software for healthcare. Design requirements were identified from the literature study and data collected via interviews. The focus was on investigating the possibilities for identifying and sharing relevant patient data for this application, concerning actual requests for interoperability, safety, and efficient communication.

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Abbreviations

ACW – Android Callable Wrappers

AI – Artificial Intelligence

AOT – Ahead of Time

ART – Android Run Time

BMI – Body Mass Index

CLI – Command Line Interface

CP – Clinical Pathway

EHR – Electronic Health Records

EMR – Electronic Medical Record

EPR – Electronic Patient Record

FAQ – Frequently Asked Questions

GDPR – General Data Protection Regulation

GP – General Practitioner

HC – Health Care

HKG – Helse Kort for Gravide

HS-Designer – Health Schema Designer

HS-Viewer – Health Schema Viewer

ICT – Information and Communication Technology

IDE – Integrated Development Environment

IDE – Integrated Development Environment

JIT – Just in Time

JS – javascript

MCW – Managed Callable Wrappers

MQ – Message Que

NHN – Norwegian Health Network

NRS – Nasjonale Retningslinjene for Svangerskapsomsorgen

OEM Widget– Original Equipment Manufacturer Widget

ONC – US Office of the National Coordinator for Health IT

ORM – Object Relational Mapping

PCC – Patient-Centered Care

PP – Patient Pathway

PT – Patient Travel

PWA – Progressive Web Apps

VS Code – Visual Studio Code

XPLAT – Cross-Platform Technology

1 Introduction

New technology influences many areas of our life. Both Health Care (HC) professionals and patients meet new technologies in their activities. Examples are from the electronic storage of health data, using mobile apps supporting diverse activities, telemedicine or robotic surgery. Technology, in general, become an indispensable component of current HC welfare. But, “technology alone is not enough—it needs to be combined with innovations in processes to have the greatest effect”, to fit into the context and to deliver qualitative professional care (Howitt et al., 2012). However, implementing and using new technologies in complex institutions as the HC and its patients is not easy.

To have technologies supporting professional and fare care, data has to be managed and shared. Handling data meet a considerable number of privacy and security challenges. A way to handle data worldwide, with a large number of standardizations associated with HC, is via Electronic Health Records (EHR or EPR).

But, the use of EPR can lead to unexpected adverse effects. What was designed to bring efficiency and harmony in health, for some clinicians has turned familiarly things upside down causing them to be disoriented, losing their attention from their patients to managing technologies. (Rosenbaum, 2015) They name the following leading causes: missing to prepare the medical staff for such significant changes, possible wrong usage, problems with interoperability.

Mobile health-related applications are a branch of electronic health application and developed actively during the last years. Now, it can be considered as a separate industry.

1.1 Motivation & problem description

There are more health-related applications supporting the pregnant women, e.g., about the growth of the fetus, different pregnancy tools (weight tracking, ovulation calendar, etc.) and social support from different tailored social sites. According to my knowledge now, there are no mobile applications supporting women’s communication with care institutions responsible for women’s health and her doctors and nurses knowing more about the pregnancy and providing support for the process.

New parents usually require support and involvement from responsible organizations. This support regards information related to the specific stage of their pregnancy and the possible problems and questions related to that specific stage of pregnancy they are experiencing. During this time of the pregnancy, the life of the parents are not necessarily changing; they often need to balance between work and home, but considering additional activities as well. They need to know more about each stage and plan their activities adjusted to new circumstances. However, even in western countries, like Norway, according to the Norwegian Directorate, maternity HC and child care are fragmented. Future mothers, and fathers who are often young individuals can feel discontinuity in the provided care and not enough knowledge about the responsibility and function of the

different care provider organization. As a consequence, they can experience a lower quality of care. (Helsedirektoratet, 2005)

Sometimes the parent does not get the necessary information regarding their rights and possibilities, i.e., what they have to and can to do during the pregnancy and depending on the specific phases of the pregnancy or after birth. There is a large amount of information provided during pregnancy, and the parent does not know what information is needed for further planning.

1.2 Aim and research questions

The main aim of this thesis is to design and develop a prototype of a mobile application supporting parents to plan their activities during and after pregnancy. Related to this we proposed a hypothesis that mobile application developed in this thesis will help future parents to better plan their meetings with HC institutions

The greatest challenge behind this MSc thesis is to investigate several different aspects, behind developing a mobile application supporting future parents in their new situations. This challenge is multifaceted, influenced by user needs, possible support and challenges from the technology.

In order to develop this prototype, the following **research questions** will be answered:

> **RQ1 What is the most common pathway for a pregnancy, without complications?**
> **RQ2 What are the most common challenges in a pregnancy period for parents, and healthcare professionals during this time?**
> **RQ3 How can a mobile application best support parents during their pregnancy?**
> **RQ4 Which are the most suitable technologies for supporting pregnancy apps?**

Some important terminology needs to be introduced already here. For this thesis, a *patient* is a parent who needs to communicate with HC. She/he usually is an entirely healthy person, seldom having access to specific health-related information influencing her/his new status during several months. Another important terminology is her/his *pathway*. This is the chain of activities the patient has to do or can do after observing the pregnancy until the child is one year old, or in some countries a few years old. Even if this thesis considers planning for activities with childcare, the focus mainly is on time from pregnancy is discovered until the child is born.

Here is also introduced the terminology for mobile applications (*mHealth)* supporting parents: *mParent*[1]. The application supporting future parents in their planning activities; the current mParent app aimed to be designed and developed will be called *ELISA*.

[1] The notation, terminology mParent was introduced by this work.

For this MSc thesis, knowledge from software engineering, health informatics, and handling new technology innovations are needed. While this thesis takes an interdisciplinary approach, the main focus is on design and development of ELISA from software engineering.

1.3 The outline of the report

This report is divided into 10 Chapters. An appendix follows as a separate document and contains all code samples from the developed platform not meant to be public. After the first Chapter including introductory information, the second and third Chapter discusses terminologies, theoretical concepts and technologies influenced this work. Chapter 4 was dedicated to methodologies. Chapter 5 and 6 outlines all interdisciplinary requirements for the creation of the ELISA and define interdependencies among the areas needed to develop it. Chapter 7 describes the technical part of the development and most important technical elements and the way to identify these. Chapter 8 shows a high-end overview of the developed platform (which ensure communication of the ELISA with HC) and ELISA according to targeted aims. In Chapter 9 includes methodological discussion, the applicability of the app, issues related to the readiness of it and future work. Chapter 10 highlights the main conclusions.

1.4 Limitations

To develop a full functional mParent application would require several months of intensive work from interdisciplinary teams, due to the involvement of a large number of aspects influencing pregnancy and different usage of information involved in this process. Information required to be contained and handled in such a broadly usable app was not thoroughly investigated. Aspects like living habits, diet, patient rights and other related to these were only briefly mentioned when needed. Interviews with patients were done just with one category from the four identified categories. Based on the most common pregnancy process a Patient Pathway (Chapter 5.4) was proposed. The pathway covers the period until childbirth, even if many secondary documents suggest including the intensive childcare period (in many countries until the age of 1 year, while in others until the child becomes 2 years old). User interface solution for the proposed app has not been fully developed; neither was the server-side of the application. The tests were done mostly proving capabilities on schematic aspects of the communication and consent functionalities. However, backend functionalities for video-audio chatting were partly implemented on the server side. Security of the application was developed on the server side, in the mobile application is still a subject of further work. Post-development tests (usability tests with principal stakeholders) and post-development adjustments were planned at the beginning of this thesis, but due to not anticipate the complexity of the project, the focus was moved to developing basic requirements in the server-part of the app. While a considerable effort was laid down for developing a solution for the identified requirements, the prototype needs to be further developed.

2 Theoretical and practical influences

This Chapter covers basic theories, and current practices influencing this MSc thesis. Sections 2.1 and 2.2 present background information related to understanding parenthood and maternity, and the narrative[2] with necessary activities young parents use to follow after discovering the pregnancy. These issues influenced defining components which are essential for the construction of the mobile app ELISA, while sections 2.3, influencal technologies, and Section 2.4 presents existing mobile applications inspiring for the development of ELISA.

2.1 Health care and pregnancy

The way pregnant women get help from HC varies from country to country. Some countries have explicit guarantees, free of charge antenatal care services and have well-established institutions which are specialized in obstetrics. In others, the patient must themselves find institutions which may give help to her and in other patients are required to pay for services. Also, there are in countries where women do not get any services and have to give birth alone without any help (Ibrahim Yakubu and Salisu, 2018). As expected, the best countries with organized maternity care are developed countries; leaders are North European countries like the Netherlands, Sweden, Denmark, absolute leader for 2018 is Norway. At the other end are countries from Africa and Asia, the worst country with pregnancy HC infrastructure is Somalia. There are many factors which determine the quality of pregnancy care, from economic factors to sociocultural factors (e.g., gender equality, the absence of education, lack of parenting culture), religion, conflict zones. (save_chlidrens, 2018)

First governmental programs for antenatal care in developed countries were oriented for the vulnerable social category of the population; this had the ultimate objective to improve the quality of care for this category. Over time, these antenatal programs increased, covering all population categories. The number of planning visits to the doctors varies, (Lindmark et al., 1998) but according to a research study done by Blondel and his colleagues (1985) there is no difference in health quality during the pregnancy between women who had substantially more visits to the doctor than those who visited 4 or 5times. It is an important aspect for authorities to plan antenatal care offer, issuing more concrete recommendations for HC like the number of visits, drug administration, screening periods, preparation for birth, etc.

According to the general practice in Scandinavia is regular to plan 7 – 8 visits to the doctor for a healthy pregnancy usually including screening test in week 17-18, 37, and general blood tests in the first trimester of pregnancy for eventual abnormalities identification, BMI index control.

[2] Narrative (Noun) - a representation of a particular situation or process in such a way as to reflect or conform to an overarching set of aims or values.

Norway can be considered as one of the best countries with excellent antenatal and maternity care, e.g., with the lowest death rate for mother and child, 100% medical experts' coverage at any pregnancy stage period and child care. There is one chance from 175 that a family will lose their child before the age of 5, which is also the lowest in the world. (save_chlidrens, 2018)

However, this care also is experienced as fragmented,(Helsedirektoratet, 2005) as it is difficult to know about possible care and caregiving organizations during the period of pregnancy. Essential documents in communication with patients are paper-based, including health-card for pregnancy also known as Helse Kort for Gravide (HKG) – the essential binding document between health institutions giving antenatal care and patient. (more in Chapter 5.3)

2.2 Clinical & Patient Pathways in Health Care

This section discusses the period of pregnancy. This can be considered a narrative with activities involving different HC organizations from recognizing pregnancy. This narrative can be told as a pathway. According to European Pathway Association (EPA), the main aim of a pathway in care is "*to enhance the quality of care by improving patient outcomes, promoting patient safety, increasing patient satisfaction, and optimizing the use of resources.*" (2018) Standardization and better management of activities during a patients pathway support optimizing Health Care services. (Buchert and Butler, 2016)

Buchert and Butler (2016) state that standardization of pathways can produce a vast optimization for each category of patients with a similar pathway. They hypothesized that these pathways could reduce inefficiencies, eliminate waste and at the same time can bring standardization in the delivery of care, also known as Clinical Pathways (CP). CP can, if implemented correctly, have the potential to have a positive impact on the quality of care delivered to the patient and on the daily workflow of the professionals. CP also can optimize both economic and strategic mission on an organization providing care.

CP is named differently in different regions of the world, but the meaning of it is more or less the same. Definition from EPA (2018) state: "*A Care pathway is a complex intervention for the mutual decision making and organization of care processes for a well-defined group of patients during a well-defined period*."

A CP is a result of interdisciplinary work and is designed to sustain clinical guideline and protocol implementations. Also, they are meant to support clinical management and financial resource management. CPs give detailed guidance in each stage of a patient journey like treatment, intervention points, with some specific conditions in a specified time frame including result details. (open_clinical, 1999)

Associated terminologies to PPs (see coming paragraphs) and CPs are: critical pathways, integrated care pathways or care maps, are one of the central tools used to manage the quality of care about standardization and uniformity.

A new dimension in health pathway concepts was introduced in 2015; the so-called "Patient Pathway" (PP) aims to put a Patient-Centered Care (PCC) in the middle of the conceptual structure of the pathway. The difference is the focus, while PPs focused on effective care from the HC organizations viewpoint, in a PCC the patient is in focus, and that can be different. Based on the idea from Michel Porter about connecting Health Care services from the patients perspective. (Porter, 2009) Patient Pathway also can be an abstract description of the health care efficiency, but not necessarily. (Heldal et al., 2015) The same source states that technologies can give seamless support during the narrative patients make in the HC, the Patient Travel (PT) through the various networks of care. But several available technologies are underused, and often isolated from each other making real-time data-sharing impossible. There are a vast number of examples when different tests for one and the same patients are taken several times if they visit several HC units since their data is not accessible.

Thus, defining a pregnancy PP and seeing to be the same as PT can be beneficial for patients and HC organizations. For achieving the primary goal of the thesis and designing a mParent application which will help parents to plan their meetings with all involved HC institutions, we use a general pathway that all healthy pregnant women follow. (more in Chapter 5.4)

2.3 Existing Health Care solutions influencing ELISA

There are several social and technical issues influencing the handling of patient data, e.g., in order to respect patient's integrity allowing safe and secure technical communication. This can be difficult. According to Buchert and Butler (2016), HC is filled mostly with IT systems that are too complex, inefficient, and expensive. Furthermore, health care delivery is not harmonized among different providers and services of care, also leading to a high degree of inefficiency. There may be several causes for this. For some clinicians, technologies designed to bring efficiency and harmony in health, have turned familiar things upside down causing them to be disoriented, changing their attention from their patients to managing technologies (Rosenbaum, 2015).The same source enumerates reasons, e.g.:

- underestimation of importance to prepare medical staff for such radical changes., Wachter and Age tell that after changes, in one day a medical "staff came to work, and nobody knew how to do their job." (Wachter and Age, 2015:p.6).

- EPR[3] was for the vast majority developed by IT personnel knowing very little about the daily workflow of the clinicians.

-due to significant variation among vendors and complexity of medical data structure, EPR was challenging to guarantee interoperability, which led to poor automation and much data being introduced manually.

[3] Electronic Patient Record

To solve the above-mentioned issues, it is required to re-think several parts of the EPR specifications. One way can be about how interoperability shall be implemented, with the help of standards describing data formats for electronic journals. For instance, can FHIR[4] or OpenEHR[5], have the potential to achieve seamless semantical interoperability.

Another possibility is the use of mobile devices for the automation of data collection; and yet, another is the use of patient involvement and engagement in care. ELISA can be the perfect platform for both, data collection and sharing information with decisional character (like decisional aids) which will lead to more parents engagement in care and better-informed patient participation. Effect on the information sharing with the decisional character (included but not limited to decisional aids) was measured in research conducted by Say and her colleagues (2011) on a group of pregnant women. They developed patient decision aids for decisions concerning prenatal testing, vaginal birth, and Caesarean section. The objective of this work was to see how the decision aids can rise a degree of informed decisions from a patient perspective. The result showed a positive impact for both patients and experts involved in obstetrics, led to lower decisional conflicts, enhanced knowledge, better overall satisfaction among individuals involved in this process.

For the development of an IT solution which has the potential to solve challenges as mentioned earlier, all these discussed areas of the EPR improvement shall be considered interdependent, even if after that, the hardest part is to combine knowledge coming from different disciplines. However, as pointed out earlier, interdisciplinary work is vital to increase the likelihood of creating IT solutions which will solve the issues discussed in these paragraphs.

In the following sub-sections, these influencing parts are going to be described. All of these contribute to understanding how to share data from a patient perspective between her and the HC organizations, and also between the different HC organizations about the same patient.

2.3.1 Helsenett

Norsk Helsenett (Norwegian health net, NHN) is a separate network where all health care institutions can communicate and exchange sensitive data with each other. NHN is a network owned by the Norwegian Ministry of Health and Care Services since 2009. Central principle around NHN is security and availability according to the owner of:

> "*Safe and efficient information flow in the health sector is something that concerns us all. All this is about life. We have not reached our target until all therapists get*

[4] FHIR: "Fast Healthcare Interoperability Resources (FHIR) is an interoperability standard for electronic exchange of healthcare information. FHIR was developed by Health Level Seven International (HL7). (Rouse, 2017)

[5] openEHR is a virtual community working on means of *turning health data from the physical form into electronic form* and ensuring *universal interoperability* among all forms of electronic data. The primary focus of its endeavor is on *electronic health records (EHR)* and related systems. (openEHR, 2019)

access to the patient information they need –when needed. Norwegian Helsenett works for all health information to always be safe and accessible."

(NHN, 2018)

The Main benefits from connection with Helsenett are access to a closed and secure digital interaction network for all HC professionals in Norway. Because of isolation from the outside web, it has a low risk to be attacked with malicious intent and thus all sensitive health data can be legally shared across the health actors.

In Norway, all the data flow which health organizations use for their work is on Helsenett. On the other hand, all patients who can deliver valuable health information is on the web. Thus, for achieving communication between these two worlds, it is necessary to design and create a communication gate which will offer such capabilities.

2.3.2 Electronic Patient Records (EPRs)

According to ONC (Office of the National Coordinator for Health IT), an Electronic Patient Record (EPR) is a digital version of the paper-based patient health records chart. They offer real-time information exchanging between health actors participants, with intent to give quick and best possible care services for patients. (ONC, 2018) EPR has high-security requirements, and in order to use the services which NHN offers, it requires to pass a series of acceptance tests defined for different types of services which they offer. An example can be a "Message validator service", in order to use the messaging system for communication service between health institutions. An EPR requires to be implemented in accordance with NHN electronic journal specifications and pass a series of acceptance tests. These tests will guarantee to users that the system has been developed under NHN specifications, which intend to ensure a sufficient level of security to be trusted and used for sensitive message sharing on NHN.

In Norway exist a few EPR, the biggest one is an EPR developed by DIPS ASA. This is a leading supplier for HC institutions in Norway who owns 80% of the Norwegian health market. In 2018 DIPS ASA officially released a new EPR called DIPS Arena, the audience for this EPR is mainly helse personnel from hospitals. (DIPS, 2019)

Another big actor is VISMA which have a wide range of EPR solutions. One of EPR called Visma Omsorg HsPro is for Health stations (Helsestasjoner), this EPR is used by almost all Health stations in Norway which offer health services for children until the age of 5. (VISMA, 2019)

2.3.3 EPR at AVANS AS[6]

In Norwegian EPR market also exist new arising journal systems which quickly gain popularity among the private market. There are several organizations focusing on health technology development and develop solutions handling EPR.

One of these is AVANS AS - a company delivering intelligent software solutions for the health sector has developed an EPR called Ad Vitam, which has the approval to be used on Helsenett. It is a complete journal system that simplifies HC professional's everyday workflow. All data in Ad Vitam are structured, which make Ad Vitam a good concurrent for the leading EPR systems on the Norwegian market. This means that manual tasks like reporting, time lists, statistics are no longer required.

Since handling EPR is crucial to develop ELISA with the possibility to add an integration module on backend service which will ensure automation of the data collection and data structuring directly in EPR. One of the intentions of this MSc thesis is to integrate the proposed system with Ad Vitam and all relevant data for pregnancy period coming from different sources to be automatically structured in this EPR, as well as offer an open API for use with others EPR.

2.3.4 Existing communication infrastructure between Patients and Health Care.

Today there are few solutions performing digital communication between HC and patients in Norway. This chapter discusses some of these solutions available on the market today. With one of these played an essential role in the architecture of the ELISA.

CheckWare

One of the providers, CheckWare, offer solutions in health domains that use psychometric tests. They do not have their own EPR but offer a so-called partner API which offers integration of their test solutions with the patient journals. CheckWare involves above 1000 psychometric tests, interviews, forms, and screening tools. (Husby, 2018) However, they do not have the opportunity to edit schemas by medical staff, and to add or modify an existing schema has to be ordered from them.

[6] Avans AS is a company which gave me opportunity to use concept of communication based on *cari* principles and to develop a whole new backend system which will replace *cari,* allowing to integrate ELISA and with their new EPJ specialized for HC called Ad Vitam.

Cari

Cari consists of several applications (Figure 1)- It is based on two servers in which runs two different apps: one is *cari* second is a message queue server, which only communicates with a shared database, Ad Opus[7] (EPR). *Cari* offers schema-based communication: a schema can be sent directly from a portal section of EPR. From there the sent schemas can also be managed. The patient gets SMS invitation to complete schema, by visiting cari.no portal. To be able to complete schema user need to authenticate itself with Norwegian BankID[8]. After the schema is completed *cari* sends to MQ-server[9] schema, and it is stored in MQ-db[10]. After the schema is stored Ad Opus make a call to the MQ-Server and fetch completed schema.

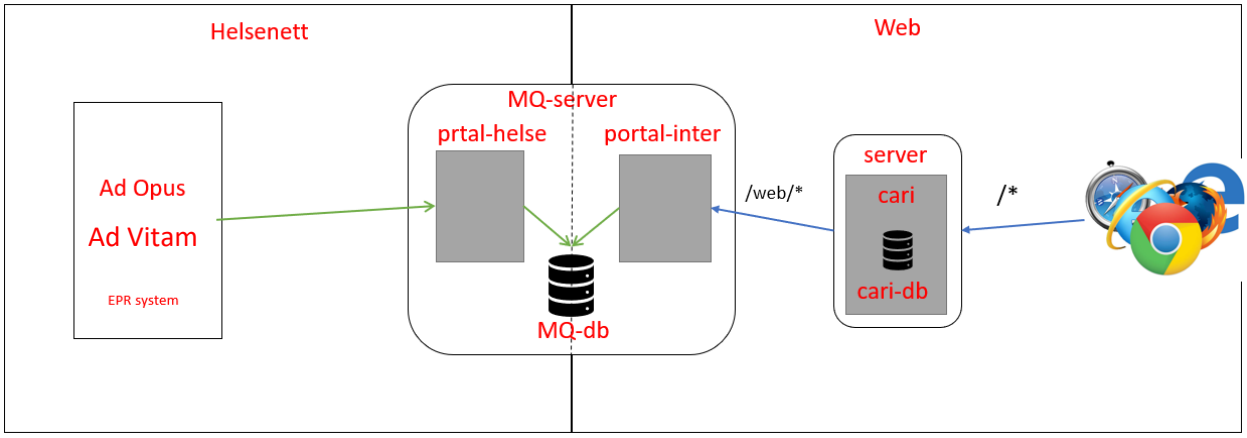


Figure 1: *Cari* Architecture.

MQ-server is driven by a series of four statuses: **sent, received, delivered** and **processed,** which control the whole life cycle of the schemas. When schema assigned to a patient it is stored in MQ-db with status **sent**, however, templates are located in cari-db, and at this stage, MQ-db holds only reference to that schema. After the schema is received by *cari* its status changes to **received** meaning that it is ready to be answered. After the schema is completed, by the patient, it gets status **delivered,** and it is ready to be fetched by EPR. Moreover, after schema has been successfully stored to EPR db is receives status **processed,** and schema is no longer active.

The schema is created with the help of lime survey, which is a popular open source schema generator used worldwide by many survey-based portals. This is a powerful tool offering a considerable variety of question templates. However, for the health sector was

[7] Ad Opus – EPR system owned by AVANS AS. This EPR is not used in HC directly but rather is for rehabilitation industry "atføringbedrifter".

[8] BankID is a personal electronic ID that is used when identifying and signing online. Service offered by banks(Nor)

[9] MQ-server is is a server which acts as a gate between Helsenett and web. MQ-server consist of two applications which communicates only with Helsenett (portal-helse) or web(portal-inther) and have a common DB. Portal-helse communicates with DB through port 3306 and portal-inther though port 3307

[10] An MQ-db is a Database server which hold all sensitive data and information about schemas and patients. To MQ-db is connected two application which runs on MQ-server.

proven to be too generic, lime survey designer is too complicated and requires a good level of user knowledge to be able to create a simple schema. Another drawback is that with such approach it is possible to create only one type of schema which needs to be completed once (for more about schema types see Chapter 5.3.1). As mentioned above, organizations are looking for a solution with having the possibility to correct schemas self.

While the idea behind *cari* is bright and straightforward, helping to solve many issues elegantly in communication between HC and patients, the technical solution was proved to be too tightly coupled to its own messy code files, not modular so difficult to interpret. Therefore, it was difficult to develop it further and allow adding additional functionalities. Since developing ELISA needs additional functionalities, rewriting *cari* was considered in this thesis (discussed in Chapter 6.1).

2.4 mParent apps

This subchapter reviews existing mParent apps, to see what the situation is worldwide vs. on the Norwegian market in this domain, what are the current benefits and shortcomings.

mParent applications are new on the market. Agarwal and Labrique (2014) write that at the macroscopic level, a mParent application should include tracking of essential events like main term periods and most common actions at the followed time. Examples are point-of-care diagnostics which can quickly provide knowledge about each event under pregnancy, routine data collection for pregnancy monitoring, EPR for access of the patient records by the experts when they travel to patients home. Also, it is necessarily an improved communication facility among system components of health and participants. Some projects led by UNICEF in emerging countries consisted of an open-source data management platform based on SMS, lifted the quality of provided pregnancy-related services in some cases with 40%. Direct measurements of the reduction of mortality and after birth consequences not were mentioned in the study. (Agarwal and Labrique, 2014)

In the developed countries the mParent apps can be considered as the most growing health-related market. In 2013 this was on the 3'rd place (Dolan, 2013), and in 2016 on the second place (Rosbrow-Telem, 2016) among the most used apps on mobile platforms. Another study showed that more than 75% of pregnant women use pregnancy-related apps (Perry et al., 2017).

The creation of a mParent app can have a significant potential for parents in enhancing the quality of their planned activities under pregnancy and through child care as we pointed out in the first, a motivating part of this study (Heldal et al., 2018).

2.4.1 mParent apps on the market

Doing a simple android-market search reveals thousands of mParent apps, and most of them are rated with more than four stars[11] from users. 70% of the apps are in English;

[11] The higher stars value is, better is user satisfaction. Best is 5 stars.

the rest can be found in more than 20 languages. Also, I found just TWO apps in Norwegian; the best rating has “Gravid og barn” developed by Sandvik (Norway) with 3.1-star and 50 thousand downloads. Best rating among other apps had “Pregnancy” developed by AMILA (US) with 4.8 stars and 1 million downloads. These apps were free to download, and all functionalities can be used free of charge. Among paid apps, the best is rated with 4.5 stars with 5 million downloads and named “Pregnancy+”, developed by “Health and Parenting LTD” (US).

We examined three apps that inspired us to create ELISA. They were chosen by user satisfaction criteria which are represented in stars. These apps are great, but in relation to ELISA, as we are showing they don’t have communication facilities with HC institutions, neither possibility to collect relevant health data for institutions. The apps are mainly used to estimate the development of the baby based on the time of the pregnancy. All of them have an ovulation calculator and contraction tracker.

Even if the number of mParent apps is increasing, on the Norwegian market of mParent apps situation is not. There are a few more simple designed apps with poor functionalities and not inspired designs from which they got well-deserved three stars. One of the reasons for this may be a large number of Norwegians who speaks English well.

Between the free application, one can find more information for pregnant women and their baby. However, these are still missing an organization based on the information flow depending on their stage in pregnancy. Some additional, essential functionalities such as monitoring of the baby are hard to find.

Applications which require payment in order to be used have more functionalities. e.g., almost all available monitoring and analyzing of pregnancy tools can be found here. Usually, they have good support for organizing the activities for the pregnant women, with intuitive design and flexible interface. Some functionalities are “hidden” or have some usability problems. For example, in “Pregnancy+”, contraction and weight monitor are located in the “other” button from the “more” button on the main page.

None of the analyzed apps provides any connections or communications facilities with healthcare organizations or direct connections to relevant groups on social media. Some of these apps (e.g. “Pregnancy+”) provide timeline events which shall happen, and actions need to be done during pregnancy period routines, but timeline looks overloaded with information. So if some part of the timeline is not clear, they do not provide information or something similar in order to give a more comprehensive explanation about this event.

Finally, one can conclude that the mParent market is just at the beginning of growth and smart apps are still missing. Some key aspect of the successful pregnancy is still ignored by the majority of developers, like Patient pathway and implicit/explicit tailoring of patient travel experience with health organizations.

3 Influences from mobile technologies

Especially in last decade, the world has witnessed a fierce battle between giants like Google, Apple, Microsoft, Blackberry and other smaller companies, often worn dishonest, that has resulted in present days in two absolute leaders; Google and Apple (TechAltar, 2017). This chapter discusses what are the best suitable mobile OS platforms, tools, and frameworks for developing ELISA, in particular for the Norwegian market. Chapter 3.1 will discuss mobile OS Market today, who are the leaders worldwide and in Norway and similarities between them. Chapter 3.2 covers new OS tendencies and how they can change today's mobile market. Chapter 3.3 discusses the main streams for cross-platform mobile deponent.

3.1 OS platforms in the mobile market - Worldwide VS Norway

In the past, mobile usage pattern was quite simple. The user started applications for data management of offline games; sometimes downloaded static web pages, or for reading emails. Now the situation has changed radically, and the device acts more like a portal to the environment, where many providers offer a massive number of services.

It is no secret for anyone that mobile devices have become more used than laptops and stationary Personal Computers (PC). The mobile operating systems (OS) hold more than 50% of the world's market. (Statcounter, 2018c). Today's mobile OS (IOS and Android) have more similar features than differences:

- Both have documented software development kits (SDKs), which allow creating applications for these OS
- Both have marked places where developers publish their applications and from where users can download them.
- All of them support similar sensor features and 3D graphics engines
- Both platforms are built on the same kernel[12]. IOS uses a derivate from UNIX and Android kernel is based on Linux, which itself is a UNIX derivate. Specifications are the same but have a different implementation.
- In both, applications interact similarly with the system (Figure 2).

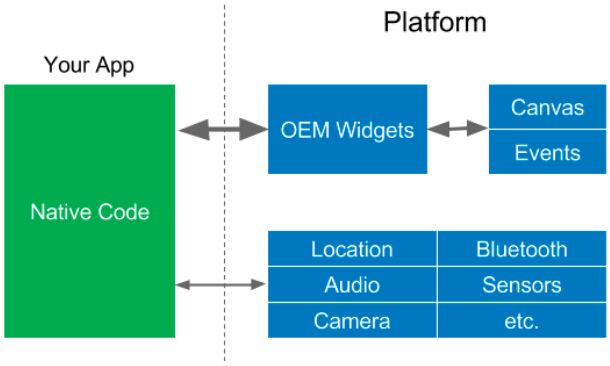


Figure 2. Native apps

(difffen, 2016)

Worldwide the most popular mobile OS by far is Android, which has 72% of the market followed by IOS with 24.4 % (Statcounter, 2018b). According to these statistics numbers,

[12] **Kernel** – "*A kernel is the core component of an operating system. Using inter-process communication and system calls, it acts as a bridge between applications and the data processing performed at the hardware level.(tehnopedia, 2011)*

one can easily conclude that the best platform for developing a prototype is Android. However, the Norwegian mobile OS market situation is entirely different. For November 2018 IOS holds nearly 60% of the market, while Android 40% (Statcounter, 2018a). For long-term analysis, it is visible that these two OS systems nearly equally share 100% of the market in Norway. To develop ELISA should be considered for both platforms.

3.2 New arising OS systems

For the robust use of apps, some new solutions with huge potential have to be presented. These have great potential to change the future of many existing apps aimed to be widely usable. Some issues from these new OS systems already influenced the development of ELISA

This dual dominance does not mean that the world does not have a place for more OS systems. And businesses rapidly head to the third category of users who cannot afford even a budget smartphone for under 100$, so-called non-touch devices. These are becoming more and more popular in African and Asian countries. Such devices run on open Kai OS system, which is based on the Linux kernel and is the successor of Firefox OS. By the end of 2018 Kai OS was the second most popular OS system in India, with 15% of the market. It is estimated that globally it would reach IOS in popularity by the end of 2019. (TechAltar, 2018)

Another new OS system called *fuchsia* started in 2016 when a code describing a new capability based system for all platforms including mobile ones appeared on GitHub. Behind this OS is Google, and the main SDK framework for app development in *fuchsia* is “Flutter” (see Chapter 3.3.4). *Fuchsia* will give a stunning integration across multiple devices, for example, music playing at home will be possible to transfer on the phone automatically, and onto the car player immediately when the person leaves the house. Also, it will be much easier for Google and partners using *fuchsia* to customize and update their systems independently, which Android struggle with today (Bird, 2017).

3.3 Mobile Cross-Platform (XPLAT) development Frameworks.

In a mobile world dominated by two OS systems, a prominent issue is to write an app to cover both platforms, especially for small and medium-sized businesses with limited resources. To solve this issue, the so-called XPLAT SDK’s become more popular. Some of them use web technologies (PWA[13], hybrid apps), others compile code into a so-called cross-compiled code and interact with a platform through bridges (see for example Xamarin, react native). Another possibility is to interact with the system directly at a low level (Flutter).

3.3.1 Progressive Web Applications (PWA)

In 2015 Google announced the creation of new technology – PWA or progressive web apps. However, only in the first semester of 2018 more companies began to look seriously into this technology, which now is becoming a popular trend(Bordescu, 2018).

[13] Progressive Web Application

PWA is a product of the joint evolution of the mobile browsers and the functionality of the native apps, like push notifications, GPS-navigation, and other native functions, which have merged. Developing a PWA application can be several times cheaper and faster than native versions, which can be beneficial for small companies. This can be beneficial for the user too; since it does not take device hardware space in the phone memory, and there is no need to download the application from app stores(Kubrak, 2018).

One of the main advantages of PWA over native apps is the absence of a middleman, e.g., Android Store or IOS Store. By eliminating this extra link for developers means that they no longer need to be guided by the established rules and policies of Apple and Google.

For installing a PWA app on the device it is enough to go to the relevant web site which has adapted their site, and the associated PWA app will be downloaded directly to the device. A native app-like icon will be installed on the phone screen after the user agrees on terms and conditions for that site.

However, even if PWA has speed near to native code, this technology is very young with many things still to be developed. Interactions with device sensors are not fully covered, features like a fingerprint, face recognition, gyroscope are issues which hopefully will be solved in the future (Kubrak, 2018) This list can continue, but my opinion is that in some years we will see a spectacular rise in popularity of this technology, and differences between PWA and Native will disappear.

3.3.2 Hybrid apps

Hybrid applications are a combination of web and native applications, unlike PWA they are mobile sites in the native wrapper such that this app can work on the mobile device and should have access to native features like sensors, intern storage so on. Such applications can be downloaded exclusively from the marketplaces of each platform (App store or Google Play). These types of applications do not work without an internet connection because a big part of their logic usually is written with the help of web technologies (HTML, JS) and needs server support. On the market today there are dozens of Hybrid frameworks, Cordova, PhoneGap, Ionic are ones most popular; all of them offer a wide range of tools and plugins to facilitate app development. (Cunha, 2018)

As we can see in Figure 3, a Hybrid app consists of an application written with HTML and JS, a WebView - which communicates directly with native platform canvas for drawing or firing events and bridge (native wrappers) - a series of plugins which ensure use of device native features. Everything that is seen on the screen is depending on WebView, but it does not use OEM Widgets (original UI

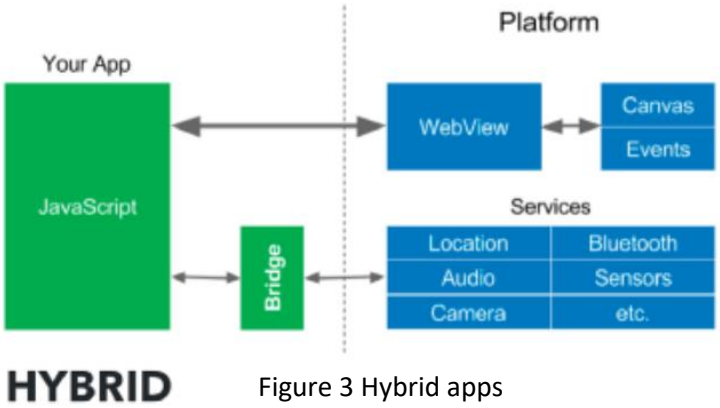


Figure 3 Hybrid apps

elements offered by each OS) of the platform, but instead, it takes an HTML element and paints it with WebView. This is the main reason why Hybrid apps can be used on across multiple platforms. Bridges are written partially in native code and partially in javascript. Because of such approach Hybrid app are much slower than native ones, and usually, they offer a poor UI Architecture (Cunha, 2018).

This framework is worth to be considered for a company with limited resources and needing a simple application with fewer, lighter transitions and loads. However, the development process for such applications is quite complex and require advanced knowledge of the programming language in which the app is developed.

3.3.3 Web Native and Cross Compiled

These technologies are relatively new. Both are similar in their overall architecture, by the code of the application is written in non-native code (in JS or C#) and through a bridge communicates with OEM Widgets (unlike previously discussed framework) and platform native features. Most popular frameworks in this category are React Native and Xamarin (for more see Chapter 6.2.2). As we can see in Figure 4, there is no WebView intermediator for the UI layer. The entire job is done through an interpreter (bridge) which communicates with the native features of the phone. Non-native code cannot be understood directly by Android or IOS platform, and it is shipped with an engine (v8 in case of React Native and Mono in case of Xamarin) which runs all commands, actions, events and through bridge, trigger events, call Original Equipped Manufacturer (OEM) Widgets which are drawn on the screen, or it performs other actions. Non-native code for both platforms runs fast, close

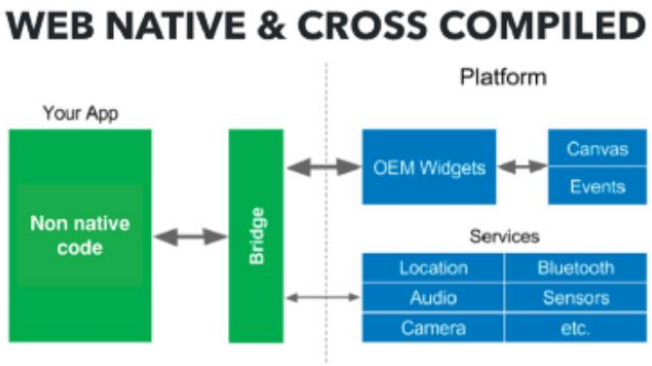


Figure 4 React Native and Xamarin

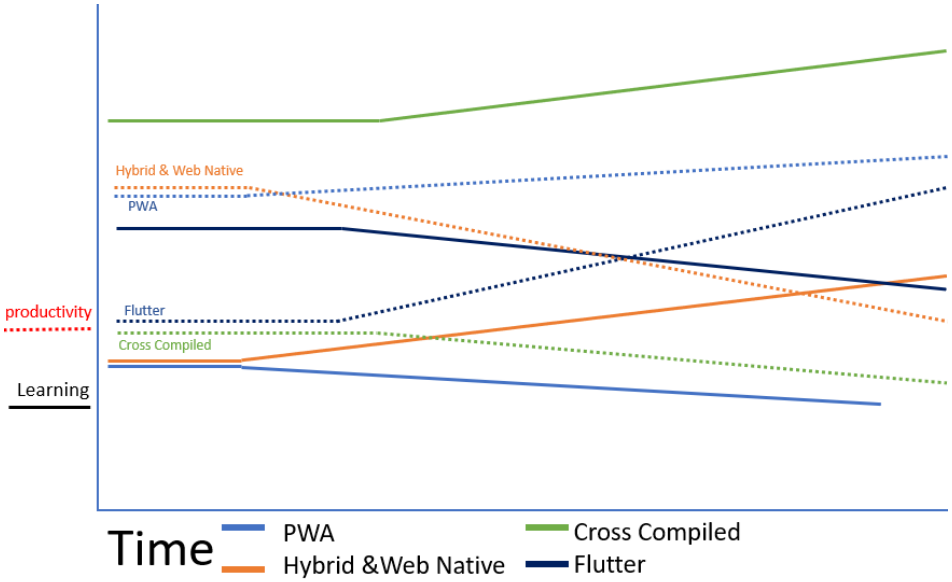


Figure 5 Learning and Productivity curves

to native speed, but a bottleneck in this architecture is the bridge which often can slow down application up to 5 or 10 times depending on performed action. Such a transition platform usually render on screen with the frequency up to 60 frames per second, thus using these technologies is not recommended to perform many transitions or have massive visual effects (Cunha, 2018).

Another parameter which may be taken into consideration is the initial learning curve (Figure 5) which are relatively low in case of React Native and high for Xamarin. For example, to write a hello world application in React Native is quite simple and straightforward but things become more and more complicated when is required to do more advanced features in the application and slows down productivity curve. To use Xamarin is required a high level of C# knowledge, a good understanding of the platform. (Schwarzmüller, 2018)

3.3.4 Flutter

At the Mobile World Congress in 2018, Google officially announced the launch of a beta version of the framework called *Flutter* for creating mobile interfaces (in December 2018 Flutter reached 1.0 stable version). (Flutter.io, 2018a) From the beginning, it must be mentioned that Flutter, unlike other discussed platforms, does not use popular languages like JS or C#, but an entirely new one - the **Dart** language. Dart was used some years internally in Google and was developed before the Flutter project started, with the purpose to replace JS. Later it was adopted for the Flutter framework. Dart will be a familiar language for web developers as well as for those who are knowing Java (Flutter.io, 2018a).

What is unique about Dart is that it can be JIT[14] and AOT compiled. In other words, Flutter provides the function of separate compilation of files in development and production modes. Instead of an AOT[15] for the finished product, the JIT compiler allows increasing the

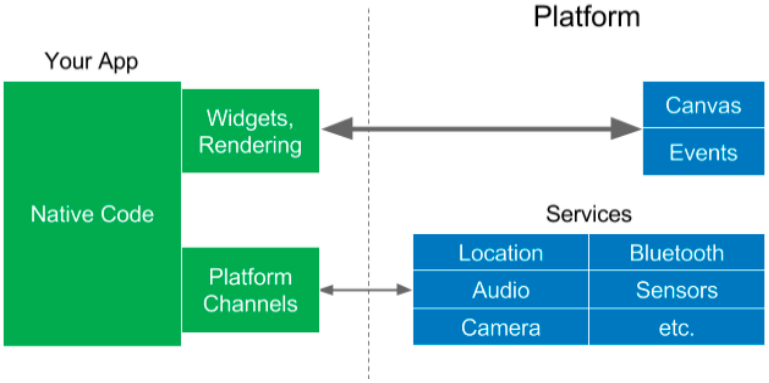


Figure 6 Flutter

[14] **JIT compilation** – "(**J**ust-**I**n-**T**ime compiler) A compiler that converts program source code into native machine code just before the program is run. In the case of Java, a JIT compiler converts Java's intermediate language (bytecode) into native machine code as needed. It tries to predict which instructions will be executed next so that it can compile the code in advance. Compiled code resides in memory until the application is closed." (pcmag, 2011)

[15] **AOT compilation** – "In computer science, **ahead-of-time (AOT) compilation** is the act of compiling a higher-level programming language such as C or C++, or an intermediate representation such as Java bytecode or .NET Framework Common Intermediate Language (CIL) code, into a native (system-dependent) machine code so that the resulting binary file can execute natively. (Wikipedia, 2018)

speed of creating and debugging programs. Moreover, Flutter has a high level of compatibility with third-party libraries including native ones (through platform channels).

The UI framework of Flutter seems to deviate slightly from the traditional representations in all other frameworks. UI is written directly in code and not using a markup language which traditionally is used. Such an approach immediately minimizes the code and makes interaction easy between background application logic and UI part (Flutter.io, 2018c). Flutter does not compile directly into IOS and Android applications; it runs on a rendering engine written partially in C++ and partially in the dart. Files are hooked up to each application, and SDK assembles compile the program for a specific platform.

This approach is called video game application development. Just as game applications ignore nearly entire high-level framework components and shift their primary work on its low-level engine, applications on the Flutter framework replace all possible parts of the native platform with flutter parts (Figure 6) (Flutter.io, 2018c). Such an approach also has downsides; the compactness of the application suffers. For example, a basic application "weight" is around 4.06 MB (the similar Android app is about 500 kb and Xamarin about 35 MB) where the most significant part is taken by the core engine (about 2.7 MB) (Flutter.io, 2018a). However, the Flutter app works quickly near native speed.(Schwarzmüller, 2018).

Cross-platform development in case of Flutter does not mean a degradation in the quality of software products, like experience in other XPLAT frameworks. The framework provides all native widgets of the Android (material design) and IOS (Cupertino widgets) interfaces and can change the behavior of individual elements so that programs are maximum similar with native behavior of apps (Flutter.io, 2018c). Applications written in Flutter are **pixel-perfect**. This means that they look the same on both platforms; this can be considered as plus and minus at the same time. If the task is to make an application maximally close to native ones, the developer must specify imperatively in the code how the app will look like on each platform. Otherwise the UI will be the same on both platforms.

In flutter every UI element is a widget; they are instances of the classes which inherits from abstract widget class. Widgets allow to draw text, images, position elements, execute animation or doing any kind of visual effects. Flutter has two types of widgets - **stateful** and **stateless** widgets. The difference between them is that stateful widget allows keeping the state of the page (for instance sum result from two numbers or last visualized element on the list etc.) while stateless does not. As a consequence, the framework prioritizes **composition** over inheritance. In Flutter new customized widgets can be created by combining other widgets together in a chain of nested elements, allowing developers to use their creativity and combine widgets in a way that the developers who created Flutter did not anticipate.

4 Methodology

This chapter addresses some methodological issues taken into consideration in this thesis. The idea, to construct an app supporting future (or current) parents to plan their activities, by involving communication with HC organizations, come from own problems the author met during the same process. Much of the inspiration for design and development and considering existing literature and practical background came from the design science methodology (Hevner et al., 2004).

Usually, a design science methodology suits research informing multiple audiences and creating an artifact. The results of this thesis aim to produce a prototype for a mobile app and inform end-users, professionals from HC and engineering, but also researchers about new possibilities. End-users can be informed by a process description and information about the usability of the prototype. HC professionals can learn about handling supportive apps for patients being under a long time in the HC network. Health technology developers can be inspired by choosing and using specific technologies for creating such an app. Research can be informed by using PP (or CP) that involves several stakeholders and need to consider communication between these, and how it can be supported by mobile apps. Accordingly, this work aims to produce an artifact and inform multiple audiences, not only future/new parents.

This study was organized via multiple iterations, which periodically was run in parallel. This made it possible to develop interdependent prototypes, test these and improve them based on the input from one or more stakeholders.

This work started with examining literature and practices about current applications based on the narratives described by patients. Based on the existing international and Norwegian documents, a PP diagram was designed (see Figure 23), to illustrate each step in the pregnancy process and how these can be supported by guidance from HC institutions. Mapping the communication activities (suggestions and possibilities) from official documents, a first semi-structured interview was made with an experienced midwife, with 25 years of experiences in her profession. This interview lasted 2 hours and discussed the PP process and important communication moments based on the PP diagram. It was a semi-structured interview (see Appendix 14) with only a few given questions from the beginning but discussing thoroughly the moments when patient-HC professional communication, or HC professional – HC professional communication about the patients is essential.

Based on results from the interview and documents suggested a first prototype, with six basic functionalities, was designed. At the same time, other possible mobile applications supporting future parents, and these functionalities and usefulness were investigated. The aim was to define the most basic functionalities.

Shortly after, an interview with one UI experts was performed, with a design professional. The interviews were focused on design elements on the screen, colors, and buttons, how

large some letters are, etc. It lasted approximately 45 minutes (for questions see Appendix 15). This interview resulted in a new UI prototype with 9 main functionalities.

After this, a group interview was performed with 5 mothers (and future mothers) and their experiences during pregnancy and right after. This interview was semi-structured as well (for questions see Appendix 16) and lasted approximately 90 minutes. The interviewees have described experiences regarding communication with HC, but also missing and possible functionalities for such a mobile app. These women were friends with the same background, between 20 and 30 years old. The structured parted of the interview separated questions about communication with HC professionals, the family and eventually other friends.

This interview was followed by another interview with a GP. The interview was semi-structured and discussed patient GP communication. The GP was working at a hospital and had several years' experiences in helping women to give birth. This interview was followed by a literature study when some issues suggested by the mothers, was investigated in the literature. These activities resulted in a publication, when the idea and the role of having a functional prototype early in the process were discussed (Heldal et al., 2018).

Another UI researcher was interviewed (more about the meaning behind the app, the different layers in the interface and the design of certain symbols used). This also was a semi-structured interview, more like a cognitive walkthrough of the app (Wood, 1997) and lasted approx. 60 minutes. The interviewee was also a new parent, with fresh observations about communication possibilities with HC experts.

Before the development process, popular mobile OS platforms and SDK's were investigated, to find suitable requirements for ELISA. Some of these technologies were changed during the whole development process to allow to develop better prototypes due to more suitable functionalities such as scheduler and notification manager etc. (see Chapter 8.2) or to better suit requirements, such as dynamical adjustment of the functionalities according to user needs, possibility to visualize implicit/explicit PP during whole period of pregnancy as well as short terms like only events planned for 3 weeks ahead (see Chapter 7).

The development process followed *agile* software development methodology (Abrahamsson et al., 2017).

In the following, the guidelines (see Table 2) from Hevner et al. (2004) are discussed in terms of this study. This thesis contributed to designing a prototype and improving it in several iterations based on research or evaluations from stakeholders (guideline 1). To develop this mobile app was considered an important and relevant issue from all stakeholders (guideline 2). While the evaluations could be considered from more, or more representative stakeholders, in order to go further and certain compromises were made. More and different end-users involved in the process and further discussions with several

GPs and midwife having a different role remain the next step in this development (also guideline 3 was only partly followed). While several earlier studies accentuated that is enough to construct a simple prototype, this study showed the importance of a functional UI already at the beginning. It is difficult to understand the interdisciplinary problem without illustrating it more appropriately (guideline 4 was followed). To design and develop ELISA this work relied upon rigorous methods in construction and as rigorous as it was possible in the evaluation of the prototype, therefore design guideline 5 was only partly followed. The interviews were rigorously planned, but the compromises did at the design evaluation phases influence this part of the study. However, the search for a useful prototype was planned and communicated according to guideline 6 and 7.

5 Finding suitable requirements for ELISA.

This chapter aims to determine the most relevant requirements for the development of ELISA. These requirements are coming from a range of disciplines such as Reproductive care, Health Informatics as well as from General Data Protection Regulation (GDPR[16]).

Chapter 5.1 discusses National Guidelines for Pregnancy (version 2018) provided by Norwegian Directorate. Chapter 5.2 discusses the most critical binding document under the pregnancy in Norway and changes made to it in 2018. In chapter 5.3 Interview results both with patients and HC, practitioner are presented, pointing to challenges experienced during the pregnancy process form both sides. Chapter 5.4 proposes a PP based on discussion with HC expert and related specialized literature officially approved in Norway. In Chapter 5.5 discusses GDPR regulation policies. This sub-chapter has a significant impact on the way data shall be stored in the system and puts the accent on user control upon her/his own data.

5.1 New National Guidelines for Pregnancy (2018)

An essential document for guidance in Norwegian pregnancy HC is "National Guidelines for Pregnancy" (Nasjonale Retningslinjene for Svangerskapsomsorgen, NRS). This is a large document published by Norwegian Health Directorate in 2005, which touches upon major aspects of care, during pregnancy and childhood period. The document also contains recommendations from international practice. However, some adaptation to Norwegian reality is marked too (for instance routine visits to Midwife during pregnancy). During the time of writing this thesis, NRS was entirely updated again (in June 2018).

The guidelines from 2018 contain less detailed and fewer recommendations than the previous one from 2005. Another significant change is the Health Card for pregnant women (Helsekort for Gravide), for short HKG. HKG has been updated so that the headings comply with the new guidelines (see chapter 5.2). One of the biggest concerns addressed by Directorate is increased obesity in pregnancy, living habits, experiences with domestic violence from different risk categories, like women who have exposed to genital mutilation, or diabetes, etc. At the first visits especially, the women need to go through a number of routine tests.

One of the major policies of Norwegian Directorate, highlighted by the NRS document, is **knowledge-based-pregnancy. This aims to contribute to a health-promoting lifestyle and to reduce morbidity, childbirth and maternity mortality** (Helsedirektoratet, 2018). Another aim is to promote participation and co-determination, accordingly:

[16] Regulation (EU) 2016/679[1], the European Union's ('EU') new General Data Protection Regulation ('GDPR'), regulates the processing by an **individual, a company or an organization** of **personal data** relating to **individuals** in the EU.
(EC, 2016)

> «**For å oppfylle lovkravet om delaktighet og medbestemmelse er det viktig for helsepersonell i svangerskapsomsorgen å være lydhøre og ta hensyn til kvinnenes unike behov. Hensikten er å styrke autonomien og mestring av morsrollen. Tilrettelegging av tjenesten på en brukervennlig måte kan bidra til å gi gravide og partner/familie medbestemmelse. Gravide skal oppleve en samordnet tjeneste og få vite hvem som skal yte de aktuelle tjenestene i fødsels- og barselomsorgen i helseforetaket og i det lokale tilbudet i den kommunale helse- og omsorgstjenesten inkludert psykisk helsetjeneste. Når fastlege, jordmor og helsestasjon ikke er tilgjengelig, skal gravide vite hvor de kan henvende seg for svangerskapsrelaterte forhold.»**
> *(Helsedirektoratet, 2018:p.6)*

According to this new regulation, support for pregnant women is needed. They need to understand the whole process of pregnancy and the presence and roles of the involved stakeholders helping them, in a more easier way than with current existing documentation and fragmented knowledge in the different health organizations.

At the same time, the pregnant women need to understand the concerns named before, and discussed below, since these issues can be collected and presented in an app.

Pregnancy overweight

Today in Norway, obesity is one of the most critical risk factors in pregnancy. Latest statistical data says that 33% of all pregnant women in Norway are in the overweight category Body Mass Index (BMI)>30. It is crucial to now BMI already at first consultation, and if she is in a risk group, it is strongly recommended to start changing her life habits as soon as possible. If a woman has a BMI > 30 in the pregnancy, she will have 7 times increased risk of developing gestational diabetes, 9 times increased the risk of pregnancy poisoning and a higher risk of losing the baby.

The new guidelines recommend that anyone with MBI>30, with previous gestational diabetes; persons with ethnic backgrounds from Asia or Africa; persons who have diabetes in the close family; who had children whos wight is more than 4500 g at delivery, should take a long-term blood sugar test (HbA1c) before week 16. After week 16 this test is not relevant. The guidelines also recommend that all woman who falls in these factors of risk including those who have BMI>25 should take a glucose test between week 24-28. (Helsedirektoratet, 2018)

Early consultation and advice about living habits.

Most pregnant women are motivated to live healthily, and guidance on diet and physical activity in pregnancy can help reduce maternal overweight gained in pregnancy. The recommendations are based on Nordic nutrition recommendations. The primary goal is to inform and help pregnant women to abandon potential habits which are harmful to fetus and health in general (smoking, drug or alcohol consumption, etc.). The Directorate of

Health considers that the first consultation with midwife / doctor should take place no more than one week after the woman has contacted for pregnancy control.

Experiences with domestic violence.

Healthcare professionals are encouraged to ask all pregnant women about experiences with violence, both current and past experiences. Physicians / midwives should emphasize that all pregnant women are asked and that at least one consultation is given during pregnancy with only the woman present.

Women's exposed to genital mutilation.

It is recommended that a GP or midwife to identify women who may have been exposed to genital mutilation. The risk of complications increases the more extensive intervention the woman has been exposed to.

Routine tests.

It is essential to do routine tests especially at the first pregnancy check such as blood percentage (Hgb), urine stripping for glucose and protein, blood type and Rhesus-D typing, syphilis and HIV. In addition to these, it is now recommended that all pregnant women in the first trimester be offered routine urine cultivation, regardless of risk factors, to detect asymptomatic bacteriuria, measurement of serum ferritin to assess iron status and testing of hepatitis B antibodies. The Health Directorate recommends iron supplements from week 18 to 20 and pregnancy if serum ferritin is below 70 mg / L measured in the first trimester.

Diabetes and gestational diabetes.

The recommendations in the Guidelines for Gestational Diabetes are continued with the focus on identifying on undetected diabetes, early hyperglycemia, the risk of gestational diabetes and gestational diabetes. These are women at increased risk of complications in pregnancy.

Risky Pregnancy.

It is recommended that a GP or midwife at first pregnancy check out any risk factors and conditions that may affect pregnancy. In some states, specific recommendations for referral to the second line service are provided. Generally, healthcare professionals are encouraged to individually assess the need for more controls or referral to a specialist for women which is supposed to conditions that may affect pregnancy, birth or maternity leave. Also, after the age of 32, it is recommended to do additional tests such as chromosomal test because patients present higher risks to have a fetus with chromosomal abnormalities.

Knowledge-based-pregnancy.

Every pregnant woman should be well informed about each aspect of the pathway through which she needs to pass and make informed decisions for a successful outcome. It is the Health personnel´s responsibility to hear and see the uniqueness of the needs of

each woman. The document goes further to point about the necessity for a qualified translator for women who have weak Norwegian understanding, to ensure that they understand the importance and all knowledge provided by HC experts.

5.2 Health Card for pregnant women

According to Norwegian Health Directorate, the Health Card for Pregnancy (HKG) is the most important document which is a link between patient, GP, Midwife, and HC-institution. This document guarantees that all HC practitioners get the same information about the health situation of the patient. It is in the patients right to choose which information she wants to provide. The main idea behind HKG is to ensure that pregnant women receive proper treatment.

This document is emitted at first visit to the GP or Midwife and is filled out by both Doctor and patient; the patient should take care of it. At all visits with HC-institution, she should bring HKG with her.

All data registered on the Health Card have importance to pregnancy and birth (Figure 20). The Health Card consists of a series of rubrics of different aspects of data like Information about **Mother and father/mother**. This includes address, relationship status, education, profession, workplace, country of origin, language, and information about GP and midwife. If women are not married to the biological father of the child, there is a need to be completed paternity certificate.

Next rubric holds data about **earlier history** like all previous pregnancies, births, spontaneous abortion. May also be relevant about near family births because this may be genetically conditioned.

Use of medicines is registered in HKG both type prescription-free and prescription-coated should be mentioned. Eventual drug allergy should be registered as well.

A rubric which plays a unique role is the patients **living habits.** Its records information like patient diet and supplements, physical activity, working conditions, use of tobacco, alcohol, narcotics. It is essential to register the number of cigarettes smoked per day because it helps to determine how high is the level of risk for patient's health as well as for fetus health.

HKG also registers the **term** of the patient's pregnancy, it is initially calculated based on the patient´s last menstruation and later corrected at ultrasound visit in week 18-20.

During the pregnancy, it is needed to take different **routine examinations and tests**. These steps are particularly essential to register due to the fact that it helps to monitor the evolution of the gestation and eventually intervenes before eventual deviations could have health consequences for both fetus and mother.

5.3 Facing challenges.

Findings presented in this chapter are a synthesis of international practice from the literature survey, and from the recommendations from Norwegian health organization

through “National faglig retningslinje for svangerskapsomsorgen” 2005-2018, Norwegian gynecological organization through portal legeforeningen.no, and Interview with Midwife and GP.

5.3.1 From a professional perspective.

In accordance with international practice and recommendation from the Norwegian Health Organization, it has been identified that a healthy pregnancy is recommended to have no more than 8 meetings on average, with GP or Midwife (Backe, 2002). This recommendation is not known or followed in practice, which results in an administrative and financial burden for health authorities (Helsedirektoratet, 2018).

During the interviews with HC staff, we discovered that professionals have too few digital options for communication with patients. The most used digital communication is phone calls, SMS, and also often used is paper-based letters. The HC professionals collect information relevant for treatment and information in a paper-based report. This is afterward translated into the Journal system. Such workflow is proved to be ineffective and time-consuming, having higher risk probability for introducing erroneous data about the patient in the system.

The midwife specified that, when they are visiting patients at home, they use a portable pc. Data are introduced but are stored locally. Much work needs to be done again when the stored data has to be manually inserted in a Patient journal. This approach is not much better than the first one, due to double work.

A crucial factor for best outcomes in pregnancy, in particular, and patient healing, in general, is patient co-participation. This requires patients to have valuable knowledge about their situation and future options for treatment. Patients have a legal right to have 8 visits to the GP or Midwife. However, these are not always enough to provide such a large amount of information, and thus patients have little knowledge or misleading information about this period.

HC institutions require a large amount of information from the patient, which often are collected in the form of Schemas. This is also true for collecting data from pregnant patients. Under the whole period of pregnancy and after delivery a woman needs to complete several schemas. These schemas contain substantial variety questions like living habits, life situation, mental and physical state, etc. For successful development of ELISA, it is essential to have knowledge about what kind of schemas HC institutions use for data collection from a pregnant patient. Also, one of the main functionalities for ELISA is to have the opportunity to receive and complete these schemas coming from all HC actors involved in antenatal care.

During literature research, I not found relevant information about types and categories of the schema used in HC. Thus, from the interview results, we identified 5 categories of schema types; **Simple Schema, Continuous Schema, Periodical Schema, Progressive Schema,** and **Anonymous Schema.** Critical criteria for differentiating

schemas were the nature (e.g., personal information, physical and mental abilities, drug consumption, etc.) and periodicity of these schemas. There are also schemas which can fall in multiple categories, like HKG (can be treated as continuous, periodical and progressive). Such type (the sixth category) I call **hybrid schema,** which also can be different depending on category combination.

Next, is explained the content of each schema category, as this influenced the development of the HS-designer[17] and HS-viewer (see Chapter 6.1):

Simple Schema – This category contains schemas which require one-time completion. Schema like an application or personal information falls into this category. They require one time to be completed, and data provided in these schemas are rarely changed.

Continuous schema – This category contains schemas which need to be completed over a more extended period with supplementary data every day or several times a day. They are used for example to monitor health habit changes or "short period" observation about all kinds of changes in reaction or psychological state of the patient.

Periodical Schema – This category contains schemas which need to be repeatedly completed after some periods. These schemas are used to collect information about the patient and future changes over more extended periods of time like weeks or months.

Progressive Schema - This type of schema is like a continuous one, the difference is that patient answers different questions and period of answers can vary from multiple times in one day to one time in a week. Main particularity is that these schemas have a small number of questions (maximum 10 questions) and often every time is different (or coming with additional questions).

Anonymous Schema – The name of this category is suggestive and clearly explains what type of information is collected. These schemas are often used by institutions to find out which services were given to patients, or for some category of patients where there is a higher probability of getting honest answers (like drug addicted category). Information from these schemas has research values for larger groups of individuals rather than for particular individual treatment. Anonymous schemas have also a second type, namely those who are targeting larger masses of peoples regardless of their category particularities. This type usually does not require an invitation and life period they are extended. Another type concerns mainly groups of persons having common social or activity background (50 women who gave birth in Kvinnekliniken Bergen, in December,

[17] HS-designer and HS-viewer also known as schema designer and schema viewer is a concept initiated by Avans AS. This supposed to give access to create and modify schemas (questionnaires) which HC expert uses under patient treatment. They gave me possibility to consolidate concept and develop a functional tool which according to findings from my research will satisfy creation of all types of schemas which HC experts uses without compromises.

for instance). These schemas are usually sent with an invitation and invitation code to participate.

5.3.2 From a patient perspective.

In Norway in 2016, 27% of babies are born by women who have not Norwegian citizenship (Tiller, 2017). Thus, for analyzing collected data, it is taken into consideration two big groups of patients; one with a Norwegian background, the second one with the foreign background.

Another parameter to be taken into consideration is the woman´s age, mothers who got their first child before age of 32, and after. In Norway, according to Norwegian Statistic Office average mother at first child was 29 years, for 2016. The last ten years it has been observed a tendency that mothers become older; this fact is associated with more health risks for child and mother (SSB, 2018).

During the group-interview with the 5 interviewees, we identified a series of challenges the patients faced. Six categories of problems were identified; these problems can be divided into "***Critical***," "***Important***" and "***Desired***":

1. Critical:
    - Information about decisions required to be taken by mothers during pregnancy regarding delivery.
2. Important:
    - Routine timeline activity.
    - Drug administration and evidence.
    - Information regarded to patients' rights.
    - Communication facility with HC organizations.
3. Desired:
    - Communication facility with other mothers in the same situations.

Information regarding decisions a mother must take during the care pathway

This type of challenges belongs to **"*Critical*"** group of categories due to severe consequences in some cases, which can last for a more extended period.

Most of the patients reported that during the meetings with health representatives they were not offered information about the possible decisions they must make regarding their pregnancy or birth. For example, some patients did not get enough information about Epidural (anesthesia administered in the vertebral column of the patient) before birth, in order to make an informed decision regarded usage of it. Another example is missing information about birth options such as provoked delivery or cesarean section. Since such cases are not unique, pregnant women need more appropriate information about such procedures and treatments and their own options. (Sandvik, 2011)

In Norway, the clinicians decide if it is appropriate to operate a cesarean section for each case. But according to the law, it may be taken into consideration the desire of the patient on available cure options. As Norwegian Medical Associations suggest: a correctly informed patient can lead to simpler solutions which can help for a better outcome for both patients and medical staff (Meisingset, 2009).

Routine timeline activity

Patients were asked if they know how many regular planned visits are required to GP/ Midwife. All of them gave the wrong answer. On average patients thought, there were 12 meetings they have the right to appoint during their pregnancy period. Similar results have been found in research done in Norway in the year 2000. A survey was done with 1780 women for 14 days in 5 most prominent cities of Norway (Backe, 2002) According to International practice and Guideline for Pregnancy care from 1984; it is recommended having fewer controls for a healthy pregnancy. It is recommended no more than ten visits at first-time pregnancy and no more than seven visits at multiple-birth (BCPHP, 2010). This recommendation is not followed in practice, which leads to more administrative burden in the HC system.

Drug administration and evidence

Patients revealed that they sometimes had misunderstood how to use and in which combination to use different types of medication during pregnancy. For example, some medication is recommended to use three times during the day, but it is not clear from prescription if it should be 24 hours time calculation or only daytime calculation. They were unsure about answers to questions: Is it relevant if medication is taken before a meal or not? In which combination (with other medication or maybe some specific diet) it should not be taken? What contraindications does the medication have, etc. In order to address this issue, the mamamedisin.no portal was created, but none of the interviewed knew about the existence of such a portal. Some patients said that they have trouble remembering to take regularly required medication, which is an issue that can affect the effectivity of prescribed treatment.

None of the apps discussed in Chapter 2.4 provide information about drugs and potentially bad habits that can affect the baby. Such knowledge is one of the crucial aspects of a successful outcome, as it is discussed at the first visit to the doctor. None of the apps have reminders about where a user can introduce data about medication the patients should take. According to the interview results with pregnant patients, 60 % of the patients have forgotten to take their recommended supplements or didn't take it regularly (4 of the interviewed mothers had at least once forgotten to take medication).

Information regarded to patients' rights

Not all patients were informed about their rights and in which areas they can influence the decision-making process. For example, right for abortion or choosing whom to visit of GP or Midwife, to decide upon which medication they will administrate and not, etc.

Communication facility with HC organizations

The main communication channel with HC organization is phone or post. The patient reports that often they wait a long time at the phone until they get in contact with HC organization. Information about tests/health examinations results is sent by post only if they abnormal and cure is needed. One of the patients reported a situation when her GP was temporarily unavailable for one year, while the last test results were sent only to him. To read them, it was necessary to go to the Health station, to pick printed results and to show them to another Expert.

To define and implement interactive communication channels between health and patients was identified as a “highly prioritized requirement.”. This will cover the communication gap and will bring economic and time-saving benefits for both HC institutions and patients.

Communication facility with other mothers in the same situations

Many patients have shown a desire for a specific communication channel in the form of social media, where mothers with similar situations can “meet” online and discuss or support each other on similar health/life situations. Such channels already exist, but they primarily are open forums which make communication more non-personally, and such channels are not secure enough. Thus, pregnant women want a specific communication channel which will provide synchronous/ asynchronous communication facilities.

5.4 Identifying Patient Pathway during pregnancy.

All pregnant women’s in Norway have right for antenatal care. They have the opportunity to choose visits to GP or Midwife, or they can choose both. (helseNorge, 2018)

According to international practice at the healthy pregnancy is recommended on average eight visits. More at first-time pregnancy (no more than ten visits) and less at multi-time pregnancy (7 visits). (BCPHP, 2010)

In Norway Health organization giving antenatal care follows international practice and recommendations. The first trimester of pregnancy routine visits shall be no more than once in a month and after every 14 days. All routine controls are optional, with different levels of recommendations: “**strongly recommended**,” “**recommended**” (interview). Is strongly recommended that women who are planning to get pregnant, shall start to use B9 vitamin 0.4 mg daily. (Bjørn Backe et al., 2014) First pregnancy control shall be between weeks 8-12 of pregnancy. Between weeks 17-19 is strongly recommended to take an ultrasound check. Usually, an appointment for this control is made at GP or Midwife. Ultrasound control takes place at Women clinic. (Helsedirektoratet, 2005)

By the recommendation given by health directorate of Norway, Norwegian gynecology association and confirmation form interview with Midwife with experience in the domain more than 20 years, were compiled following table on recommended control intervals in a fresh pregnancy (see Table 1)

Table 1. Type of checks, gestation and the corresponding recommendations

Type of check	**Gestation**	**Level of recommendation.**
First check	8-12	S. recommended
Routine Ultrasound	17-19	S. recommended
Further checks	24	recommended
	28	One of them is strongly recommended
	32	
	36	
	38	One is S. Recommended
	40	
Overtime controls	After 40	S. Recommended

As can be seen in the table presented below, controls at the week (28, 32, 36) and (38, 40) are strongly recommended (at least one form each group). If delivery not happened until week 40, women will be invited to overtime controls at women clinic (Kvine Kliniken). If birth does not happen until week 42, then birth will be provoked artificially. There are a few variations on how delivery may be initiated, and there is not an ideally recommended option. Thus, in each case, the doctor decide which approach is better to take. There is a requirement, to inform the patient about existing options and what they consist of, but patients seldom are aware of these. (Helsedirektoratet, 2018)

By the recommendation form, the tutorial given by the European Pathway association in 2016 Oslo and data presented in this chapter, a Patient Pathway (PP) was created. PP was built with the help of an online version of **UML diagram Editor** called *cacoo* available at cacoo.com. The primary purpose of designed PP is to show control checkpoints at an abstract level, but at the same time to make accessible to visualize through which control points every pregnant woman have to pass (Figure 23).

As can be seen in the proposed PP there are eight controls until week 40 and after that can be two more control if baby not was born yet. With orange dots are represented decisional points which shall decide patient. The patient can decide to choose visits between GP or midwife, or she can visit both. Practitioners shall prepare the patient for birth and for coming period after, especially noteworthy is the psychological part of preparation at first birth; because birth implies enormous changes in women's psychology and body. (Helsedirektoratet, 2018)

According to the Norwegian health organization, women to a large extent are satisfied and meet respect, but they are less satisfied with the overall information provided form

professionals. (Helsedirektoratet, 2005) Same evolution of thoughts was found at a group interview with pregnant women done in Bergen, in November 2017. The patients showed a desire to be more informed about their options to give birth. For example, how a patient can choose to give birth, which pain killer medication to use or not to use. The professionals should have in their duty to provide enough information about these issues.

5.5 Communication platform & GDPR

Due to necessity in communication between patients and HC institutions, there is a need for developing a new communication platform which will connect ELISA and handle the Patient journals. This must allow communication in a secure, predictable way for patients and according to privacy principles grounded in data protection regulation (GDPR).

Because of excessive, unreasonable and unethical consumption of personal data by companies, the EU voted “data protection regulation” law, also known as GDPR, in 2016, enforced in Europe and Norway in 2018. This law affects equally all organizations and institutions, including health services also, which in any way consume, use or process personal data. This means that in any kind of application, and especially mHealth apps, all functionalities should be based on GDPR principles.

With enforcement of GDPR patients have got rights for **consent, access personal information, to be forgotten, to transfer data, to be informed, to correct information, to restrict data processing, to be notified.** (UE, 2016)

Regulation regarding patient rights played a central role in the development of this application. Thus, next, we will enumerate some of the personal rights and the Institution's bounds required in the development of the ELISA.

Consent - Companies cannot process personal information unless a specific, informed consent for each action (collection, storage, processing of data, etc.) has been given.

Access personal information - The regulation allows persons to claim access to their personal information and to know how information is used by Institutions after its collection.

To be forgotten – If customers stop their relationship with the company or if they recall the previously given consent, they have the right to have information regarded to them to be deleted.

To be informed - This covers all types of collections of personal data by companies, and persons must be informed before collecting information.

To restrict information processing - Persons may request that their information shall not be used in data processing. The information can still be stored, but it should not be used.

6 Platform and Technology for developing ELISA

This chapter investigates possible solutions for RQ4 - Which are the most suitable technologies for supporting pregnancy apps? However, to cover all aspects of the technological requirements adequately, and to meet application requirements discussed earlier in this chapter and chapter 5, four additional questions need to be answered:

a) Does this technology Support flexible (highly adjustable) UI's?
b) How does this technology support cross-platform applications?
c) Does this technology allow UI composition?
d) How will this technology ensure inter-network communication?

Chapter 6.1 touches the main platform requirements and reasons why one needs a communication platform in order to achieve integration with EPR as well as requirements for this platform. Chapter 6.2 investigates possible technologies and frameworks which are able to implement ELISA in order to meet platform requirements.

6.1 Platform's functional requirements

The main reason why a communication platform is needed in order to ensure communication between HC institution and patients is the fact that these two have access to different virtual worlds which are not connected. The first one is connected to Helsenett – a specific Norwegian network used for HC personnel - and the last one has access to the web only.

To connect these two digital worlds cooperation between HVL and AVANS AS was conducted. AVANS AS had a portal called "*cari*", which was a Schema based system which connects Helsenett and web (for more see in Chapter 2.3.3). This system was developed some years ago, before the GDPR era and was not intended to fulfill the strong data regulations requirements.

ELISA requires that platform should sustain half-duplex[18] and full-duplex communication like video-audio calls, chatting, emergency notifications, multimedia content, and more, things which *cari* neither was capable of offering. Thus, further development of the solution was proposed.

A new solution called *Ad Voca* needs to be entirely agnostic and to act as a platform, allowing to connect all types of web clients (Including ELISA) which meets security requirements. As well from Helsenett side *Ad Voca* shall provide a series of API which will give an open solution to connect any kind of journal system, regardless of the vendor, meeting security requirements.

[18] Duplex communication - A duplex communication system is a point-to-point system composed of two or more connected parties or devices that can communicate with one another in both directions.
In a full-duplex system, both parties can communicate with each other simultaneously.
In a half-duplex system, both parties can communicate with each other, but not simultaneously

The essential data collection method used by HC institutions is Schema. During pregnancy, a woman needs to complete several paper-based schemas, and even the most critical document (HKG) is a paper-based schema too. To facilitate this form of communication between Health institutions and patients, AVANS created an HS-designer and HS-viewer concept which was further developed according to findings on schemas done in the present work (see Chapter 5.3.1). HS-designer is a designer tool that allows creating Schema which HC institutions can send to patients. HS-Viewer, on the other hand, is a tool that allows one to visualize and complete these Schemas on clients (like ELISA) used by patients.

Ad Voca shall interact with ELISA and other health-related apps. To achieve this, HS-Viewer requires to be modified for portability, such that the same tool will be able easily to integrate with any application communicating with *Ad Voca*.

Interviews with HC professionals discovered that HC institutions need several types of Schema defined and categorized in Chapter 5.3.1. Thus, it was required to add more capabilities to HS-Viewer and HS-Designer (HS tools) which initially had only a basic set of capabilities, satisfying some part of Simple Schema type. Such capabilities like grouping questions by categories (identification data, life situation, civil status, previous pregnancies), Continuous Schema fulfilment (here is included HKG), schema caching, “right of withdrawal”, decomposition of complex schemas (those who have more than 100 questions) was just some of the required ones, dictating further development of HS tools. (For more about this, see Chapter 7.2)

The main idea behind schema steering was adopted from the *cari* portal, based on a series of statuses (see Chapter 2.3.4). To satisfy the growing complexity of schema variations in *Ad Voca*, these were modified to **five** statuses and **two** states. Status is a specifier which tells the system in which phase the schema is, the state is a combination of statuses. When a schema is issued, it gets the status **awaiting_reply**. When a user starts to answer to this schema, but he does not finish yet the status changes to **in_progress,** and after the schema is fully answered the status changes to **complete**. After HC institutions request schema the status changes to **processed**. All schemas have an expiry date which is by default one month, however from Patient journal it is possible to adjust expiry time. If a schema was not answered within the validity period, it automatically gets status **expired**, and after 2 days, it will be deleted. In the development process, we found that to cover all needs in handling process it was required to add two more states, **all** includes all statuses. Is important to mention that processed schemas and expired ones are deleted from db and advoca_proxy holds only a reference to them. Second state **active** include all statuses except expired, completed, and processed, the last one is required when an HC institution wants to have an overview of the situation in schemas which were not responded yet.

Ad Voca also requires a capability which will offer easy consent handling on both sides for HC institutions and patients). This needs to ensure that even after data is consumed

(Schema is completed, or a health-related multimedia content was already sent) and consent was given, the patient has easy access to that consent for all validity period of that consent to withdraw it, if he wants so and HC processor immediately need to be informed to act accordingly.

Moreover, last but not least Ad Voca should be built on security by design and security by default principles. The first principle states that application must be designed secure from its foundation, from planning phases. The second one means that application should be enabled “by default” the highest security level (King et al., 2001)

6.2 Choosing a development environment.

For successful development, one should understand that ELISA is more than a simple mobile application; it is a system composed of multiple applications communicating with each other. Each piece of the system is developed with different technologies most suitable for their part of the responsibility. The following subchapters will have focus on Frameworks and tools used for the development of ELISA and communication platform *Ad Voca* needed to connect HC-practitioners with patients.

6.2.1 UI designer tools.

For the sake of the successful advancement of this thesis, it was crucial to have a mocked visualization of ELISA’s UI early in the interview iterations phase. This objective was achieved with the help of designer tools.

For the creation of icons, custom background images, color adjustment/modification of existing images, customization of shapes Photoshop was used. Also, for differentiation of UI elements and adapting them to different phone screen sizes, two sizes (small and medium-sized) versions of each image and icon were created.

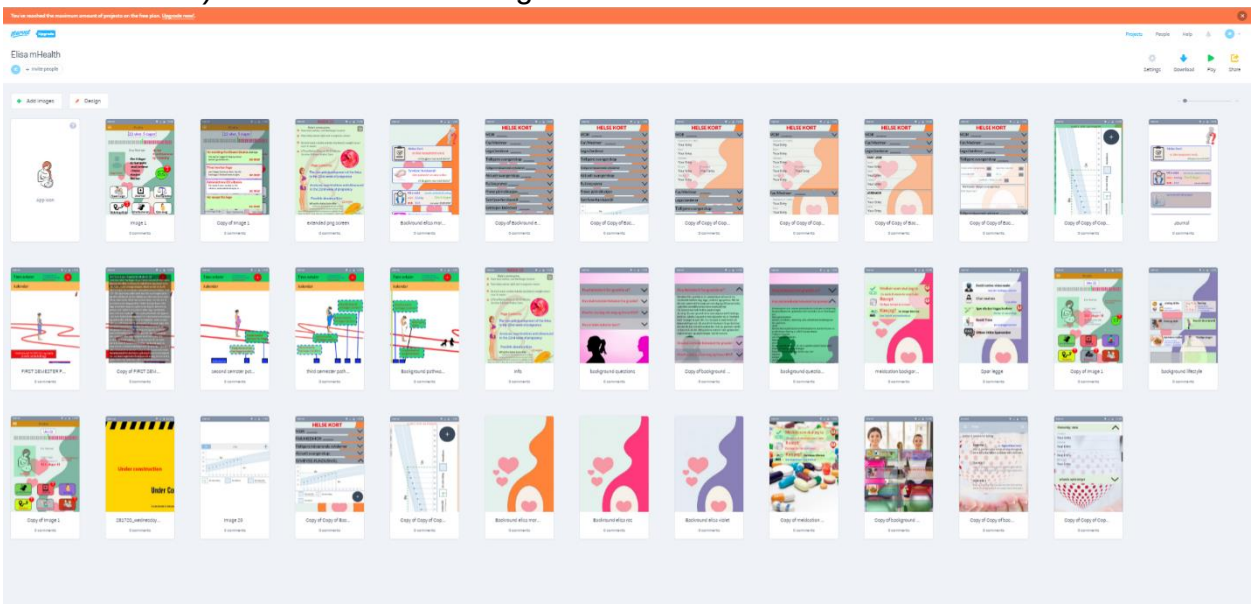


Figure 7: Marvelapp dashboard.

For the mocked UI to behave as a real app, firstly we used a prototyping tool called marvel app (www.marvelapp.com). This is a web-based tool to rapidly prototype mobile apps and visualize newly created frames directly on the web. A screenshot of MarvelApp is shown in Figure 7.

To create a prototype, (Figure 8) it is possible to make page transitions and mock click and gesture events for navigation between pages. Here it is also possible to choose the type of screen transition like fade in, fade out, ease in and so on. It allows linking UI elements of the page with other pages such that when a gesture is detected, it will navigate to another page. Is possible to add easily transition for the navigation such that it will look like a real app.

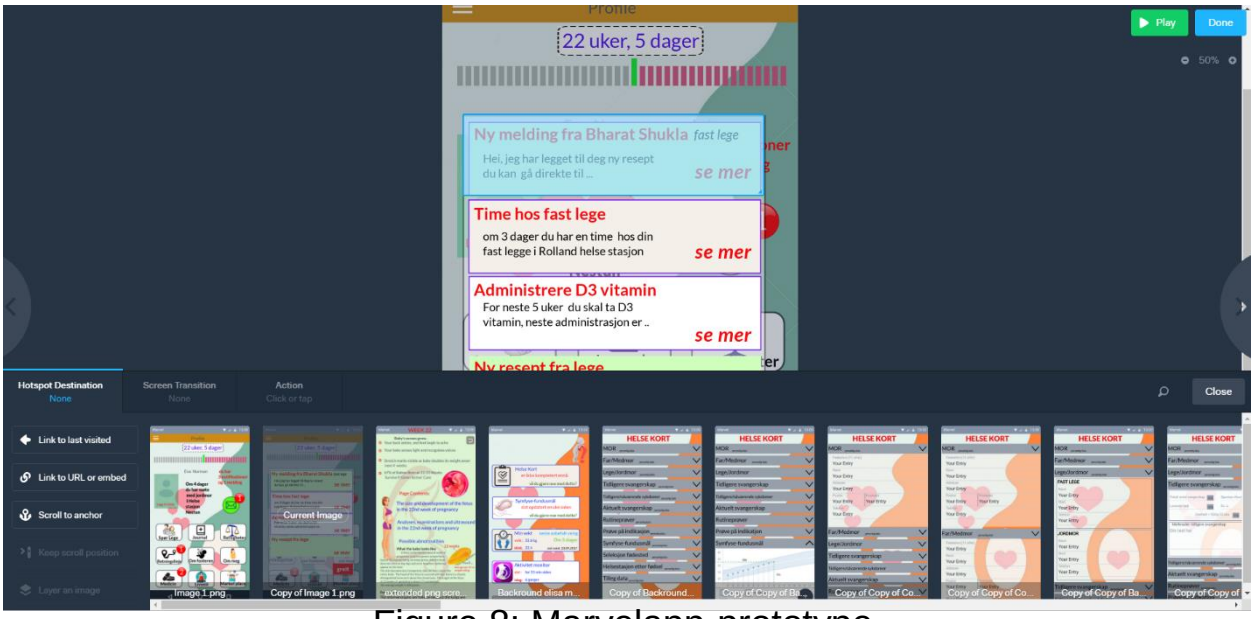


Figure 8: Marvelapp-prototype.

Marvelapp has a mobile application where one can see a prototype directly on the phone. Another plus is that this tool allows sharing the same UI across multiple devices without the need to be logged in from their web page. This feature facilitated interviews with stakeholders and other participants influenced ELISA. Marvelapp gives online “share and cooperate” functionality which allows working with multiple designers simultaneously at the same project. This is especially important for large applications.

However, Marvelapp was still under development (during the prototyping period of ELISA December-June 2017), and not all functions worked smoothly. An example can be a scaling mechanism. During the designing process, it is often necessary to scale page and scroll up, down or from right to left quickly. In the marvelapp, this process was cumbersome and sometimes even frustrating. The development process was hampered by limited or missing tooling features like the possibility to create 3d Visual effects. Some effects like transparency or color picker were not intuitive to use in the beginning.

Another missing thing was sharing common elements of functionality. In the Marvelapp it was not possible to share copies of the same element across multiple pages when needed. It was painful especially when a requirement was to change some parameters in a common element present in many places; this implied making changes for every copy of that element (Event met many times during prototyping of ELISA). The prototype was impossible to export as separate visual elements for further usage in the development process.

Due to challenges faced in the prototyping process, it was decided to migrate to another mobile designer tool called Figma. Like the Marvelapp tool it is a web-based tool which has a mobile application on IOS and Android, but unlike the previous tool, the user needs to be logged on account to visualize prototype on mobile. This was quite challenging; there is a requirement to show a prototype on mobile on multiple devices. On the other hand, Figma showed good performance for app designing and prototyping. Scaling in Figma works well, providing a pleasant working experience.

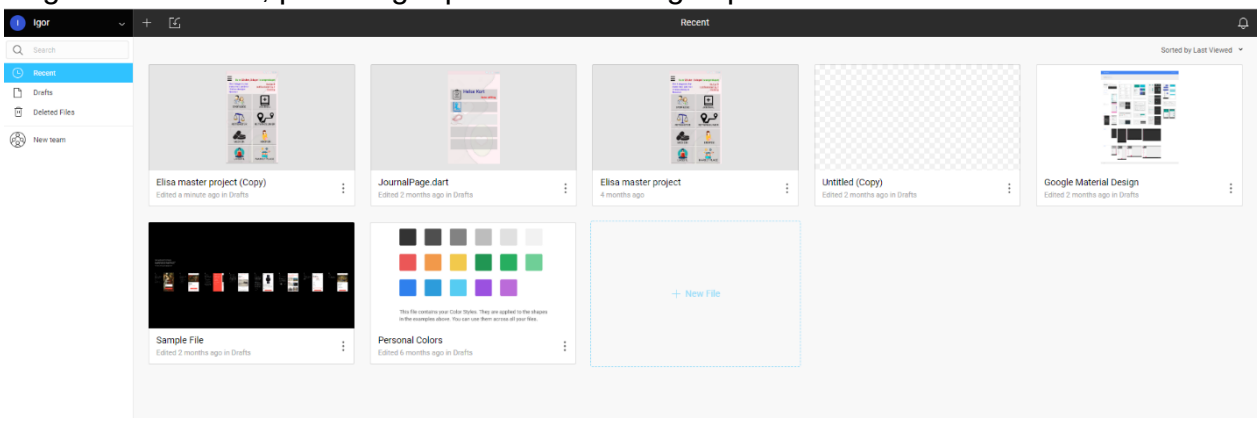


Figure 9: Figma-dashboard.

The dashboard in Figma (see Figure 9) is quite similar to MarvelApp; the difference is that one can list all projects. Figma proved to be a mature, powerful prototyping tool, offering an endless possibility in a matter of designing and prototyping applications. Even though Figma have a complex set of functionalities, its design is intuitive and easy to learn. The only missing element is a good mobile application for visualization like Marvelapp does but considering commodity and handiness of designing and prototyping process. This can be considered as a little flaw, which hopefully will be corrected in the future.

6.2.2 Mobile development frameworks and tools.

Since Android and IOS equally share nearly 100% of the Norwegian mobile market (discussed in Chapter 3.1), it is a requirement to develop ELISA with one of the mobile

XPLAT[19] SDK. Based on research on this subject and the experience from the development of ELISA we used Xamarin and Flutter successively.

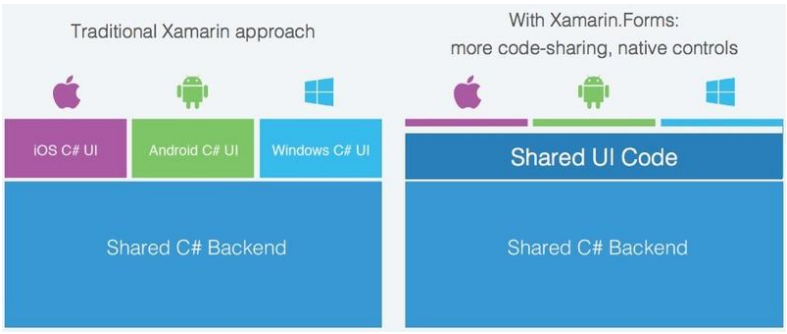


Figure 10- Xamarin.Native vs Xamarin.Forms

For the period of the research (2017), the best cross-platform framework for developing ELISA was Xamarin. Functionally, this framework represents several sub-platforms. (Figure 10) Xamarin.IOS together with Xamarin.Android (Also called Xamarin.Native) and Xamarin.Forms which is built on top of the first two mentioned above. Xamarin.Native plays a significant role – through them, apps interact directly with OEM Widgets of IOS or Android platform.

Thanks to Native platform, it is possible to create separate applications for Android and IOS at the same time, sharing backend code holding the logic. With this approach up to 60% commonly shared code can be achieved, keeping separate only UI logic and some platform-specific action like the interaction with a database or accessing phone camera, microphone and so on.

Things become more interesting with the ability to create cross-platform applications including UI part. That means that one can define a UI once, attach some logic to it once, and this one codebase will work for both Android and IOS. This is possible with the help of Xamarin.Forms. With Forms, in theory, up to 100% of the common code can be shared, but in practice, because of platform-specific features, different interaction approaches with phone sensors, the maximum can be achieved is 85% of the shared code. (Applikey_Team, 2018)

Xamarin.Forms is a good choice if the target application does not require a lot of complex graphics or multiple interactive elements, which ELISA did not require in the beginning. Also, Forms is not pixel perfect; this means that there is no guarantee that common shared UI will look exactly on both platforms; this was also not required for ELISA.

With Xamarin one can use all the power of C# and Visual Studio. It means that it is possible to find a package for every issue, which will give some solution to it. Xamarin also has a tool called Xamarin previewer; it promised to visualize UI under development in real time.

However, Xamarin was not beginner friendly, to be able to develop on this framework it required a lot of advanced knowledge and a developer coming from the web or junior one

[19] Cross platform technologies

will require several weeks to learn the framework before starting to be productive. The development process was quite challenging, the working process was tedious, with a lot of unexpected errors, and sometimes it was not possible to find a solution. Once, after the platform has upgraded to the newest version, the application did not start, and the only solution I found at that time was to rebuild the app from scratch and copy all developed code completely. Not all tools worked smoothly, especially the previewer, it often hanged and was not foreseen with the refresh button, relaunching required until 35 seconds. With emulator situation it was even worse, to visualize changes made in the code required up to 60 seconds to wait. Not all proposed UI was possible to develop due to limited UI elements variations and poor configurability of them. An early version of ELISA's UI required that in the main page buttons shall have dotted borders, which was impossible to achieve because of missing functionality on buttons or any other UI components in Xamarin. To develop with Xamarin one is bound to use Xamarin Studio (a variation of Visual Studio) which required around 6GB of space and for a period of development with Xamarin, I was required to use 2 code editors — one for Xamarin development and a second one VS code for the development of *Ad Voca*.

Due to all the challenges mentioned above, it was decided to change the development platform to Flutter. This framework is designed for developers at any level and to start development in Flutter for a novice is quite easy. The framework is intuitive for developers coming from web development and to learn basic concepts for a beginner can take up to two weeks before it can start to produce, which is much better than Xamarin (Flutter.io, 2018a).

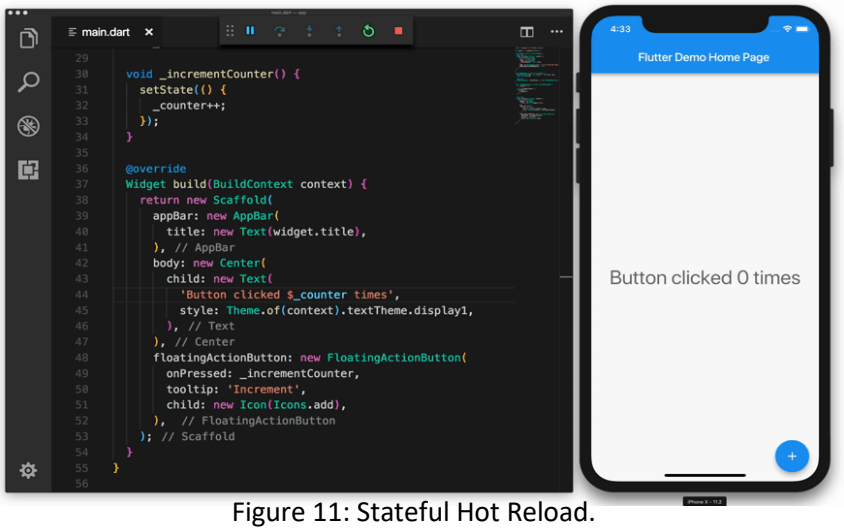


Figure 11: Stateful Hot Reload.

What is unique about Flutter to deserve our attention? The answer is its tools. Besides the fact that it is technically unique (discussed in Chapter 3.3.4), the Flutter team managed to create great tools which drastically increased productivity during the development of ELISA. With hot reload[20] (Figure 11), changes done in the code can be visualized in Emulator in less than one second, other frameworks really struggle with this (Flutter.io, 2018b). Hot reload is stateful, which means that if there were made some

[20] **Hot Reload** – "Flutter's hot reload feature helps you quickly and easily experiment, build UIs, add features, and fix bugs. Hot reload works by injecting updated source code files into the running Dart Virtual Machine (VM). After the VM updates classes with the new versions of fields and functions, the Flutter framework automatically rebuilds the widget tree, allowing you to view the effects of your changes quickly." (Flutter.io, 2018b)

changes deep in navigation pages tree, it would keep the state of the page changing only that element which was changed. Another great tool called flutter inspector (Figure 12) allows visualizing widget tree of a page. Inspector is a great debugging instrument; it shows how beautiful widgets are composing each other, and also helps to understand the structure of the page and how widget rendering works (Flutter.io, 2018d). If one can see where a particular Widget in a tree is located by clicking on the element from the emulator, and the tool will jump directly into that element in the code. Application size is relatively small; it has round 7 MB for an average application (Flutter.io, 2018a) comparatively with Xamarin which is a minimum of 35 MB in size (Adam_P, 2015). Size is essential especially if the target audience of the apps uses devices with limited physical capacities.

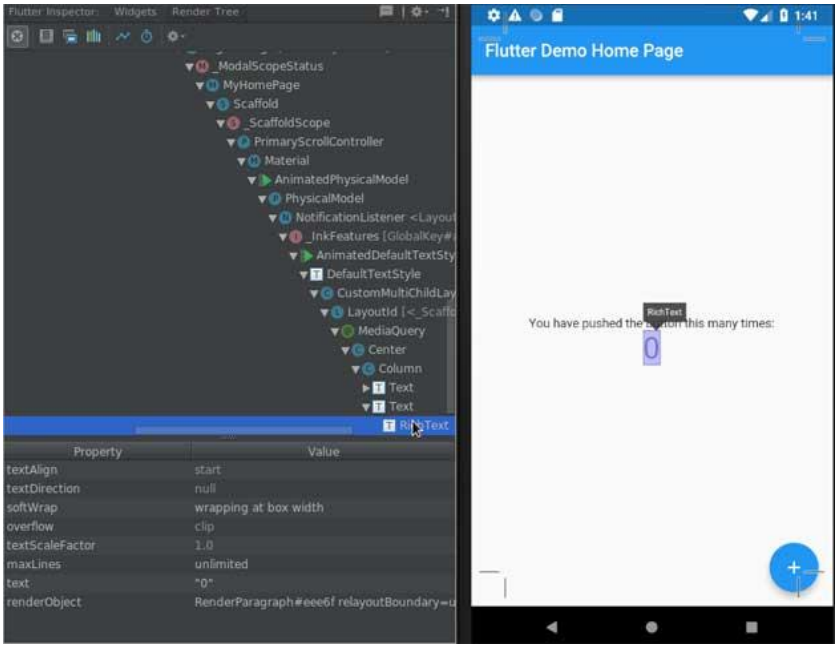


Figure 12: Flutter Inspector.

Flutter SDK does not give preference to any IDE[21]'s and works perfectly with several, including VS Code. VS Code is lightweight (have around 100 MB) and allows plugins, which define it as extensible IDE for all languages and frameworks. This makes the VS Code a Universal IDE where it is possible to develop for any platform. With a flutter, for the interframework system (like ELISA is) VS Code was used for development of all parts of the system, including *Ad Voca* and advoca_proxy, unlike my experience with Xamarin.

Flutter proved to be the right choice, allowing to develop a pixel-perfect application, at least two times faster. After moving to Flutter, I never had to compromise design before Framework limitations. Disadvantages of using flutter are very few. The biggest one is that Flutter was in beta, and sometimes I experienced some framework bugs with Emulators or code editor, but they were not critical, and all the time I was able to find some workarounds. However, on 5 December 2018 Google announced its 1.0 official release, which means that the platform is in the stable version, and all known bugs were

[21] Integrated development environment - An **integrated development environment** (**IDE**) is a software application that provides comprehensive facilities to computer programmers for software development. An IDE normally consists of a source code editor, build automation tools, and a debugger.

addressed. During development, other issues than those mentioned above were not observed.

However, some articles reported platform disadvantages like using Dart as Framework language which many developers are skeptical too (alexsoft_engineering, 2018). Some of them struggle to understand the new coding style, which is not a traditional approach in other languages. I had a similar feeling when I started using Flutter, but after a while, it became logical and forced me to admit that such a structure is necessary to benefit from the most significant advantage in platforms code feature called, composition (discussed in Chapter 3.3.4). Other issues like Libraries & Support, continuous integration support fall apart with the announcement of official release.

6.2.3 Web development frameworks and tools

For successful development of *Ad Voca* (discussed in Chapter 6.1), it was essential to pick one of the web frameworks which are simple enough to start programming in right away, and powerful enough to be able to sustain complex features, as *Ad Voca* requires.

Today there are so many web technologies claiming to have all that is required, to be simple to use, and powerful enough to build everything. Generally, web frameworks can be divided into the subdomains **back-end** - those who are responsible for running on a server with all its required functionalities and **front-end** – those who do all the logic on the client device. Frameworks like Express, Django, Rails, Laravel are just some of the most popular backend-framework and if accounting those who are on front-end like Angular, React, Vue, and for a novice, a right choice is not obvious. (Goel, 2018)

surprisingly enough for development of *Ad Voca,* I selected the most used, hated and loved at the same time, PHP language. It is not a secret that PHP is considered to require only a minimum set of knowledge for development. This is a programming language with a very low entry threshold. (DatadogHQ.com, 2016)

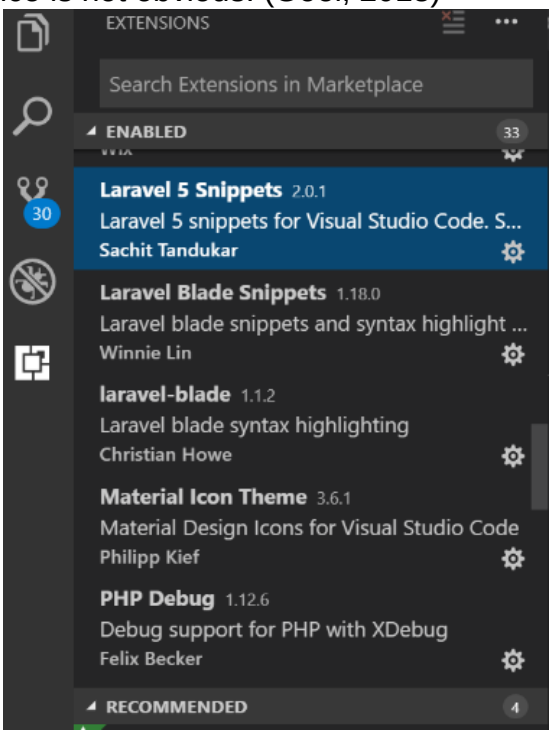


Figure 13: Laravel plugins.

Most likely experienced developers will say that this is a heresy to choose PHP for such a complex system like *Ad Voca* is. However, for those who consider so, please read the whole chapter and see the reasons behind this choice!

Is it possible to create a serious product with PHP? How to prove that PHP is mature enough for complex systems? Fair enough is to say that PHP alone is NOT a good choice, but if Laravel is taken into consideration, a framework which is built on PHP, things begin to clarify.

Development of any project requires far more than just knowledge of the development language (a fact proven by this whole MSc thesis). To create and maintain it, a developer needs much other interdisciplinary knowledge, and laravel is an ideal solution for those who want to develop quickly and thoroughly a secure and reliable web project, while always staying at the peak of the web development technologies.

As declared previously, for development of the whole project we used VS Code IDE. To set up the environment we added several plugins for working with PHP and Laravel – PHP Inteliphence, PHP Debug, Laravel 5 snippets, Laravel Blade Snippets (Figure 13).

Laravel follows MVC pattern for the organization of the project and according to them:

“we have attempted to combine the very best of what we have seen in other web frameworks, including frameworks implemented in other languages, such as Ruby on Rails, Asp.Net MVC, and Sinatra.”(Laravel_team, 2018)

After the release of PHP7, scripts become faster and have begun to use much less RAM (in some cases more than 20 times), and in conjunction with **Zend OPCache** shows excellent results (Fidao, 2016). In particular, Laravel adjusts Zend OPCache for maximum performance.(Schie, 2017)

That is why, when it comes to the performance of a particular PHP framework, always tests are conducted without caching, working with databases or files, mainly making many calls to a regular PHP page. In this regard, this PHP framework is not significantly different from all others. However, when it comes to scalability, flexibility, the universality of embedded caching mechanisms and development speed, Laravel shine in all its power.

With Laravel a novice developer can explore its capabilities without going into the core of the framework, this certainly raises the level of knowledge not only in Laravel development but in web development in general, including an understanding of the principles for the building of high-load projects. After All, writing code with Laravel is not only beautiful, enjoyable but also lead to think very well how to write well structured extensible code.

7 Design & Implementation.

This chapter shows how knowledge obtained from Chapter 2,3, 5 and 6 were materialized in the implementation of *Ad Voca* system (including ELISA). Chapter 7.1 explains how applications interact with each other which technical steps were done to bring ELISA's innovations to life. Chapter 7.2 discuss developed of the *Ad Voca*. Chapter 7.3 discuss the development process of the ELISA. Chapter 7.4 explains how was materialized in practice principle *secure by design, secure by default* in Elisa and Ad Voca. While previous chapters are a mixture of interdisciplinary work, Chapter 7 is a practical part of software engineering discipline.

7.1 Overall architecture.

This Chapter represents a general overview of the architecture of the whole system. From the beginning, the *Ad Voca* architecture was designed to sustain all kind of communication facilities for different groups of patients. While every category of patients requires specific needs, knowledge, and treatment, it was discovered that the Architecture solution for implementation of the system for other categories of patients could be nearly the same. Thus, the same architecture can be considered in all HC institution – patient communication scenarios, which is why ELISA, a variety of mHealth app, can be considered as a blueprint in communication between HC organizations and patients. ELISA is part of Ad Voca architecture and using the example of this app; similar functionality can be added to the existing architecture of other types of mHealth apps for different groups of patients.

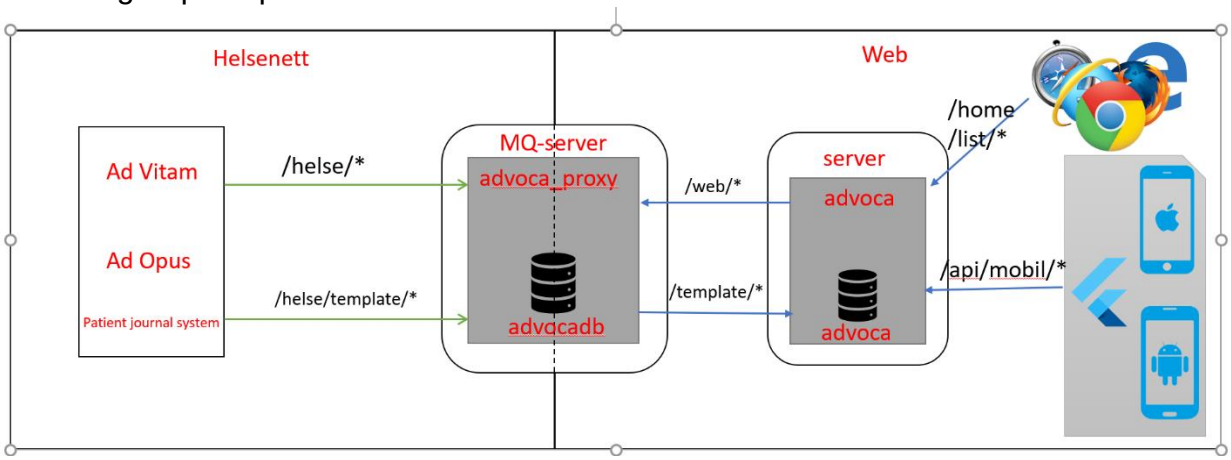


Figure 14: Overall architecture of the *Ad Voca*

Ad Voca consists of several applications; this architecture was implemented to achieve inter-network connection (between Helsenett and web) and security by design principle (for more se Chapter 7.4). As is illustrated in Figure 14, Ad Voca can be differentiated three main parts of the system:

advoca_proxy – which acts as a bridge between Helsenett and web, and also has a function to temporarily store the data in a secure and agnostic manner (see Chapter 7.4)

Ad Voca – which ensures communication with clients. *Ad Voca* is responsible for authentication and authorization of the users. Authentication is done with Norwegian Bankid, the highest level of authentication method available in Norway. It is also responsible for the authorization of mHealth applications to consume personal data from the owners of apps.

Clients - can be a web version of *Ad Voca* for secure data exchanging between HC institutions and patients, ELISA, or any other specialized mobile app for serving a different kind of category of patients.

Ad Voca is entirely agnostic. Such an approach allows communicating with any journal system, regardless of the vendor who meets security requirements. By providing a set of APIs anyone from Helsenett who have granted access to Advoca can share data with clients from the web and benefit from all facilities offered by *Ad Voca*.

Ad Voca has built-in functionality to ensure half-duplex and full-duplex communication facilities like chatting, video-audio calls, sharing of multimedia content, Schema sharing and much more. Because the complexity of the project and limitations of this MSc thesis, the prototype of ELISA was developed to demonstrate the soundness of inter-network communication between patients and HC-institutions with the help of Schema capability, thus the following paragraphs will discuss mainly the development of Schema capabilities. Implementing other ELISA functionalities proposed in this thesis, however, is a subject of further work.

7.2 Implementation of Platform Ad Voca and ELISA

As mentioned before *Ad Voca* Platform consists of 3 parts (Figure 5.1), this chapter will have some high-level overview about implementation details of advoca_proxy and *Ad Voca* and ELISA. This is a simplified version of low-level implementation details description from Appendix, page2-9.

Ad Voca and advoca_proxy

Both applications are written in PHP, *Ad Voca* with use of Laravel framework and advoca_proxy with use of lumen, which is a variation of Laravel using a minimum number of functionalities, while offering best performance instead. (laravel.io, 2018) The difference between these two applications is that advoca_proxy holds all data, manage data, schedules schema management automatically based on Schema-validity, and consent validity periods if it is relevant too. *Ad Voca* is responsible for authentication and authorization for all clients (about security in *Ad Voca*, please read Chapter 7.3).

For the creation of specifically related classes like models, migrations, controllers, routes, etc. Laravel uses a comfortable set of CLI[22] commands. These commands make the

[22] Command line interface (CLI) is a text-based interface that is used to operate software and operating systems while allowing the user to respond to visual prompts by typing single commands into the interface and receiving a reply in the same way.

development process a lot easier, and a novice can be confident with these commands and can quickly be familiar with them.

Models are data templates which are modeled by content linked to them through migrations which comes from a database; *Ad Voca* does not have any model classes, except the User model (which plays a role in the authorization process) because it does not store any data. Advoca_proxy instead holds all relevant data and contain all models of the system. Migrations is a kind of data table generators and tell Laravel what kind of field contains a particular model.

Laravel provides a simple but powerful routing system, which allows creating restful endpoints with just one line of code. Routes can do more advanced logic including to attach middleware to each endpoint, or to change resource content before it is delivered to the requester. However, for the sake of simplicity, it was decided to keep different functionalities separate. This pays off especially when the application grows in size and complexity.

In advoca_proxy there is a set of scheduled tasks programmed to run daily. They run some cleaning commands and have a responsibility to delete from db inactive queries as well as expired Queries, to change statuses of queries based on time limits and so on

ELISA.

Similarly, to Laravel, flutter framework has a set of handy CLI commands which helps to do different actions including the creation of the new project.

Even though flutter uses the same code basis for both platforms, sometimes is required to write some native interactions, with the purpose of embedding into the application platform-specific features like notifications, app lifecycle, sensors, camera, etc. All this code can be written in android and ios folders. However, with the growing of flutter community, some packages grow which solve specific platform integration issues. They can be imported and used right away in the project without the need to write any line of platform-specific code.

During interviews was discovered that one of the features which ELISA requires, is to provide a high adjustable interface such that every user can change what functionalities are shown on the main page. To achieve this every page in flutter was created as a BasicElement (see Appendix 11). Such an approach gives the flexibility to change the content of the main page dynamically.

All Schema and additional data are saved securely in the local storage of the host device. In ELISA was used SQLite database and to easily integrate this db in the project, is required to use SQFlite package.

7.3 Secure by design! Secure by default!

The architecture of *Ad Voca* (Figure 14) guarantees the implementation of security by design principles, by separating each application of the system to be responsible for some

specific functions. Such an approach minimizes security risks and makes *Ad Voca* more trustable.

All sensitive data is stored in advoca_proxy. It is entirely generic and does not understand the type of content it holds. This content does not have any personal identification data except for a unique identification key, generated with a secure algorithm asynchronously, based on the personal number. This means that if it has generated a key two times from same personal number, the solution will give different keys, making it impossible to guess the key related to that person and accordingly to identify to whom that sensitive data belongs if a breach happens.

Content in advoca_proxy is end to end encrypted with RSA 4096 bits key size mechanism. This pushes security on an even higher level, excluding the possibility to read data even if an unauthorized identification private key is generated. Advoca_proxy communicates only with *Ad Voca* on the website and with accredited journal systems on Helse net. After Schema is consumed and sent back to the issuer of the schema, its content is automatically deleted, and the system keeps only reference to the Schema, which has no sensitive value.

Ad Voca is responsible for authentication and authorization of a client and does not register any data which can identify a person. The user is authenticated with bankid and is authorized to consume his data, based on a generated key that is generated based on the personal number. With the help of that key *Ad Voca* brings authorized data for consumption and deliver it to the client.

Ad Voca store information about each Mobile Applications authorized to connect to its services. Authentication and authorization mechanism for mobile applications are based on OAuth2 protocol. A mobile application can be activated only with an invitation from the Journal with a unique key, and the first time a person needs to authenticate it is necessary to be authenticated by using bankid. After that, a refresh token is sent to the application. Further logging from the application is based on refresh token and a pin that person should choose at app activation. When a user tries to log in from the app, he is asked to introduce his pin composed from 4 to 10 characters. After the pin is accepted, he gets a short-lived Access token which contains encrypted information making possible for him to generate unique identification key on *Ad Voca*, for accessing personal data from advoca_proxy. Only on client content is in decrypted form and then new data is delivered to *Ad Voca* client encrypts information again.

The established security mechanisms determined *Ad Voca* to be secure by default, minimizing all kind of risk for the data breach, or data leaking. Together with security mechanisms implemented by the server and with the use of Docker container, *Ad Voca* has minimal risks for any security flaws. Because of the “deliver just what is needed” policy, it is impossible for anybody to get access to all information available on the database at once.

8 Idealistic whishes vs. realistic results.

This chapter shows a high-end overview of the developed system. Chapter 7.1 presents the platform *Ad Voca* which is the responsibility to connect ELISA to an EPR on Helsenett. Chapter 7.2 demonstrates the GUI of the developed prototype, while Chapter 7.3 discusses a high-level overview of the implementation process. To achieve these aims, experiences from already existing mParent apps and challenges discussed with patients and Practitioners in previous chapters were taken into consideration.

8.1 Platform Ad Voca

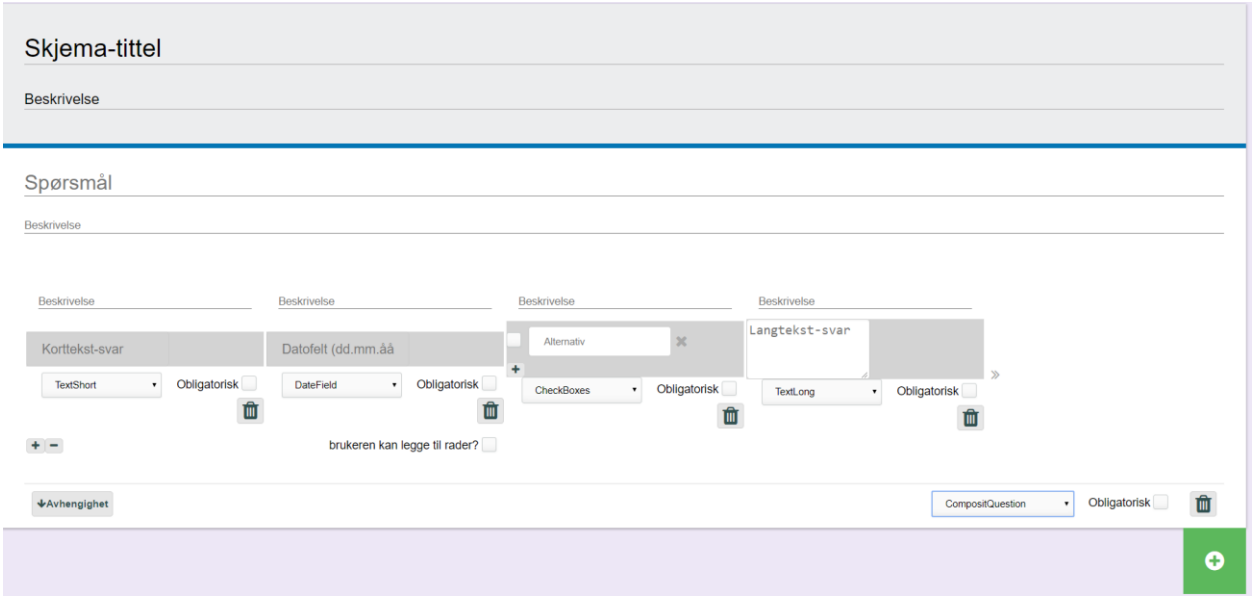


Figure 15: Schema Designer

To facilitate Schema communication between HC institutions and patients, it was discovered that the first one often needs to adapt each schema according to individual need for each patient groups. This was hard to achieve with the portal *cari* because of its restrictive architecture which implies to create each Schema manually on the web portal. This process was cumbersome and required good technical knowledge of schema creator.

To address this issue, a Schema-designer was developed (Figure 15). HS-designer has an intuitive design and does not require prior knowledge to start to use and build a Schema. Another plus is, because of its modular architecture, it is easy for a developer to add new types of templates for questions or customize existing ones.

With the help of HS-designer, a digital version of **Helse Kort for Gravide** was created. Even if HKG is the most important binding document under pregnancy, it is no more than an Advanced version of two combined schema types (discussed in Chapter 4.3.1), *Continuous Schema* and *Progressive Schema***.** HS-designer generated an XML schema

(Appendix 9). This XML schema is interpreted by HS-viewer on client application (which can be ELISA).

HS - the viewer, was upgraded such that it will be able to easily integrate into different eHealth applications targeting patients. In ELISA, it is integrated via flutter_webview_plugin (Figure 16). Integration of HS-designer directly in Widget tree will give more control and customization of HS-designer, and due to time limitations, this is a subject for further development.

Usual Schemas sent by institutions are very large, and sometimes it contains more than 100 questions. For persons with weak technical expertise to complete such schemas quickly became a nightmare. To solve this issue HS-viewer is equipped with a wizard capability which allows choosing how many questions per page the user wants to see.

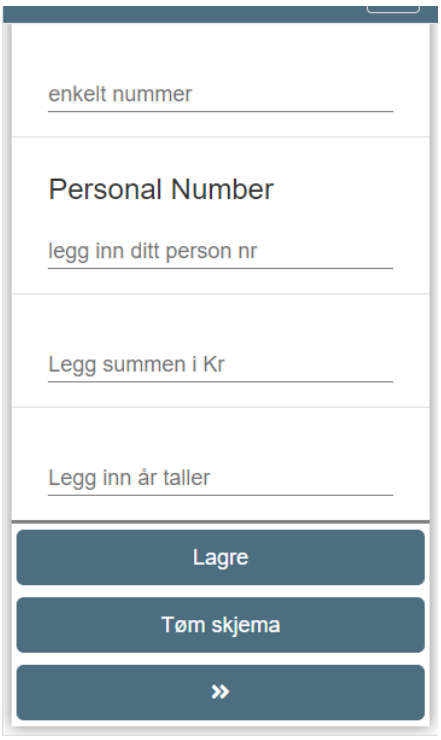


Figure 16: Elisa HS-viewer

HS-Viewer has a function; “right of withdrawal”, which deletes all answered questions. If patient during the answering process or later, but in time before Schema is sent to institution, regrets and changed his mind to send this schema, he can do so by clicking “tøm skjema,” and all data will be automatically destroyed.

However, due to the limitation of this thesis not all targeted features of HS-designer and HS-Viewer, were developed. Some Question templates like “simphyse fundus mål” were added manually and not through Designer, some types of a schema (discussed in Chapter 5.3.1) like *partial schema*, are still not supported and will be further developed on demand.

To meet the requirement for detailed and explicit consent, ELISA has a Schema administrator and Consent previewer (Figure 17). From the Journal system, with the help of the schema administrator, it can efficiently manage consents. Specifying type, the content of consent or adding multiple consents if the nature of the collected data requires so.

Figure 17: Elisa Consent Previewer

Every schema has an option for two types of consents, required and optional. If a schema has a required consent, this must be chosen before moving on and answering the

schema. The second type of consent is optional and is typically used with schemas where an institution wants to use personal data for other needs. Example of this is that the data processor uses data in research.

After sending Schema, the patient can go into a side menu “besvarte skjema” (Figure 18, 19) and find all Schemas completed by him with all given consents related to that Schema.

One important fact is to mention that the content of schema after it is sent to an institution, is automatically deleted, and *Ad Voca* only holds “a reference” to that schema for the validity period of all accepted consents related to that particular schema (for more see Chapter 7.4).

This is done with the purpose to give the patient the right to administrate consents for every answered schema easily. Once a patient modifies the content of his accepted consent, *Ad Voca* immediately sends to the processor of the patient Journal that the consent for a particular Schema was modified, instructing the data processor to act accordingly. After the action is done, according to regulation for that consent, the system sends info notice back to the patient about procedures taken and explaining why they were accomplished.

HKG is not kept on *Ad Voca*, but on the patient device. The patient can choose to keep other schemas too on his device if he wants to do so. All other data that client keeps on ELISA is not held in *Ad Voca*, and if a device is lost, it is possible to recover data only after a request to patients GP or Midwife who may have a copy of data which patient is interested in. All data from the lost device is automatically erased after “lost notification” is sent through the web version of *Ad Voca*.

All consent given by user that is not directly related to a particular Schema can be administrated in “mine samtykker.” There can be consents like

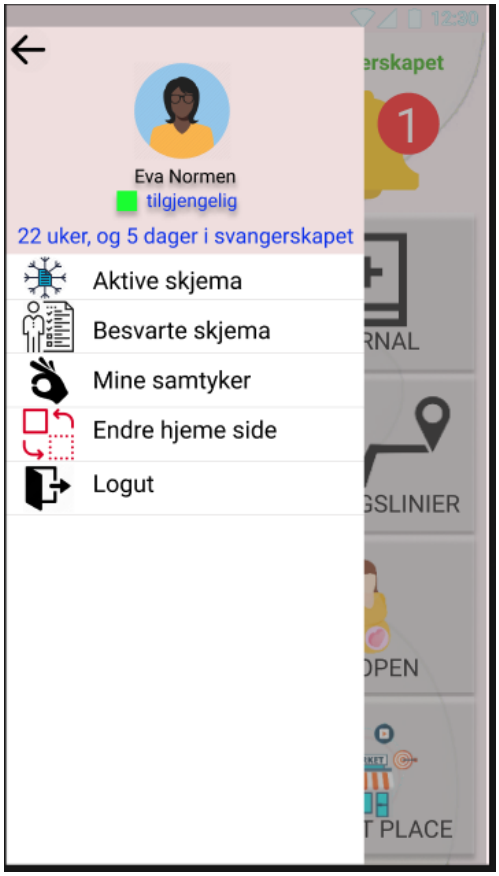


Figure 18: Elisa side menu

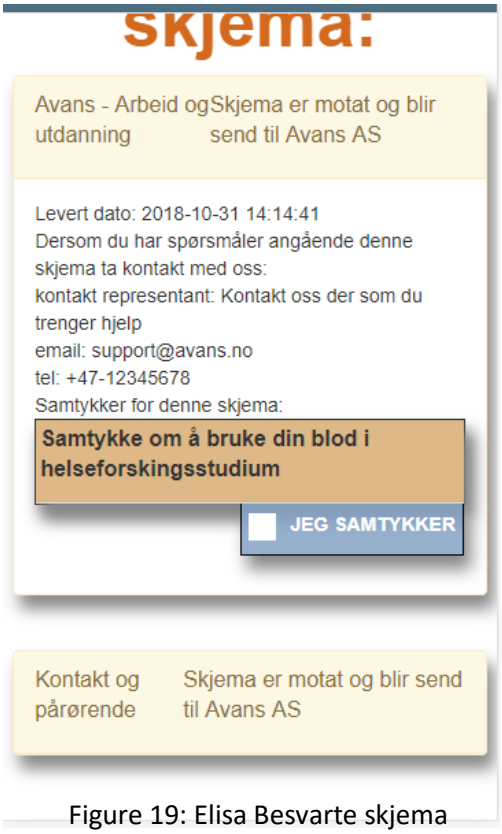


Figure 19: Elisa Besvarte skjema

storing chat conversations with Health institution, or other general purposed consents.

8.2 UI Solution for ELISA.

In accordance with findings discussed in previous chapters of this thesis, a series of the essential functionalities of ELISA was defined . Work on ELISA's prototype was organized using iterative development, with iterations done in parallel, thus creating the current version of ELISA's interface.

8.2.1 Solution description

When the user is logged on, she navigates to the home page (Frame 1), which was significantly simplified, from previous versions. According to recommendations from technical experts, the page is divided into ten main areas. On top of the page is a visible application bar with information of gravidity period in the center. On the left side, there is a **sidebar menu** button (Discussed in Chapter 8.1). Under app-bar **scheduler** and **notification panel** is located (Frame 2)**.**

By clicking on Scheduler, the user can list which activities and meetings that are planned in the nearest future. It is also possible to schedule an activity if it is needed. By clicking on planned activity, the user navigates to a page with more detailed information about that activity. If schedules exist, the user is notified with a red circle about planned activities. The notification panel behaves much as a scheduler. The difference is that the last one uses all sorts of notifications, like messages coming from HC institutions, reminders to complete some action (planed weight, measure fundus, take medication, medical prescription), received schemas for completion, etc. The remaining buttons **Spør Lege**, **Journal**, **Retigheter, Retiningslinier, Medicin, Kropen, Livstil, Market Place**, represent 8 main groups of functionalities described below.

Spør Lege: (Frame 4) In this section patients can find help about concerned questions or can book a meeting with her GP or midwife, order an online meeting through video chat or chat with one of the HC operators about issues the patient may have. Also, in this section, it is possible to write emails to the GP or to receive medication prescriptions from the doctor.

Journal: (Frame 3) The user can provide all clinically relevant data such as weight, height; a digital version of health card (HKG) can be filled in. Also, the user can find the electronic version of "Informasjonsopplysning for Fødevadelingen."(Figure 21) Today both documents are provided only in paper format, and both may be completed whenever the patient goes to the doctor. In the future functionalities of ELISA are going to be extended, and the app will also be for children under health station care. There will also be a health book for a child, which is a similar document to the health card HKG.

Rettigheter: In this section, the patient will have the opportunity to learn about her rights, and what treatment she can choose for herself and her child. The legal part of maternity protection and rights, as well as sensible data like maternity protection from violence, psychological marginalization and so on.

Retningslinjer: (Frames 5, 6, 7, 8) This section provides an implicit and explicit pathway which each patient is recommended to pass through. Implicit - because it provides regular meetings and recommendations for meetings. Explicit - because there is also information present about planned meetings with information from the practitioner about what is beneficial to know before the meeting happens. Also, in this section, it will be possible to add explicit appointments and see in the form of list what comes next.

Medisin: (Frame 9) This section provides information about medication patient should take and how it should be taken. Here patients find information about electronic medical prescriptions given by a GP. Through the portal tryggmammadedisin.no, the patient can anonymously ask sensitive questions regarding the use of different medications or some different issues regarded abuse of consuming drugs.

Kroppen: (Frame 10) As the name suggests, in this section, it provides information about the development and state of your child at that given period. Also, the patient can find all information regarding her health and physical and psychological changes through which she is going to pass. Also, she can find information about "normal" allergies, body reaction, as well as pains during pregnancy and after birth.

Livsstil: (Frame 11) Here patients can find information about recommendations from Norwegian Health Directorate regarding healthy diet, physical activities, harmful life habits, sexual activity in pregnancy, chemicals which are better to be aware of and common ailments in this period.

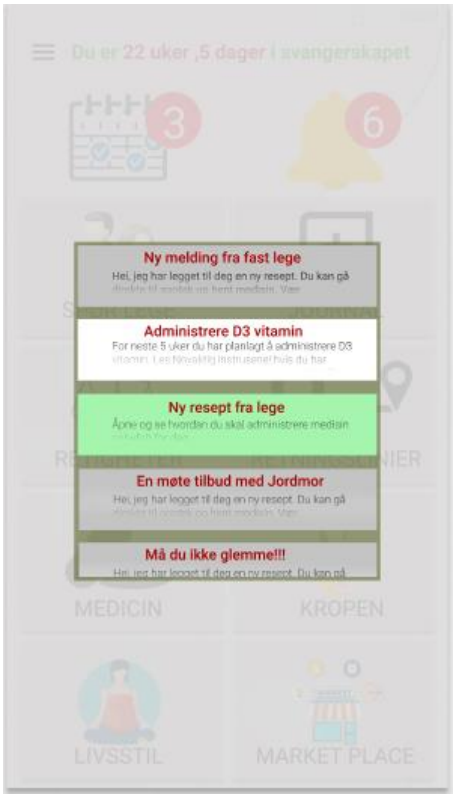
Marketplace as a response to the patient desire, in the marketplace, it is proposed to create a communication channel where mothers have the possibility to discuss in real time with each other. Also, there will be information about products which are good to use during pregnancy and after a child is born, as well as the possibility to buy or sell new or second-hand things related to pregnancy and children.

Some sections described below have terms and concepts which for a new user can be challenging to understand at once (like health card, symphyses fundus and so on) therefore it is necessary to include compartments where the user can quickly learn about these terms and concepts. To solve this need, there was added an FAQ button in some sections. **Frame 12** is an example of the FAQ in the journal section, where the user can find information about the content of the journal section as well as data which is collected and why it is relevant for pregnancy.

The prototype was created in accordance with software and design principles such as "clarity is job, conserve attention at all costs, provide a natural next step". (Bocardo, 2016) From the recommendation of a UI designer, the created UI was made modular such that if next iterations need some new changes, they can be easy introduced.

8.2.2 ELISA frames

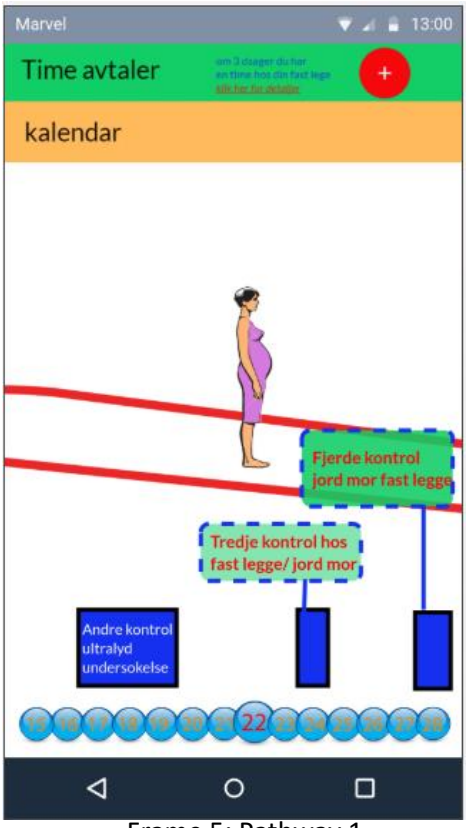
Frame 1: Home Page



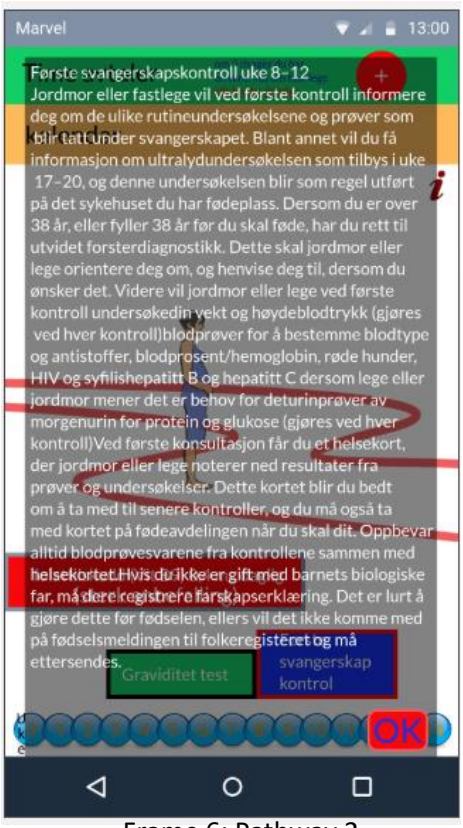
Frame 2: Notifications panel

Frame 3: Journal

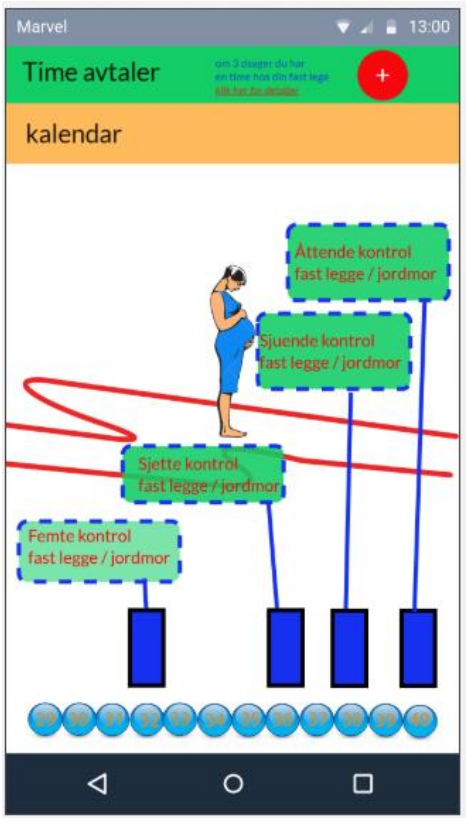
Frame 4: Ask Doctor



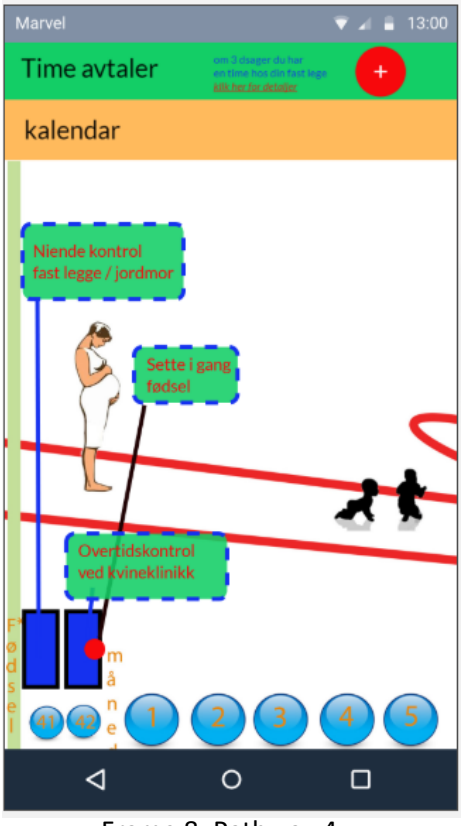
Frame 5: Pathway 1



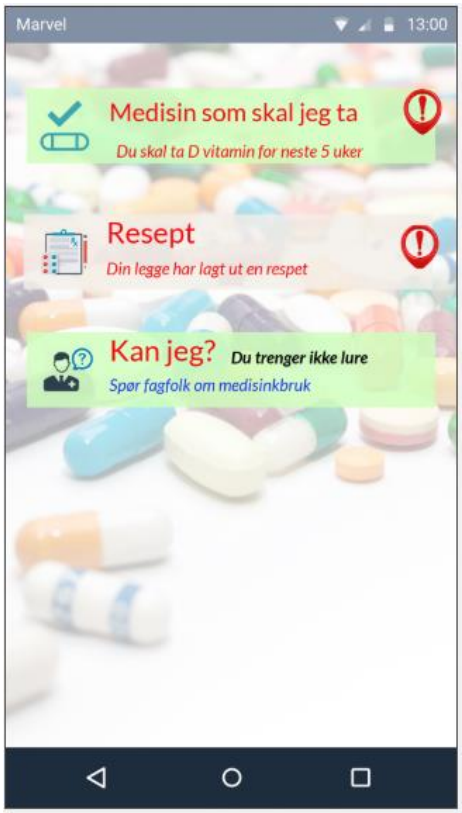
Frame 6: Pathway 2



Frame 7: Pathway 3



Frame 8: Pathway 4

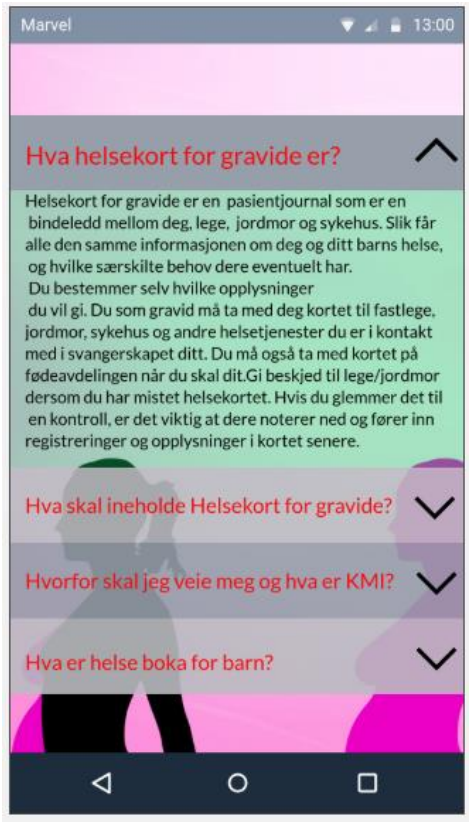


Frame 9: Medication

Frame 10: Body

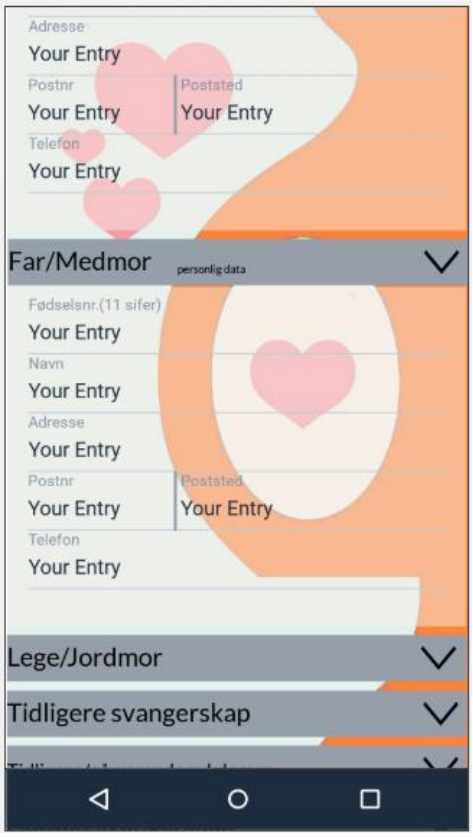
Frame 11: Lifestyle

Frame 12: FAQ

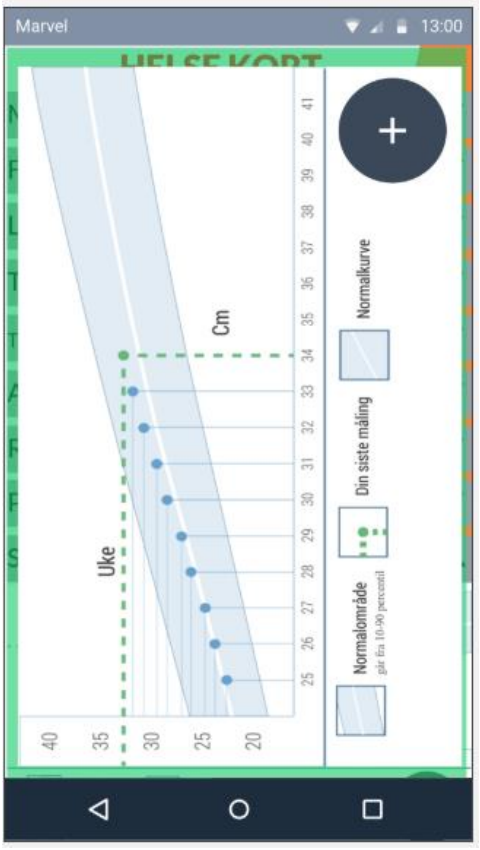


Frame 13: FAQ 2

Frame 14: HKG



Frame 15: HKG 2



Frame 16: Simphyse fundus mål

8.3 Prototype of ELISA

With the development of the ELISA, a special attention has been given to make the UI user-friendly. Most of the designed pages were translated in code. Thanks to the versatility of flutter, small features like curves, stacking of elements or animations, were achieved without compromises with Design. Some of the application logic related to storing data, establishing secure communication with the server, sending, and receiving data to the server and more were also done here. Because of Thesis limitations, not all functionality of the ELISA was developed. Features like token authentication, authorization of the user, local encryption of the data, other communication channels must be a subject of further work.

All functional elements of ELISA were declared in the code to satisfy the requirement of high interface adjustability (Chapter 5.3), thus every time when the application launches it generate dynamically content of the Home Page. Although all the code base for implementing this feature was accomplished, full implementation of it is the subject of further work.

The ELISA Prototype offers a functional solution for a Health Card, also known as HKG (Frame 14, 15, 16). This is a digitalization of paper-based version of the HKG document (Chapter 5.2). ELISA through advoca_proxy offers an API service towards Helsenett which offers the possibility for HC institutions to receive and send information to the patient. Every time the patient introduces new data, Health services get a refreshed version of the document with the latest data. Also, the health card on ELISA is automatically updated every time GP or Midwife add new data.

To visualize and complete schemas, the HS-viewer module of *Ad Voca* was integrated into ELISA. The user can list all active schemas, except Health Card, from a side-menu on active schemas (Figure 18), which make ELISA a general-purpose tool for schema completion.

In concordance with GDPR, a consent viewer module was developed as well. By Allowing HC institution to edit, create and modify consents, ELISA together with *Ad Voca* provides a robust, innovative tool for Norwegian health market. This helps doctors to have a more flexible working day , as well as to give full control to patients on their data.

Patients can see all given consents for each schema from a side menu in **my consent**, as well as all general purposed ones which are not related to any particular schema. However, during this MSc thesis, only server-side development of this feature together with API services was accomplished. Full functional and detailed implementation in ELISA is the subject of further work.

The developed system answered RQ4 showing maturity and versatility of the chosen frameworks. This can contribute to a demonstration of the hypothesis that ELISA can help parents to plan better their meetings with HC institutions.

9 Discussion and future work

This Chapter begins with reflections about methodology (Section 9.1). Section 9.2 reflects about possibilities and solutions which can offer ELISA for HC and patients challenges. Section 9.3 discusses future work towards a ready to the production system.

9.1 Reflections about methodology

Interviews performed with major stakeholders of the app showed a genuine interest and prominent potential of such an app in helping parents to understand better their relationship with the HC professionals. ELISA has the potential to discover in a straightforward, accessible manner what health organizations can offer and what responsibly they have as parents. ELISA can also reduce the communication gap between patients and pediatrics medicine in Norway.

However, many of the parts of the performed research and design and development need to be completed. Most prominent concerns which are still not solved in this thesis is the question if the specified functionality formulated through the current requirement (see Chapter 5) will give the desired result. To obtain answers for this concern performing additional tests with major stakeholders would be needed., It is not clear which impact will have on the quality of services a testing a fully functional application. To provide valuable and clear results is essential to identify proper measurements and guidance which contributing to evaluating the effectivity of ELISA in a trustful manner. To set up a test environment with such measurement's possibilities, e.g., showing data sharing about, e.g. patient tests or short and clear communication between patients and HC professionals would be necessary. Otherwise, if measurements will be wrongly selected and prioritized this project risks to repeat the experience of the EPR when it was introduced. Testing several known interoperability problems about using EPR would contribute with valuable insights to better define communication support in the app (Rosenbaum, 2015)

For a complete realization of ELISA is required to have design experiences and skills, a quality which is hard to evaluate objectively and hard to prove that level of creational power is mature enough for solving ELISA's challenges and creating technical solutions that will work in the production environment.

Today technology advances rapidly and a cutting-edge technology used here, in just two years can become "old" and unmaintained, that also may influence results about technical achievements in this thesis.

9.2 Reflections about technologies and possibilities of using ELISA in Norway

Because of the high range of specific needs for this category of patients, it is required that users self can adjust which functionalities are most relevant for them. However the most challenging part was to hold UI of ELISA clean and straightforward while was added a lot of new complex features not present in any other mParent apps.

Since in Norway nearly 100 % of the market is equally divided by Android and IOS, an important consideration was to cover both mobile OS platforms. Writing two separate application for each platform was considered to be unsustainable due to time and resource limitations. Therefore a technology that would allow a single code source to run on both platforms has been investigated. From reviewed technologies was chosen the category of frameworks which compile shared code into the native code of each platform. The so-called cross-compiled apps are faster, easier to maintain and can share up to 90% of the code, meaning less work for adding new features or for maintaining the application.

The ultimate software framework used for developing ELISA named *Flutter* (owned by Google), has proved to be a good choice. It provided a high level of flexibility, offering all necessary features to satisfy ELISA's requirements. Unlike other mobile frameworks, Flutter has a feature called Stateful hot-reload, which played one of a decisive role in speeding up the development process. Thanks to this feature, to visualize changes done in code, is needed less than one second, for comparison others cross-platform frameworks needs from sixteen seconds until ninety seconds for the same purpose. Flutter keep applications state then reloads application, which means that it does not need to start from the home page every time then a change was made deeper in application tree. This especially is important then application grows and consists of a chain of more than 5 pages deep. In Flutter all UI components are widgets. Widgets are small single purpose components which allow building other bigger widgets by composing them together. For example, Container, commonly used widget, is made up of other several smaller widgets which are responsible for layout, painting, positioning and sizing on a phone screen. Such a composition for building UI gives endless possibilities for creating innovative applications, and only imagination can stop to achieve proposed targets.

With the intent to connect Helsenett, where all HC-institutions are connected to, with the web, where all patients have access to, was build *Ad Voca* platform. Trough *Ad Voca*, ELISA give an end to end communication facility in an agnostic and secure manner, offering simplicity in communication and real-time information sharing. Thanks, that ELISA is not tied to any specific on the other end Journal systems and can communicate

with any kind of Journals Which HC-practitioners potentially use. This feature facilitates interoperability and allows to adopt more easily digitalization of **Pregnancy Health Card** (Helse Kort for Gravide), most crucial binding document among different HC institutions.

Ad Voca gives the opportunity to integrate into ELISA, chat functionality with multimedia content as well as video and audio calls, giving an opportunity for online meetings with HC practitioners. Such functionality would bring more optimization in HC. For example, it would be possible for a concerned mother to get a fast answer if irritation of skin is the subject of an emergency or it is something within the limits of acceptable symptoms for her period. By doing so, ELISA has potential to reduce numbers of unnecessary emergency visits as well as extra ungrounded “concerned visits” to the GP or Midwife, at the same time, identifying more easily cases that need to be taken urgently.

Proposed ELISA functionalities can give a unique opportunity to mParent market for two ways communication channel, contributing to pregnant women’s and young mothers, in achieving their wishes for continuity and relationship between pregnancy, birth and maternity life. And through it combine different pieces of reproductive care services in a single connected interinstitutional service, giving to the young mother more confidence in the quality of received care. Such approach makes the owner of the app, own the data, elevating him to a central element through which all involved health organization can receive valuable clinically relevant information in a secure and decentralized way, in order achieve desired heights in providing quality of services.

9.3 Future work

Even though a significant effort was oriented for identifying requirements and for the development of the ELISA (more than 1000 hours were used for development of the system), the project is complex and thus has been left a number of issues to work on. Examples are more proper usability tests. A cognitive walkthrough at this stage would lead to valuable insight. Already there are new functionalities interested (e.g., about patients’ rights, anchoring to social groups, etc) and needed to be included and tested. The different UI adaptation of the ELISA for *Ad Voca*, oriented mostly for the web version like hs-waiver, are written in JS needs to be tested, etc.. For future development, several additional iterations are recommended, in order to better anchor to existing theories and results from research regarding other mParent or HC apps focusing on similar issues, e.g. patient communication with HC experts.

A suggestion is to focus more in-depth on two areas: the technical enhancement of the prototype, and the validation of the obtained results from this thesis.

There are some concrete proposals for the first steps:

1. It will be beneficial to perform more interviews with doctors specializing in specific areas of medicine relevant for pregnancy (for instance immunologist, endocrinologist, etc.) and examine how data sharing between different HC units are regarding patient sharing about pregnancy.
2. Further develop the PP proposed in Chapter 5.4, by adding the period after birth and until the child is at intensive childcare (approx. two years), with the intention to achieve continuity in the delivered care.
3. Add functions to the ELISA app, at least to achieve the level of features implemented in Ad Voca. Features like full security authentication and authorization mechanisms, finishing UI flexibility feature, where the user can adapt the main page according to their specific needs, video-audio chatting, rewriting Schema-viewer, the module adapted for flutter applications, to give users more control on schemas.

An essential aspect for the successful development of ELISA as a fully functional app and satisfaction of GDPR is an adaptation of consent-viewer for the mParent needs. To satisfy this a more specific investigation shall be done. The features present in *Ad Voca*, are abstract enough today, to cover the specific need for a targeted category of patients, but further research is needed eventually adjusting it to ELISA. An example can serve involvement in the pregnancy process of parents, which at some stage may need more attention and need to give their consents to use their data for further investigations.

Another future work beneficial for ELISA is the development of flexible API which will provide more options to cover all aspects of the communication facilities which ELISA specification offer. Also, further integration of ELISA with EPR Ad Vitam shall be done simultaneously. This approach will give the opportunity to enhance the services offered by ELISA and control in practice their functionality on real EPR used by medical staff. This further integration with Ad Vitam has the potential to prove the usefulness of the identified requirement in this thesis.

An important area which also would produce valuable insights is the use of AI for diagnosis and identification of the patients which fall under the various group of risks for pregnancy (for instance after birth complication or bad living habit consequences).

10 Conclusion

The main aim of this MSc thesis was to develop a prototype of ELISA for helping parents to plan their activities during pregnancy. These activities include information about the changed status of the women, the situation in the family and the fetus, but also communication with supporting HC professionals.

To examine all requirements for the development and possible use for such an app, 4 research questions have been defined. the answers from these 4 questions are resulting from interdisciplinary work.

Investigating theories and practices from Health Informatics helped to identify and organize necessary activities through a patient pathway, that each pregnant and her closest persons should pass during this period. This pathway includes the most common activities needed to be done or can be done and communication between important stakeholders for these activities. For this thesis, this pathway is the most common pathway, with activities not meeting any complication or not needing special attention. The knowledge from technology development and innovation helped to find potential technical possibilities and integrate novelties about the patients' activities for designing and developing prototypes.

The first research question "*What is the most common pathway for a pregnancy, without complications?"* was answered in Chapter 5.4 with the creation of a PP. The defined PP covers the main activities during a healthy pregnancy period and shows main interactions between patients and HC institutions, e.g. the decisions about next visits and necessary communication with HC professionals. Knowing about the PP gives the possibility to plan several activities in advance and avoid eventual information inconsistencies. The possibility to plan visits with healthcare professionals can also help to avoid unnecessary visits to the GPs or the Midwives (Chapter. 5.3.1). By doing this, eventually economic and management burden can be taken away from Health Institutions.

The second research question "*What are the most common challenges in a pregnancy period for parents, and healthcare professionals during this time?*" was answered in Chapter 5.3 with the identification of most common challenges faced by patients and experts involved in antenatal care. These challenges illustrated examples for the fragmented communication between patients and the Norwegian antenatal HC services, e.g. planning problems, missing information about medication, visits etc. Results from this research promise that ELISA has a significant potential for solving many of these fragmentation related problems, as mentioned in Chapter 5.3.

The third research question "*How can a mobile application best support parents during their pregnancy?***"** was answered in Chapter 5 and 8. Different features which ELISA requires to give better support for parents. One of these features can be communication support between HC units and patients. This implies full-duplex, and half-duplex

communication with the possibility to have real-time communication channels (video audio chatting), answering questionnaires', receiving and sending notifications and much more. Another feature can be the guidelines based on PP for offering implicit-guideline - a most common PP without complications. And explicit-guideline - activities which include concrete activity plans like next visit to the doctor, essential things to learn before next meeting starts or other planned activities or actions related to pregnancy (physical activities, meetings with other future mothers, etc.), drug administration guideline, and more.

The fourth research question "*Which are the most suitable technologies for supporting pregnancy apps?*" was answered in Chapter 6 and 7 with the identification of most suitable technologies for the satisfaction of the requirements for ELISA. Answers to this question led us to understand that ELISA requires to be composed of several "pieces" of the system with different responsibilities. For example, ELISA should be seen as the part which is located closer to the patients offering a user-friendly interface with the possibility to store locally and securely data, to accomplish tasks for proper communication and planning. Another "piece" Ad Voca (server side of the application) should guarantee authentication and authorization application to benefit from offered services (like chatting, receiving of schemas and more). Another "piece" Advoca_proxy should ensure communication between EPR (connected to Helsenett) and ELISA (connected to the web). All these "pieces" have been implemented with different technologies best suited for the proposed task which these "pieces" have to accomplish.

This thesis showed the design and development process of ELISA, resulted in a prototype and anchored to some research from the area. All these activities can be further investigated with more proper design, tests and better anchoring to existing literature. However, with the available resources for this MSc thesis, it can be considered that ELISA, can support the **knowledge-based-pregnancy** policy proposed by Norwegian Directorate (Chapter. 5.1) and leading to a breakthrough for HC technologies supporting activities needed to handle during pregnancy and early child-care. This can be valuable knowledge and can be adapted to each patient needs at the *"right time and the right place."* The design of the proposed app allows to receive and send information such that unwanted consequences from bad practices, may be reduced.

By all said above one can deduce that ELISA may be more just a simple application which will facilitate planning in pregnancy. It has a potential to be a system that will allow even more social interaction, ensuring all participants in this process with secure, fast and trustable tools, helping with better access to currently available resources, and by this make parents life less stressful.

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Table 2: Design-Science research Guidelines (Hevner et al., 2004:p.83)

Guideline	Description
1: Design as an Artefact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
4: Research Contributions	Effective design-Science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach the desired end while satisfying laws in the problem environment.
7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

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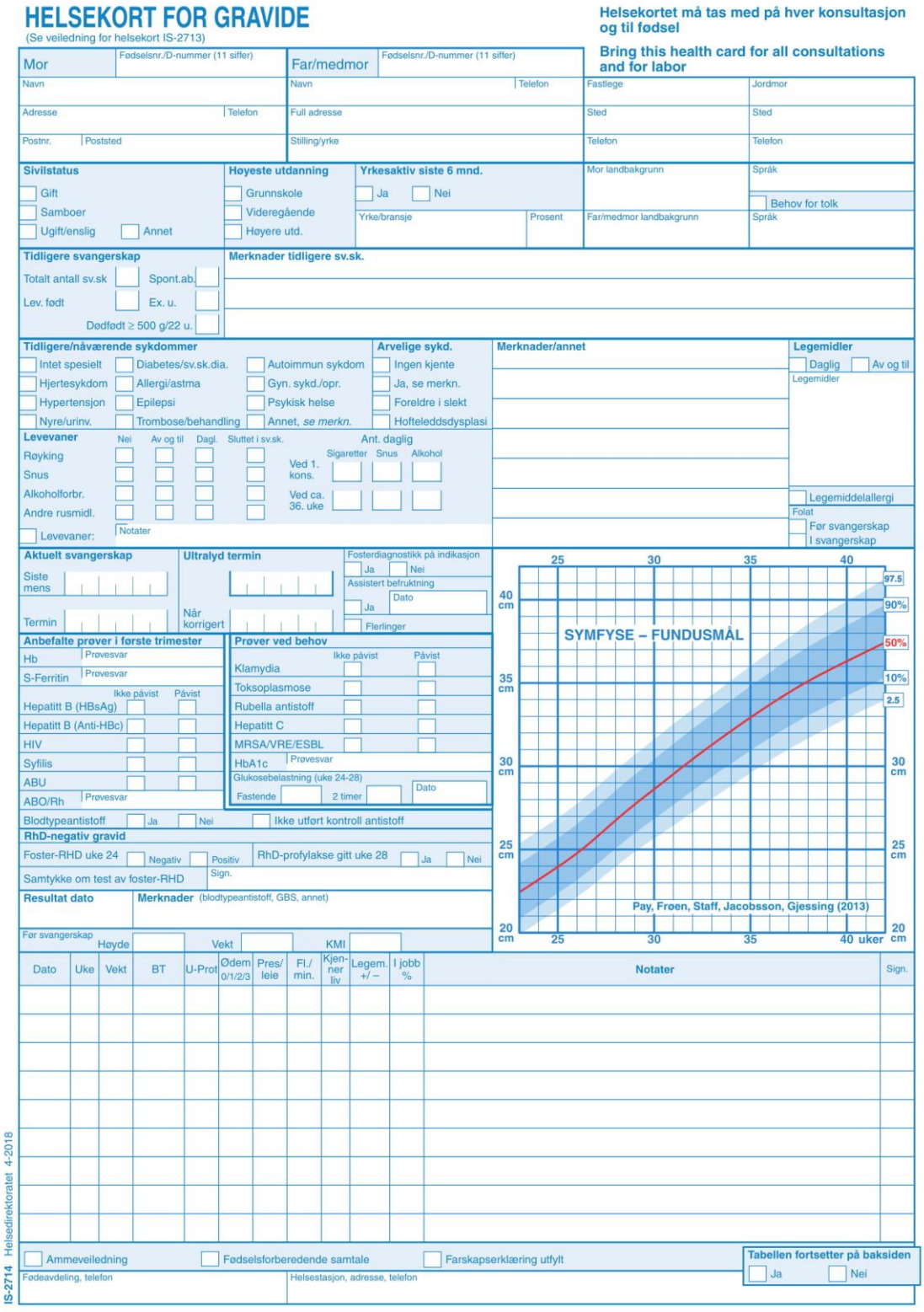
Figure 20: Helse Kort for Gravide



Mor	Fødselsnr. /D-nummer (11 siffer)	
	Navn	

HELSEKORT FOR GRAVIDE
Kontinuasjonsark

Dato	Uke	Vekt	BT	U-Prot	Ødem 0/1/2/3	Pres/ leie	Fl./ min.	Kjen-ner liv	Legem. +/ –	I jobb %	Notater	Sign.

For notater/merknader/fødeplan ved behov

INFORMASJONSSKJEMA FØDEAVDELINGEN

ST. OLAVS HOSPITAL
UNIVERSITETSSYKEHUSET I TRONDHEIM

Vi vil gjerne at du skal fylle ut dette skjemaet og ta det med ved første besøk/ultralydundersøkelse ved fødeavdelingen.

Hvis dette ikke er mulig, send det i god tid før fødselen til fødeavdelingen.

Opplysningene blir brukt i Melding om fødsel til Folkeregisteret og Melding til Medisinsk Fødselsregister

Termin ultralyd: **År:**

PERSONALIA

Etternavn:		Fornavn:	Ev. mellomnavn:
Pikenavn:		Personnummer 11 siffer:	Fødested:
Adresse i Folkeregisteret:		Postnr./-sted:	Trygdekontor:
Stilling/yrke:	☐ Ikke yrkesaktiv ☐ Yrkesaktiv heltid ☐ Yrkesaktiv deltid	Arbeidsgiver:	Utdanning: ☐ Grunnskole ☐ Videregående skole ☐ Høyere utdanning
Bransje:		Arbeidsgivers adresse:	
Tlf. privat	Tlf. mobil	Pårørendes navn, adresse, tlf.:	

STATSBORGERSKAP, SIVILSTATUS OG TROSTILHØRIGHET

Statsborgerskap:	Språk:	☐ Enslig ☐ Samboer ☐ Gift År	☐ Skilt ☐ Separert ☐ Enke
Tilhører du statskirken? JA ☐ NEI ☐	Annen trostilhørighet/kirkesamfunn:		

BARNETS FAR/MEDMOR

Navn:	Personnummer 11 siffer:	Statsborgerskap:	
Adresse i Folkeregisteret:	Postnr./-sted:	Tlf.:	Sivilstatus
Tilhører barnets far statskirken? JA ☐ NEI ☐	Annen trostilhørighet/kirkesamfunn:	Stilling/yrke:	

HELSEOPPLYSNINGER OG LIVSVANER

Navn på fastlegen din:		Navn på jordmor/helsestasjon:
Har du en kjent allergi? JA ☐ NEI ☐	Spesifiser din allergi:	
Har du annen kjent sykdom? JA ☐ NEI ☐	Hvilken sykdom/sykdommer?	
Bruker du medikamenter regelmessig? JA ☐ NEI ☐	Hvilket medikament/medikamenter?	
Regelmessig kosttilskudd? JA ☐ NEI ☐	Multivitaminer: Før sv. skap ☐ I sv. skap ☐	Folat/folatsyre: Før sv. skap ☐ I sv. skap ☐
Har du vært syk under svangerskapet JA ☐ NEI ☐	Hvilken sykdom/sykdommer:	
Har du i dette svangerskapet vært innlagt på sykehus? JA ☐ NEI ☐	Innlagt ved St. Olav: ☐ Hvilken avdeling: Annet sykehus: ☐ Årsak til innleggelse:	
Er det arvelige sykdommer i din familie eller i barnets fars familie: NEI ☐ JA ☐ Hos hvem?: Dersom ja, spesifiser: Diabetes ☐ Kromosomfeil ☐ Hjertefeil ☐ Hoftefeil ☐ Annet ☐ Spesifiser annet:		
Bruker du alkohol? JA ☐ NEI ☐ Tidligere ☐	Bruker du narkotiske stoffer? JA ☐ Nei ☐ Tidligere ☐	
Røykte du ved sv.sk. begynnelse? Nei ☐ Daglig ☐ Av og til ☐ Antall sig. Daglig:	Røykte du ved sv.sk. avslutning? Nei ☐ Daglig ☐ Av og til ☐ Antall sig. Daglig:	
Snuste du ved sv.sk. begynnelse? Nei ☐ Daglig ☐ Av og til ☐	Snuste du ved sv.sk. avslutning? Nei ☐ Daglig ☐ Av og til ☐	
Samtykker du at det blir gitt opplysninger om yrke til: Medisinsk fødselsregister? JA ☐ Nei ☐	Samtykker du at det blir gitt opplysninger om dine røykevaner til: Medisinsk fødselsregister? JA ☐ Nei ☐	

TIDLIGERE FØDSLER

År	Hvor fant fødselen sted (sykehus)?	Barnets kjønn	Barnets vekt ved fødselen	Fødselsforløp -normal -kur -keisersnitt -blødning -andre komplikasjoner	Fødselens varighet (timer)	Forløp de første uker etter fødselen -normal -feber -blødning	Ammet du lenge?	Lever barnet frisk?

ANDRE SYKEHUSINNLEGGELSER

År	Hvilket sykehus/avdeling?	Årsak/sykdom	Behandling	Ev. bemerkninger

Har du tanker eller opplevelser omkring tidligere fødsler, aborter eller den forestående fødselen som du vil at jordmor skal vite?

Dato: Signatur:

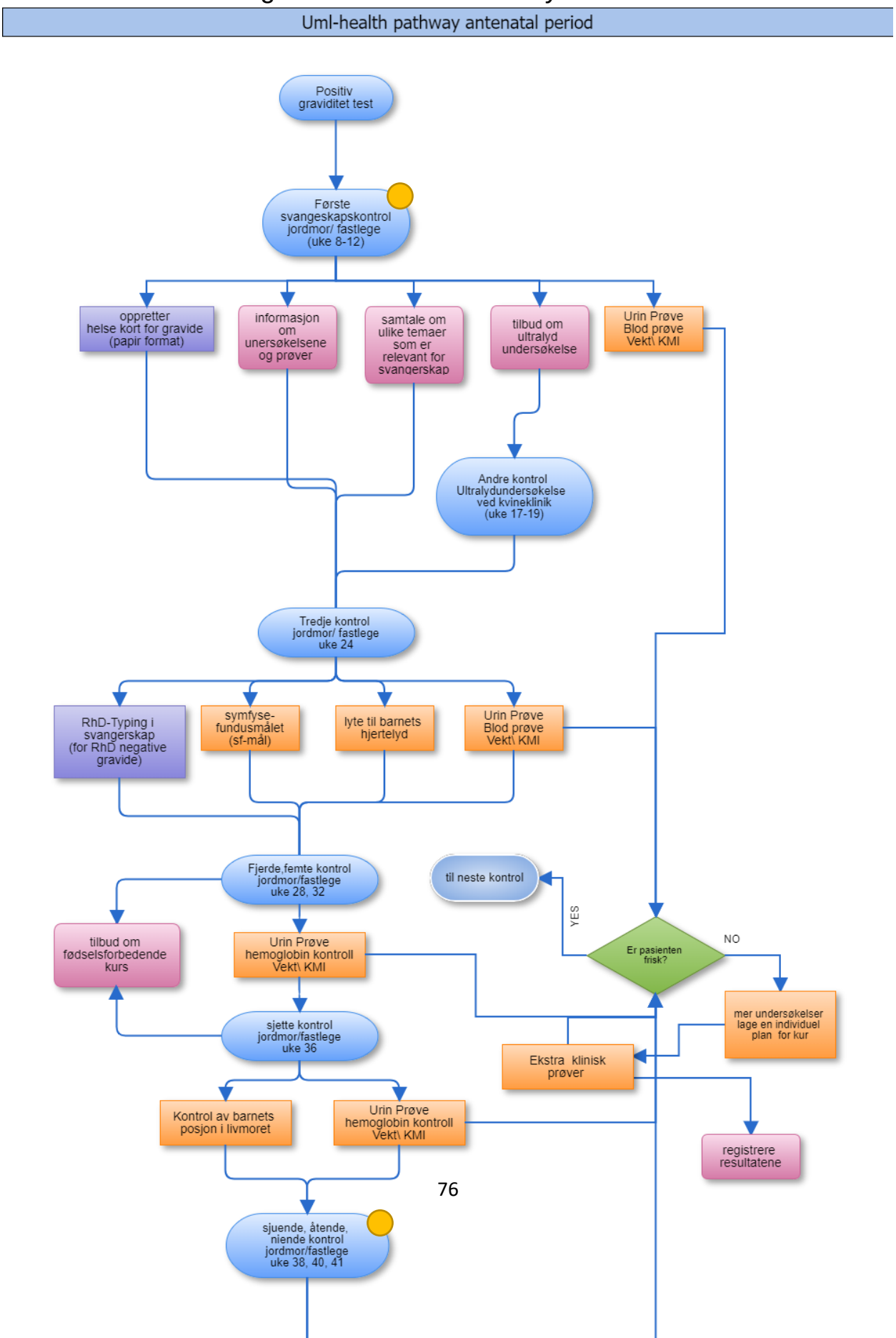
Dersom det er vanskelig å formulere tanker om fødselen eller om ev. tidligere opplevelser nå, kan du skrive et brev senere i svangerskapet, sende det til:

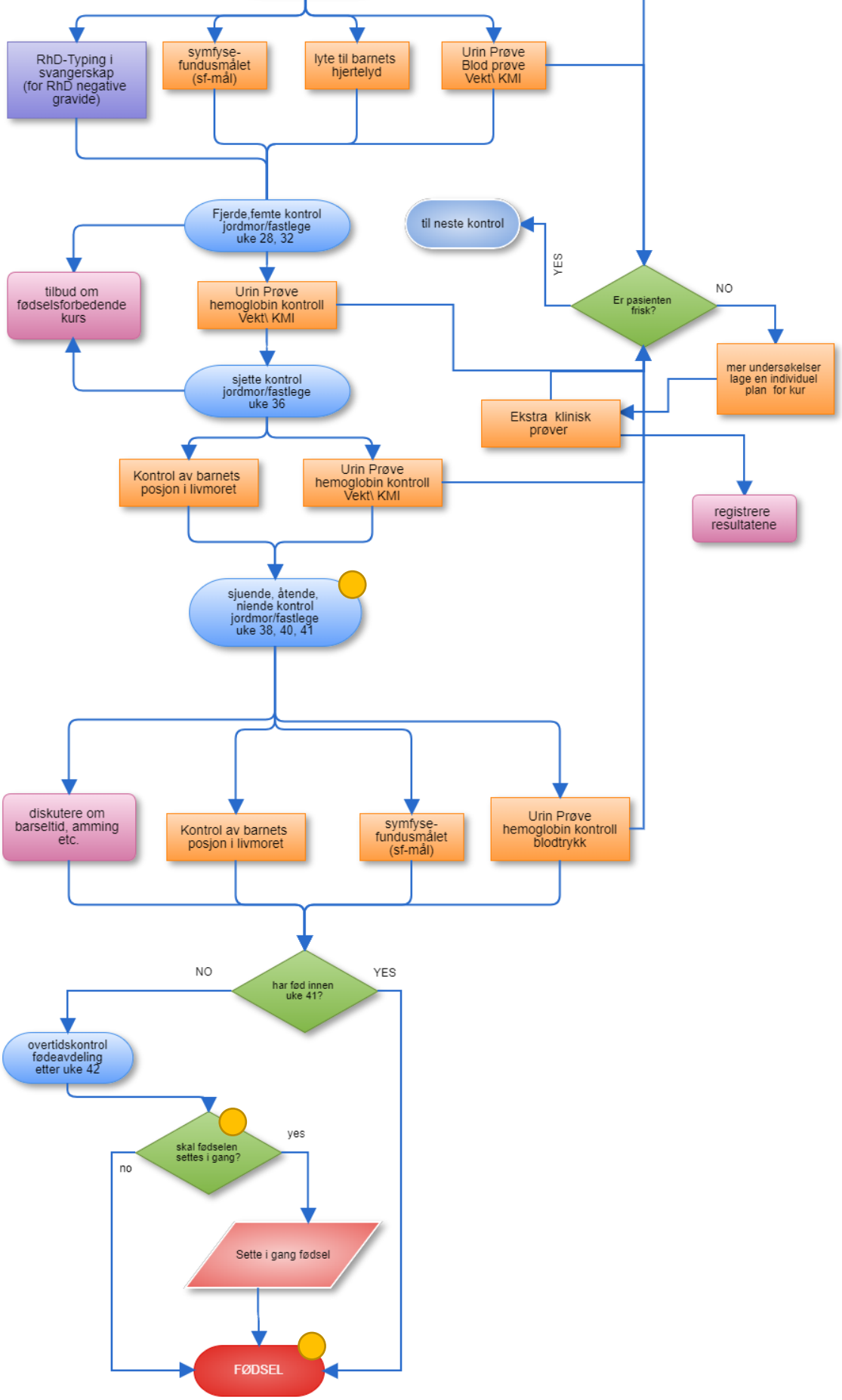
St. Olavs hospital HF
Fødeavdelingen
Postboks 3250, Torgarden
7006 TRONDHEIM

Tlf. fødeavdelingens ekspedisjon: **72 57 57 77**

Figure 21: Informasjonskjema for Fødeavdelingen

Figure 22: Patient Pathway




RhD-Typing i svangerskap (for RhD negative gravide)
symfyse-fundusmålet (sf-mål)
lyte til barnets hjertelyd
Urin Prøve Blod prøve Vekt\ KMI
Fjerde,femte kontrol jordmor/fastlege uke 28, 32
til neste kontrol
YES
Er pasienten frisk?
NO
tilbud om fødselsforbedende kurs
Urin Prøve hemoglobin kontroll Vekt\ KMI
mer undersøkelser lage en individuel plan for kur
sjette kontrol jordmor/fastlege uke 36
Ekstra klinisk prøver
Kontrol av barnets posjon i livmoret
Urin Prøve hemoglobin kontroll Vekt\ KMI
registrere resultatene
sjuende, åtende, niende kontrol jordmor/fastlege uke 38, 40, 41
diskutere om barseltid, amming etc.
Kontrol av barnets posjon i livmoret
symfyse-fundusmålet (sf-mål)
Urin Prøve hemoglobin kontroll blodtrykk
NO
har fød innen uke 41?
YES
overtidskontrol fødeavdeling etter uke 42
skal fødselen settes i gang?
yes
no
Sette i gang fødsel
FØDSEL