HOPE Platform Digital Tool for Type 2 Diabetes

Supporting Newly Diagnosed Patients in Self-Care

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Abstract

Type 2 diabetes is a chronic disease whose incidence has increased with more than 200% during the past 20 years. The increasing number of type 2 diabetes patients could result in more patients suffering from lower quality of life and life threatening complications. Furthermore, the growing need of care will increase the load on healthcare. To counteract this effect, digital tools could be used to put more care responsibility on the patient.

The aim of this project was to find and implement the relevant features for a digital type 2 diabetes tool for newly diagnosed patients. The final goal was to encourage self-care, reduce anxiety and thus improve quality of life, while decreasing the risk of complications.

The research process of this project consisted of five phases: literature study (to find relevant features and their clinical evidence), interviews (to find the desires of patients and practitioners), data analysis (to prioritise features), development of the features and evaluation of the tool.

The results showed that important features were documentation of blood glucose measurements, patient education, data transfer, communication and care plan overview, but even more important was the possibility to individualise the tool for different patients. The evaluation indicated that a clear care plan overview that was easy to understand could help the patient prioritise care activities. Furthermore, patients could be encouraged by reminders, seeing improvements and having continuous communication with healthcare. It was found that for positive clinical outcomes, high usability is essential. To reach patient acceptance the tool must be relevant and easy to use. It must also give valuable output, such as decision support for self-care or new knowledge. To reach practitioner acceptance the tool should be based on evidence based methods and integrate well with existing systems.

Finally it was concluded that the knowledge and technology needed to build a successful tool is already present, they only need to be put together and formulated in a way which is understandable and useful for both patients, caregivers and developers.

Keywords

Type 2 diabetes, diabetes management, diabetes self-care, digital tool, HOPE platform, digitised care plan
Sammanfattning

Diabetes typ 2 är en kronisk sjukdom vars incidens har ökat med mer än 200% de senaste 20 åren. Det stigande antalet patienter med diabetes typ 2 kan leda till att fler patienter blir lidande av lägre livskvalitet och livshotande komplikationer. Dessutom ökar det stigande vårdbehovet belastningen på vården. För att motverka denna effekt kan digitala verktyg utvecklas så att mer ansvar kan läggas på patienten.


Projektets forskningsprocess bestod av fem faser: litteraturstudie (finna relevanta funktioner och deras evidens), intervjuer (kartlägga krav från patienter och vårdgivare), dataanalys (prioritera funktioner), utveckling av funktioner i HOPE platform och slutligen utvärdering av verktyget i HOPE platform.


Slutligen drogs slutsatsen att kunskapen och tekniken för att skapa ett lyckat verktyg redan finns, men att kraven måste sammanställas och formuleras på ett sätt som är förståeligt och användbart för både patienter, vårdgivare och utvecklare.

Nyckelord

Diabetes typ 2, diabeteshantering, egenvård för diabetes, digitalt verktyg, HOPE platform, digitaliserad vårdplan
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List of acronyms and abbreviations

BGL  Blood Glucose Level
BMI  Body Mass Index
CE  Conformité Européenne
CGM  Continuous Glucose Monitor
EQ-5D  European Quality of life 5 Dimensions
EU  European Union
FYSS  Physical activity in disease prevention and treatment
GDPR  General Data Protection Regulation
HADS  Hospital Anxiety and Depression Scale
HbA1c  Hemoglobin A1c
HOPE  Healthcare Operability with Patient Engagement
IDF  International Diabetes Federation
PAID  Problem Areas In Diabetes
PDL  Patient Data Act
PGHD  Patient Generated Health Data
PROM  Patient Reported Outcome Measure
SBU  Swedish Agency for Health Technology Assessment and Assessment of Social Services
SSDF  Storstockholms Diabetesförening
Chapter 1

Introduction

Twenty-one years ago, in 2000, the number of adults with diabetes was estimated to 151 million worldwide [1]. Today this number has increased with more than 200%, to 463 million people. According to the International Diabetes Federation (IDF), this number is expected to keep increasing. As seen in Figure 1.1, projections made in 2019 give estimates of 578 million by 2030 and 700 million by 2045.

Figure 1.1 – Projections of global prevalence of diabetes in ages 20-79 years. Reprinted from [1] with permission from the IDF.

One of the major reasons for the increase is growing urbanisation and change of lifestyle. Higher standard of living brings more inactivity, unhealthier diets and obesity, which increases the risk of diabetes type 2 [3].

Diabetes is a chronic disease which arises when insulin production in pancreas is changed or if the cells become less sensitive to insulin [4]. If
handled correctly, the disease can be managed and the diabetic can live a long life. However, if poorly managed the risk of complications is high. In the worst case, diabetes can lead to premature death. With the increasing number of diabetes diagnosis, the number of diabetes related deaths is also increasing. According to the IDF, 11.3% of global deaths in 2019 were diabetes related [3]. The increase in diabetes-caused deaths qualified the disease to the World Health Organisation’s list of top 10 causes of death globally [5].

Some of the long-term complications of diabetes are diabetic eye disease, cardiovascular diseases, kidney disease and lower limb amputation [6]. Since diabetes affects the whole body, there are many healthcare professionals involved in the care of a single patient. In Sweden, such a team always consist of a diabetes doctor and a diabetes nurse, but it can also include a nutritionist, podiatrist, physiotherapist and psychologist, depending on the patient’s needs [7]. The purpose of the team is to give the patient the best prerequisites to handle the disease. Figure 1.2 shows the diabetes team around a patient.

![Figure 1.2 – Representation of the diabetes care team.](image)

There are different types of diabetes (type 1, type 2, pregnancy diabetes, etc.), but the most common one is type 2, which 90% of all diabetes patients are diagnosed with [4]. The significant difference between type 1 and 2 is that for type 1, the immune system destroys the insulin production cells in pancreas, while for type 2, the insulin production is inhibited and the cells become less sensitive to insulin but there is still insulin in the system. For type 2 diabetes, the disease is often related to an unhealthy lifestyle and by making adjustments in lifestyle the risk of complications can be reduced. Thus, the self-care for a type 2 diabetes patient is very important to reach the best possible outcomes.
Problem Statement

In Sweden, the fraction of diabetics is estimated to 5% of the adult population and just as in the international projections made by the IDF, the Swedish numbers are expected to keep increasing [8]. As already mentioned, diabetes demands constant monitoring, not only of glucose levels, but also for signs of complications. This means diabetes patients have a constant communication with many different parts of healthcare.

There are two major problems with the increasing number of diabetes patients. Firstly, patients suffering from disease risk lower quality of life and life threatening complications. Secondly, the increasing need of care will also increase the load on healthcare. Therefore, more research must be conducted on how to make the diabetes care more efficient.

One way to improve care structure and health outcome for type 2 diabetes patients could be to put more of the care responsibility on the patient, which can be done with the support of a digital tool. This thesis aims to contribute to the knowledge base of such tools and how they are best developed and used. The research questions to be answered by this thesis are found below.

- How can digital tools make newly diagnosed patients with type 2 diabetes feel more secure and confident in their self-care?
  - How can a mobile application help the patient in prioritisation of care activities?
  - How does healthcare communication platforms encourage self-care?
  - What are the most relevant parameters to monitor from a self-care perspective?
  - How is this data best processed and presented in the application?
  - What are the requirements for patient acceptance of a digital tool?

In this thesis, a tool for newly diagnosed diabetes type 2 patients will be implemented on ADDI Medical’s HOPE platform. The aim of the tool is to give the patient a structured care plan and a way of communicating with caregivers. Hopefully, this will encourage self-care, reduce anxiety and thus improve quality of life, while decreasing the risk of complications and make diabetes care more efficient.
Chapter 2

Background

To enable development of a successful digital tool for diabetes type 2 self-care deep knowledge of the disease, its risks and possible treatments, is needed. Studies have shown that mobile health interventions can lead to health outcome improvement for patients with chronic disease conditions [9]. Still, not all care providers are using such interventions, probably because existing tools are not fulfilling all necessary criteria. Therefore, it is crucial to take those criteria into account in the development of a diabetes tool. Research within the field has revealed some of these criteria to be: smooth and easy integration, easy administration for all parties, resulting patient engagement and clinical soundness (level of supporting evidence) [10]. Furthermore, the patient perspective must also be considered. The tool must be implemented to handle the challenges of patient acceptability, such as the application not giving enough meaning and routines, or the application being too time consuming to use [11]. This chapter will cover both the background of type 2 diabetes and a brief state of the art of similar technical tools.

2.1 Diabetes Mellitus Type 2

Diabetes mellitus is a condition of chronic hyperglycemia [4]. This condition can arise from different causes and depending on these causes diabetes can be classified into different types. The most common one is diabetes type 2, which accounts for 90% of all cases. Patients with type 2 diabetes have a gradually decreasing beta cell function, which means the insulin production is delayed and insufficient. Furthermore, the cells’ insulin sensitivity is reduced, leading to difficulties utilising glucose. Type 2 diabetes diagnosis is more common in elderly people, but can also be seen in younger patients, due to physical
inactivity, unhealthy diet and obesity [12]. The main risk factors for type 2 diabetes mentioned by the International Diabetes Federation (IDF) are:

- Family history of diabetes
- Overweight
- Unhealthy diet
- Physical inactivity
- Increasing age
- High blood pressure
- Ethnicity
- Impaired glucose tolerance (higher blood glucose than normal, but below threshold for diabetes)
- History of gestational diabetes
- Poor nutrition during pregnancy

The most important part of managing type 2 diabetes is making changes in lifestyle [12]. By being physically active, not smoking and maintaining a healthy diet, the blood glucose levels can be controlled. However, over time this might not be enough and pharmaceuticals may become necessary. Usually, type 2 diabetes patients are prescribed oral medication, such as metformin which reduces insulin resistance, or sulfonylureas which stimulate insulin production in the pancreas [4]. If the oral medication is not sufficient or if the plasma glucose values are already high when diagnosed, insulin injections can be used. To see how well the diabetes is managed, the Hemoglobin A1c (HbA1c) level is measured on a regular basis [13]. HbA1c is a measurement of how much glucose is attached to the red blood cells. HbA1c is sometimes called long-term blood glucose level because it reflects the blood glucose levels over the past 2-3 months. For well-managed type 2 diabetes, the HbA1c value should be below 42 mmol/mol. Higher values can entail greater risks of complications.
2.1.1 Complications

Diabetes complications can be divided into two categories, acute and long-term. The two major acute complications are hypoglycemia and ketoacidosis. Hypoglycemia arises when the blood glucose level is too low, which can happen to a diabetic when the time between food intakes is too long or if the person is more physically active than usual [14]. If the blood glucose gets too low, the patient can lose consciousness and repeated hypoglycemia can lead to brain damage or cardiac arrhythmia [4]. Ketoacidosis means there is too much insulin in the blood. In case of ketoacidosis, the body starts using fat instead of carbohydrates which leads to the release of ketone bodies [15]. If no action is taken against the ketoacidosis, the person will lose consciousness.

For the long-term complications, the symptoms can be more diffuse. Some of these chronic complications are cardiovascular disease, eye disease, poor oral health, kidney disease and foot complications [16]. The risk of cardiovascular disease is increased due to high blood glucose, high blood pressure and high cholesterol. Cardiovascular diseases (such as coronary artery disease and stroke) are the most common cause of death for diabetics.

The risk of both acute and long-term complications can be reduced with good diabetes management and control [16].

2.1.2 Psychological Stress

Apart from the physical complications, many diabetes patients also suffer from psychological morbidity. The results from a study by Feng et al. showed a five-fold risk of reporting significantly poorer quality of life for people with a type 2 diabetes diagnosis [17]. The study also showed that the diagnosis could be associated with spending less time with friends and family, as well as less phone contacts and other contacts outside home. This shows how diabetes type 2 can have a negative impact on the patient’s social life and thus also negatively affect mental health and disease management.

A study by Nefs et al. showed that 26% of the participants diagnosed with type 2 diabetes met the criteria for depression at least once during a 2.5 years period [18]. The study also showed that once present, it is common that depression is recurrent or becomes chronic in type 2 diabetics. Nefs et al. also stated that their results implied that a simple self-report question could help predicting future depression.

Evaluating the prevalence of depression in newly diagnosed type 2 diabetes patients (less than 3 months since diagnosis), Bajaj et al. found that the prevalence was significantly higher compared to age- and sex-matched healthy
controls [19]. The level of depression was measured with the Beck Depression Inventory self-assessment form. Both the group of diabetes patients and the control group consisted of 60 persons. The results showed that depression was present in 26 of the 60 diabetes patients and only in 8 of the 60 individuals in the control group. The article also highlighted the importance of depression screening with self-scored questionnaires.

2.1.3 National Treatment Guidelines

In Sweden, the National Board of Health and Welfare has created national guidelines for support and guidance for decision makers within the field of diabetes. The guidelines include recommendations regarding measures to be taken for adult diabetics [8]. The national guidelines consists of 140 recommendations about prevention and lifestyle, cardiovascular disease, glucose control, diabetes care, complications and diabetes and pregnancy. A priority score between 1 and 10 has been assigned to all recommendations, where 1 is most important and 10 is less crucial. There are 10 recommendations rated as priority 1, eight of them with the purpose of preventing complications and the other two to control glucose levels. Some of the top rated (priority score 1) recommendations that are relevant for this thesis project are:

- Provide support to quit smoking
- Provide support for increased physical activity
- Offer yearly test of albumin levels in urine, for early detection of renal disease
- Offer fundus photography every third year, for early detection of retinopathy
- Offer diagnosis and treatment from a multidisciplinary foot team, for prevention of diabetes feet with wounds that are hard to cure

The first version of the national guidelines for diabetes was written in 2015 and the document has been reviewed twice (2017 and 2018) since then.

2.1.4 Prevalence in Sweden

According to projections by the IDF, there would be 700 million diabetics worldwide by 2045 [3]. This projection implies an increase with more than 50% in about 15 years. In 2015, similar projections were made for the diabetes
situation in Sweden specifically [20]. This study considered four different scenarios: constant incidence and decreased mortality, increased incidence and decreased mortality, decreased incidence and mortality, and both constant incidence and mortality. For all scenarios considered, the prevalence of diabetes was expected to increase between 2014 and 2050.

2.2 Patient Involvement

Healthcare is moving towards a system in which the patient is taking a more active role than ever [21]. With the goal to take the patient’s preferences and values into account, while giving the best possible care, medicine is taking a more patient-centered approach. This way of working also favours the ethical principle of autonomy, by letting the patient make their own informed decisions about their health.

In a report by the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU), patient involvement is defined as the patient being somewhat involved in care and treatment decisions [22]. However, it is also mentioned that patient involvement could be defined as the patient’s engagement in their life situation, or a relation between patient and caregiver in which the caregiver lets the patient make decisions. The report by SBU includes a summary of the effects of various interventions within patient centred care. In the summary, the evidence of each intervention is graded, to show how interventions can enhance patient involvement. Some of the interventions with evidences on various levels are person-centred care planning, patient-directed decision support, group education in self-care, motivating conversations and chronic disease self-management program (CDSMP). By using these methods within care of chronic diseased patients, positive effects can be received for outcome measures related to patient involvement.

2.2.1 Patient Generated Health Data

An example of enhancing patient involvement is to give diabetes patients the possibility to regulate their insulin dosage with support from their diabetes nurse [22]. To make this possible, the patient makes continuous measurements of their blood glucose levels. This is an example of making use of Patient Generated Health Data (PGHD). PGHD are data recorded by the patient themselves [23]. The purpose of PGHD is to gain further understanding of the patient’s health and thus make more informed decisions about how to
address health concerns. Other examples of what can be included in PGHD are symptoms, lifestyle choices and biometric data, but it can also be other data.

In a study by Cohen et al. the experiences of healthcare workers using PGHD in outpatient clinics were examined [24]. The study was conducted in five different areas: adults with asthma, elders at risk for cognitive decline, young adults with overweight, people with Crohn disease and premature infant caregivers. What data was collected differed slightly between the areas, but all groups were provided with a tool to visualise the data to more easily find patterns. The following three main advantages were identified by the caregivers:

1. "Deeper insight into a patient’s condition"
2. "More accurate patient information, particularly when of clinical relevance"
3. "Insight into a patient’s health between clinic visits, enabling revision of care plans for improved health goal achievement, while avoiding unnecessary clinic visits"

The study also revealed three areas of consideration for implementation. These areas were to develop protocols and practice workflows for the use of PGHD, how the data should be stored, accessed and how to deal with privacy concerns and finally how to make the use of PGHD easy.

### 2.2.2 Self-Care

As already mentioned in Section 2.1, self-care is an important part to minimise the risk of diabetes complications. To promote self-care, it is important to give relevant support to the patient. In Sweden, the most common methods to promote self-care for chronic diseased patients are group education, internet based tools, motivational conversations and education in empowerment [22]. The findings in the report by SBU showed that there is limited or moderate evidence for the positive effects of group education, more specifically it could increase confidence in self-care and reduce HbA1c. For motivational conversations, there was moderate evidence that physical activity could increase temporary for some chronic states. The evidence of empowerment and internet based tools was not assessed.
2.2.3 Evidence Based Methods

In Sweden, evidence based methods are used in healthcare by systematically striving to build healthcare from best available knowledge [25]. The National Board of Health and Welfare has developed an evidence based model, which describes how several knowledge sources should be weighed together to reach be best possible outcome. The model shows how professional expertise should build on knowledge from the patient’s situation and contextual circumstances, the patient’s experience and wishes, and finally also the best knowledge available. An illustration of the model can be found in Figure 2.1.

![Figure 2.1 – The evidence based model: professional expertise is based on the other three sources of knowledge.](image)

The quality of best knowledge available can vary depending on how much research has been conducted on the intervention [25]. Reliable evidence comes from scientific studies evaluating the effects of an intervention and thus such studies can be called best available knowledge. However, sometimes no scientific studies have been conducted, in which case one might have to rely on other sources giving an indication about the outcomes of an intervention. By combining the sources of the evidence based model, optimal healthcare decisions can be made.

2.3 Digital Healthcare

One of the most important parts of type 2 diabetes management is self-care [4]. To help diabetes patients make the right health decisions in their daily lives, the development of digital tools has increased with the raising use of smart phones [26]. Existing digital interventions have various aims and are using different technologies. Thirteen interventions, such as insulin management applications, continuous glucose meters, automated text messages, digital
health diaries and virtual health guidance, were evaluated in a state of the art by Shan et al. (2019) [26]. Out of the 13 interventions studied, eight demonstrated clinically and statistically significant efficacy. However, Shan et al. (2019) also draw the conclusion that more research is needed to find what particular features promote patient engagement and clinical efficacy.

2.3.1 Virtual Clinics

An area that has been explored in Sweden recent years are virtual clinics. The concept of a virtual diabetes clinic is currently tested and evaluated in a Swedish study at Ersta Hospital [27]. The application used in the study is Vista Dialog and it is tested with diabetes type 1 patients. The aim of the application is to withhold a continuous dialogue between patient and caregiver, during a long-term care commitment [28]. Vista Dialog allows the patient to initiate contact and to book meetings with caregivers. It is also possible to upload documents, photos and data from insulin sensors. The clinical trial study of Vista Dialog has not been completed yet and thus no conclusions can be drawn on the topic of clinical improvements. However, the virtual clinics has been discussed globally too. Due to the COVID-19 pandemic the question of virtual diabetes consultations was raised in the UK [29]. According to Quinn et al. the pandemic has brought the opportunity to take a big step towards digitised diabetes care. Some of the identified advantages of virtual clinics are not having to be exposed to a high-risk environment (such as hospitals), higher accessibility, collaboration between different healthcare professionals could be simplified and a chance to have a social contact in the time of social distancing and shielding. Apart from these positive aspects there are also challenges to overcome, such as the patients having a negative view of the virtual clinics or the problem of not being able to take blood tests, urine samples, etc. However, even if these are the challenges that developers struggle with today, they are not impossible to overcome in the future.

2.3.2 Mobile Applications for Diabetes Care

Over the past decade, the use of mobile applications for managing chronic diseases have become more and more common [30]. The applications can be categorised into different groups depending on their target groups and strategies. In a report by the IDF Europe, the applications were divided into the following three groups [30]:

1. Tracking/logging
2. Nutrition

3. Fitness

Tracking gives the patient a tool for documenting relevant information, such as glucose levels, pharmaceutical intake and physical activity. This information can later be analysed and treatment can be based on found patterns in the patient’s everyday life. Nutrition applications aim to help the diabetic with food choice and nutrition tracking. Again, this can help the patient find patterns and also give motivation to a healthier lifestyle. The purpose of the fitness applications, the final category, is to help the patient keep track of their physical activity. They might include features such as progress measurements and the possibility to set goals.

Overall, the IDF Europe report takes a positive stand on using mobile applications for diabetes management [30]. However, the quality of these interventions are very variant and it can sometimes be hard for patients to find what can actually be of help. In the end of the report, the IDF Europe gives recommendations on several different levels (patient, caregiver, political and developer) on how to reach the full capacity of mobile applications. Patients are recommended to read application reviews, both by patients and caregivers, look for information about the developing company and also to test the application in coordination with their caregiver. Among other things, healthcare professionals are encouraged to review scientific literature and listen to feedback from patients. Finally, it is suggested that developers should consult with patients and caregivers during development and also refer to scientific research within the application.

2.3.3 Technology Integration in Clinical Workflow

One of the most challenging parts of implementing digital healthcare tools is the integration in the clinical workflow. In a study from 2017 Swedish primary healthcare nurses were interviewed about their perception of digital eHealth services for support of patient self-management [31]. Based on the interviews, Öberg et al. identified the following three themes:

1. "Caregiving in the midst of digital chaos"
2. "Lacking overview and control in one’s daily work"
3. "Mixed feelings towards digitalisation"
The first theme included not having time or skills to follow the fast development and seeing digitisation as a threat to the nurse-patient-relationship. The second theme was about professional expertise being questioned and work schedules not being adapted to the new circumstances. Finally, the last theme covered the topic of mixed feelings such as exciting but exhausting and both impaired and improved care. The conclusion drawn by Öberg et al., is that moving towards extended use of technology in healthcare requires further education for practitioners. Furthermore, it is important that care providers are given the chance to use digital tools for supporting patient self-management, while still maintaining the highly valued person-centered care.

Similar research has been conducted outside Sweden. An Australian study from 2019 revealed the fear of technology increasing clinicians’ workload without giving enough benefit [32]. Clinicians also expressed the concern of change in their role as caregivers. Face-to-face care, as well as the nature of consultations were highly valued and the risk of technology changing these resulted in an acceptance barrier. The solution proposed by Ayre et al. is to minimise disruption in clinical workflow and ease workload by automation and integration with current technology. This action, along with others mentioned in the article, could lead to stronger practitioner engagement in the development of digital tools.

2.3.4 HOPE Platform

Just as the rest of the society, healthcare is constantly becoming more and more digitised. eHealth is already a given part of many of the work tasks performed by hospital workers on a daily basis [33]. As healthcare keeps going towards extensive digitising, many of the routine controls can be done by the patient herself. To enable this progression, HOPE (Healthcare Operability with Patient Engagement) platform was developed for communication around each patient.

The platform consists of several building blocks, such as activity planning, clinical decision support, automation, visualisation, etc. The flowchart in Figure 2.2 shows the different parts of the system that are closely linked to support the information and communication flow between patient and care provider [2]. HOPE automation includes automated care flows, clinical decision support, triage and evidence based scores. HOPE integration enables integration with other systems such as "BankID", "Swish" and "PayEx". With HOPE communication, notifications, confirmations, etc., can be used. Finally HOPE meetings includes chat and video functionalities.
HOPE platform is CE marked [34], which separates the application from other commercial health applications. The CE mark ensures quality and enables medical counseling.

Apart from MDD93/42/EEC, HOPE platform also fulfils the following laws and regulations:

- General Data Protection Regulation (GDPR)
- Patient Data Act (PDL) (2008: 355)
- Regulations of the National Board of Health and Welfare, (SOSFS 2008: 14)
- Record keeping and processing of personal data in healthcare (HSLF-FS 2016: 40)

Other safety measures taken are authorisation with BankID or SITHS (a safe e-identification for healthcare workers) and transfer of encrypted data with Transport Layer Security. These, in combination with the ones mentioned above, make HOPE a secure platform, suitable for sensitive data handling.
2.3.5 Laws and Regulations for Digital Healthcare

To be able to put a medical device on the European market it has to comply with the European safety requirements [35]. Depending on what type of medical device, there are different directives to follow. HOPE platform is Conformité Européenne (CE) marked with the Medical Device Directive (MDD 93/42/EEC). In 2017, the Medical Device Regulations were adopted to replace the two existing directives (Medical Device Directive and Active Implantable Medical Devices Directive) [36]. However, due to a four-year transition period the new regulations will not enter into force until May 25th 2021. The purpose of the new regulation is to address weaknesses in the old ones, for instance reinforcing the designation and process criteria for oversight of Notified bodies, increased transparency through an European Union (EU) database and stricter requirements on manufacturers to perform post-market surveillance.

Apart from the Medical Device Directive, the application must also fulfill other directives and regulations [35]. Two important regulations for medical information systems are GDPR and PDL. GDPR for handling personal information and PDL for personal health data.

General Data Protection Regulation (GDPR)

The aim of GDPR is to regulate rules regarding protection of processing of personal data and free movement of personal data [37]. Anyone processing data from the European Union must comply with the the seven protection and accountability principles defined in GDPR. These principle are:

1. Processing must be lawful, fair and transparent to data subject
2. The data processing must comply with the purposes which were initially specified to the data subject at collection
3. Data collection should be minimised to what is necessary for the purpose specified
4. Personal data must be accurate and updated
5. Personally identifying data may only be stored for as long as necessary for specified purpose
6. Appropriate security, integrity and confidentiality must be ensured during processing
7. The person responsible for the data must be able to show how all principles above are fulfilled

In addition to these principles one of six instances, in which personal data processing is legal, must also be fulfilled. An example of such an instances is unambiguous consent from the data subject.

**Patient Data Act, PDL (2008: 355)**

The Patient Data Act (PDL) applies to all caregivers, in both public and private sector and it includes regulations for handling personal health data [38]. Some of the regulations in PDL are concerned with:

- **Direct access:** the caregiver can give the patients direct access to care documentation
- **Electronic health records:** records can be shared between several caregivers if the requirements in PDL are fulfilled
- **Inner confidentiality:** only the person in need of the data for their work within healthcare are eligible for access
- **Record blocking:** the patient has the right to block data in their record

Health data is further regulated by the Patient Data Regulation (2008:360), as well as the National Board of Health and Welfare’s regulations and general guidelines concerning patient records and processing of personal data within health and medical care (HSLF-FS 2016:40) [38].
Chapter 3

Methodology

The research approach in this thesis was to use qualitative methods, such as literature searches and interviews, to formulate requirements for a digital type 2 diabetes tool. The development of the tool was based on the results found with the qualitative methods. Finally, the tool was evaluated through an evaluation form after a four days long pilot run.

3.1 Research Process

The research process consisted of five major phases, with several sub-tasks. Each major phase was dependent on the previous phase, which gave the project a natural workflow. The five major phases of the project were literature study, interviews, data analysis, development and evaluation. The research process, with phases and sub-tasks, are found in Figure 3.1.

Figure 3.1 – The research process of the project.
3.2 Literature Study

The first phase of the thesis work consisted of a literature study. The aim of the literature study was to gain deeper understanding of diabetes and technical interventions used in diabetes care today, as well as to learn more about possible features and how they can influence the patient. By studying official guidelines and multiple clinical studies of different features, the tool could be built with features that have proven clinical advantages. Further searches were carried out to determine the most suitable interview technique. Based on these searches and the literature study, the interview protocols were created. Two protocols were created, one for patients and one for practitioners. The protocols can be found in Appendix A and B.

3.2.1 Database Search

The searches for the literature study were carried out in two databases, "PubMed" and "MEDLINE". The search words used were "diabetes" or "diabetes type 2" or "type 2 diabetes" combined with "digital tool", "mobile application" or "digital patient education". The inclusion and exclusion criteria used can be found in Table 3.1.

<table>
<thead>
<tr>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature identified via selected search words in PUBMED and MEDLINE</td>
<td>Literature from other sources</td>
</tr>
<tr>
<td>Primary sources</td>
<td>Reviews and systematic reviews</td>
</tr>
<tr>
<td>Literature in English</td>
<td>Other languages than English</td>
</tr>
<tr>
<td>Published between 2011 and 2021</td>
<td>Published before 2011</td>
</tr>
<tr>
<td>Considering type 2 diabetes</td>
<td>Only considering type 1 diabetes</td>
</tr>
</tbody>
</table>

Table 3.1 – Inclusion and exclusion criteria for literature review.

From the findings in the literature study, a list of features was created and the features’ impact on patients were summarised.

3.3 Interviews

Eight interviews were conducted to gain better understanding of diabetes and the course of disease the first three months. Since the aim of the thesis work was to create a tool both for patients and caregivers, individuals from both
groups were interviewed, five patients and three nurses. Patient interviews gave knowledge in how different people react to a type 2 diabetes diagnosis and what is desirable in a digital tool. Practitioner interviews complemented this information with details on how newly diagnosed patients are handled and what data is valuable to them for giving the best possible care and support.

3.3.1 Interview Protocols

After considering several interview forms described in literature [39], a semi-structured interview approach was selected. This approach ensured that the necessary information was gathered while still being open for new ideas or suggestions. Two interview protocols, one for patients and one for caregivers, were created to make sure the important main questions were answered. The protocols can be found in Appendix A and B. Questions were asked in an open manner to encourage wide and thorough answers.

After the interviews, the participants were asked to rank features on a list. These were the features found in literature. The list included 21 features, categorised into three categories. The themes of the categories were patient features, practitioner features and feedback/visualisation. The ranking form can be found in Appendix C.

3.3.2 Interview Analysis

For the qualitative analysis of the interview material, a coding process was carried out. First, all interview recordings were transcribed. Then, the following coding steps described by Bryman et al. were conducted [40]:

1. Initial transcripts were read without taking notes
2. Transcripts were read again, this time making marginal notes with key words (codes)
3. Codes were reviewed: words or phrases describing the same phenomenon were removed
4. More general ideas in relation to codes and data were considered

The aim of using this method was to identify themes in each interview and find what they had in common, to enable more general conclusions.
3.4 Data Analysis

The results from the literature study analysis, the interview analysis and ranking sheet were compiled to find what features should be implemented. The top features and their importance were mapped. In this analysis, the evidence found in previous clinical studies and usability studies of applications with different features were weighed together with the desires of patients and caregivers. From this analysis, a list of features to be developed was created.

3.5 Development

The development of the tool was divided into two sub-tasks. The first sub-task was creating forms for tasks such as answering lifestyle questionnaires. The second sub-task was to write the automation code, so that input could be handled and transformed into valuable output.

3.5.1 Forms

The first sub-task of the implementation was to create the forms that would be filled in mainly by the patient. For each feature that was planned to be implemented, evidence based methods for data collection of the specific type were found and implemented.

Simple forms were created for input of blood glucose level, weight, waist circumference, steps taken and blood pressure. These forms only included two input lines, one for the measurement (blood glucose level and one for the date and time of the measurement). More complex forms were created for lifestyle evaluation, physical activity monitoring, psychological health monitoring and goal setting. The number of input values to these forms varied between 2 and 20 and could be of different formats, such as strings, numerical or single- or multiple choices. The questions of these forms could also be set to depend on previous answers, to make them more individualised for the specific patient.

3.5.2 Automation Code

Automation code was written to handle the input from the application. The main purpose of the automation code was to take in measurements from the patient and output relevant feedback. The code was written using several libraries provided by ADDI Medical. The libraries made it possible to take input values from the application and return output values.
The blood glucose value visualisation was created using the .NET plotting library ScottPlot. The diagram class took in all blood glucose measurements, food intake input and goal values from the application. The blood glucose curve was plotted, with blood glucose value in mmol/liter on the y-axis and date and time on the x-axis. The goal value was also plotted in the same graph as a red horizontal line. Furthermore, food intake was marked with different symbols for meal and snack, using the PlotBitmap function included in ScottPlot.

In the automation code for physical activity representation, a dictionary for storing the physical activity of the current week was created. When an activity was registered in a new week, a new dictionary was created. Each time a new physical activity form was filled in, the values of the dictionary were updated. The weekly summary was presented to the user in text at the bottom of the physical activity form.

In the PAID form, the patient answers each statement on a five point scale. The scale ranges from not a problem to severe problem. Each answer was converted into a numerical value from zero to four. Each value was added to the total sum. If the score was above two, the statement was added to a list of problem areas. Finally, the total sum was multiplied by 1.25 to get the PAID score. If the PAID score was above 40, the level of distress was returned as severe. If the PAID score was below 40, the level of distress was set to low. The results of the PAID form was displayed at the bottom of the form.

3.6 Evaluation

Finally, the usability of the application was evaluated in a small pilot run. Due to lack of time, the application could not be tested on diabetics. Instead, personas with different diabetes backgrounds were created to model user experiences.

For each persona, tasks were created. The persona description, tasks and instructions for participants can be found in Appendix E. Eight fellow students were provided with a persona and asked to download the application to their phone. An unmoderated remote usability testing approach was chosen so that the participants could test the application for several days and integrate it in their everyday life. After four days of use, all participants filled in a post-test questionnaire in HOPE. This questionnaire can be found in Appendix D. The results from the form were compiled and analysed, and improvements based on the analysis were suggested.
3.6.1 Diabetes Personas

Four newly diagnosed diabetes personas were created. All personas were represented by a set of elements and textual descriptions to communicate their personality, behaviour and tasks, as suggested in literature on usability testing [41]. An example of such a representation is found in Figure 3.2. The personas were inspired by material provided by ADDI Medical and by the findings in the interviews. Furthermore, scenarios for each persona were created, to guide the participant in their use of the tool. An example of the tasks of a scenario for one persona is found in Figure 3.3. All personas and scenarios can be found in Appendix E.

![Figure 3.2 – Example of persona.](image-url)
3.6.2 Post-test Questionnaire

The form was designed to let the participants evaluate their overall experience, as suggested in *Usability Testing Essentials* [42]. The questionnaire consisted of 18 questions and the questions were formulated to map back to the research questions of the thesis. For most questions a five point Likert scale was used. Some questions were answered with a three point scale, because they might be hard to answer more specifically than that. These types of scales were chosen to allow the participants degrees of opinions, instead of limiting them to yes or no. The form also included some open questions, giving the participant the possibility to give more elaborated answers. The post-test questionnaire can be found in Appendix D.
Chapter 4

Results and Analysis

This chapter covers the results and analysis of the project. The major results found are presented in five sections: results from literature study, results from interviews, results from data analysis, development and evaluation. The literature study and interviews sections also include an analysis of the results.

4.1 Results from Literature Study

The main focus of the database search was to find clinical studies and usability evaluations for digital tools with various features. Furthermore, studies aiming to find relevant features through interviews and questionnaires were also included to extend the support for prioritising features.

4.1.1 Database Search

The searches stated in Section 3.2.1 resulted in 1606 potentially relevant publications. Out of the 1606 publications, 31 fulfilled the inclusion/exclusion criteria stated in Table 3.1 and were included in the analysis.

A total of 21 different features for digital diabetes tools were found in literature. These 21 features were divided into three groups, practitioner input, patient input and feedback/visualisation. This division was made to clarify what is inputted by whom and what is automatically outputted or provided by the system. The features in the patient input group could be further categorised into measurable parameters (blood glucose, body weight, blood pressure, medication, sleep, diet and physical activity) and mental aspects (self reflection, goal setting and diabetes diary). All features are found in Table 4.1. The features can also be seen as information going between patient
Results and Analysis

and practitioner, through the application. A visual representation of this information flow can be seen in Figure 4.1.

<table>
<thead>
<tr>
<th>Practitioner input</th>
<th>Patient input</th>
<th>Feedback/visualisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet plan</td>
<td>Blood glucose</td>
<td>Blood glucose over time</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Body weight</td>
<td>Physical activity over time</td>
</tr>
<tr>
<td>recommendations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overview of care plan</td>
<td>Blood pressure</td>
<td>Links to external resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medication</td>
<td>Guidelines</td>
<td></td>
</tr>
<tr>
<td>Sleep</td>
<td>Patient education</td>
<td></td>
</tr>
<tr>
<td>Self reflection/emotional</td>
<td>Messaging system</td>
<td>Communication via chat/email</td>
</tr>
<tr>
<td>change</td>
<td>(reminders/motivation)</td>
<td></td>
</tr>
<tr>
<td>Goal setting/action planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes diary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1 – Features found in literature.

Practitioner Features

Overall, 19 out of the 31 publications included some sort of practitioner feature [43–61]. The most common feature was data transfer to clinician, which was included in 13 publications [43, 45–47, 49, 50, 55–61]. Other practitioner features mentioned in literature were overview of care plan [45, 54, 56], motivational feedback [43, 44, 46], recommendations regarding physical activity and diet [48, 60], virtual coaching [43], and personalised advice [49]. In Table 4.1, virtual coaching, motivational feedback and personalised advice are included in communication and messaging system under feedback and visualisation.
Patient Features

The patient features were divided into the two subgroups measurable parameters and mental aspects. For both groups of features, the patient gives input to the application.

Measurable Parameters

A total of 24 out of the 31 publications described some sort of measuring feature [43–56, 58–60, 62–68]. The most common measurement was blood glucose levels (20 out of 24 publications) [43–56, 58–60, 63, 64, 66, 67], closely followed by diet (18 publications) [43–53, 62–68] and exercise (14 publications) [43, 44, 46, 47, 49–52, 63–68]. Other measurements mentioned in the literature were weight [44, 47–50, 54, 62, 64, 66, 67], blood pressure [44, 45, 47, 50, 54, 60, 62], medication intake [44–47, 50, 60], BMI [44, 54], sleep [54] and cholesterol [64].

Mental Aspects

The mental aspect or quality of life in respect to diabetes was only considered in eight out of the 31 publications [43–47, 54, 69, 70]. The quality of life was measured with the Problem Areas In Diabetes (PAID) form, the EQ-5D [43, 47], Short-Form 36v2 Health Survey [44], Hospital Anxiety and
Depression Scale (HADS) [47], Quality of Life scale (IQL-test) [47] or the diabetes distress scale [69]. Furthermore, psychosocial data was collected simply by having the patient answer questions such as “Have you been feeling nervous and stressed?”, “Do you feel that you get enough sleep and do you feel rested?” and “How are you doing?” [54] or by having the patient rating their quality of life on a numerical scale [70]. One of the interventions did not include any assessment of mental health [46]. However, the importance of the mental aspect was still stressed in a segment called lack of motivation. This segment aimed to keep the patient committed to treatment. Some interventions included features such as digital counselling with a nurse supervised by a clinical psychologist [44] and diabetes related emotional state monitoring [45].

Feedback and visualisation

Feedback and visualisation features were included in 29 of the 31 publications [43–67, 69, 71–73]. The most common feedback or visualisation feature was some kind of representation or visual graph of blood glucose measurements. This feature was included in 19 publications [43–52, 54–56, 58, 60, 62, 63, 66, 67]. The second most common feature in this category was patient education, which was included in 18 publications [45, 46, 48–51, 54–56, 60, 64–67, 69, 71–73]. Patient education could include messages with information about diabetes, video clips and quizzes in the application. Depending on the depth of the patient education, it could cover everything from blood glucose measurements to physical activity and diet to mental coping with the disease. Other common features were chat, email or sms communication with practitioner (found in 12 publications) [46, 48–50, 53, 56, 57, 59, 61, 66, 73], goal setting (11 publications) [44, 46, 47, 50, 51, 54, 55, 63, 64, 66, 69] and messaging system with reminders (11 publications) [46, 48–50, 53, 56, 57, 59, 61, 66, 73]. Less common features were practitioner feedback on blood glucose values, which was included in six studies [44, 50, 55, 60, 63, 66] and motivating feedback, included in five studies [43, 44, 46, 49, 51]. Finally, two features were found only in one publication each, these were guidelines [53] and links to external resources [65].

4.1.2 Literature Study Analysis

In Section 4.1.1, the most frequently mentioned features were presented. In this section, the level of evidence in each publication is considered to find the features with the strongest evidence of positive outcomes. The publications
found in the literature study included both clinical studies, with quantitative results, and usability and patient engagement studies, with both qualitative and quantitative results. To simplify analysis, these two kinds of publications were analysed separately. Some of the publications did not include any evaluations of inventions, instead these only used interviews or questionnaires to find relevant features. Thus, these publications are not considered in this section.

**Clinical Evidence**

Out of the 31 publications, 11 included a clinical study. Among these, six stated that their invention could reduce HbA1c levels or improve glycemic control [43, 55, 58–60, 73]. Five could not prove any significant change in HbA1c levels [44, 47, 62, 68, 69]. However, in most of these articles it was also mentioned that changes were greater for those who used the application more. Also, many of the articles with significant change in HbA1c mentioned that greater improvements were related to more frequent use of the tool. One of the reports with clinical studies evaluated the weight reduction, rather than HbA1c [68]. This study showed that stronger engagement lead to greater weight loss. The relation between more frequent use of application and greater clinical improvements proves the importance of usability, for a tool to trigger patient engagement.

Considering the features of the studies with positive clinical outcomes, the most common features were input of blood glucose levels and data transfer to practitioner. These features were present in five of the six studies with clinical evidence. Among the five studies that could not prove any clinical effects, only two included tracking of blood glucose and only one included data transfer to clinician. Furthermore, four of the studies with proven clinical effects included a blood glucose visualisation over time and three studies included patient education. These features were found in less of the studies with no proven positive outcome.

**Usability and Patient Engagement**

Ten publications included in the literature study claimed that their invention improved patient awareness or helped patient engage in their diabetes care [45, 48, 49, 54, 61, 63, 69–72]. Considering the features of these studies, the most common one was patient education, which was included in eight out of the ten publications. The second most common feature was blood glucose input, which was present in six studies. Furthermore, some studies suggests use of theoretical models for behaviour change to improve patient engagement [50–
Apart from these features, no other features were found in more than half of the patient engagement publications. Only three publications in the literature study that included letting patient test an application, also included an analysis of what features were actually used. For two of these, the top feature was blood glucose measurements [43, 54] and for the third it was viewing prescriptions and clinical data [46]. Other top features in terms of usage were recording of well-being and overview of care plan.

Two studies showed that usage of the application went down over time [43, 47]. Considerations for prolonging the use of the application could be making the application easy to use [49, 52] and not too time consuming [49]. Furthermore, the application needs to be meaningful and have good accuracy, as well as being easy to integrate into everyday life with minimum effort [63].

### 4.2 Results from Interviews

To get the perspectives of both patients and caregivers, interviews were conducted with individuals from both groups. Participants were found via Storstockholms Diabetesförening (SSDF). In total eight people participated in individual video call interviews. Out of which three were healthcare professionals working with type 2 diabetes in primary care, and five were patients diagnosed with type 2 diabetes. All nurses were female and working mainly with type 2 diabetes care. The group of patients included both males and females, with time since diagnosis ranging from 3 to 16 years. The interview time varied between 20 and 45 minutes, depending on how thorough answers were given. All interviews were conducted in Swedish.

#### Diagnosis and first meeting

All three nurses said that depending on the how the patient is diagnosed, the delivery of the diagnosis and the help the patient receives can be different. Sometimes the patient is diagnosed by a doctor and then gets an appointment with a diabetes nurse, and sometimes the patient is diagnosed by a nurse. However, most often the patient meets with a diabetes nurse as soon as possible after diagnosis for more information and guidance.

The first meeting with the diabetes nurse is shaped after the background of the patient. Usually, the first meeting includes a discussion about lifestyle and how diabetes affects the body. The nurses described how they tell the patient about how food, physical activity and weight reduction can minimise
the negative effects of diabetes. Also, complications are described, and the patient learns how to measure their blood glucose level. As already mentioned, the meeting varies a lot between patients since it is based on the patient’s prior knowledge. Therefore, the information can sometimes be spread out on more than one meeting, some people might need up to 5 meetings. During or before the first meeting, the patient fills in a lifestyle form. Two of the nurses used a “Self-evaluation lifestyle form”, while the third one filled in the lifestyle details directly into the patient record. Filling in this form gives the nurse a rough indication about the lifestyle of the patient and what might be possible areas to improve.

During the patient interviews it became clear that the diagnosis handling was different for all the patients. Some patients did not understand the meaning of the diagnosis and did not take it very seriously or denied it, while others panicked and felt very sad about being diagnosed with a chronic disease. Many of the interviewees did not have type 2 diabetes in their family, and for them it was hard to understand why they had gotten the disease. The main cause of worries at the debut seemed to be having to take medications, unstable blood glucose levels and getting complications.

Some of the things the diabetics mentioned as things they would have wanted to know at the debut of the disease were: more precisely what to eat, that the HbA1c value could be pushed down, what was included in their care plan, how physical activity and stress affects the blood glucose levels and more strict ordinations so that the patient understands that it is a serious disease.

**Care plan and first ordinations**

According to the nurses, a care plan is created for all patients. This plan can include several different activities and it is custom made to fit the specific patient. The care plan includes activities such as weight reduction, stop smoking, physical activity, but also follow-up meetings with doctor and nurse, eye doctor consultations and foot specialists. All nurses said the care plan is usually delivered to the patient orally.

The most common first ordination seems to be lifestyle changes. The patient is recommended to be more physically active. The nurses also mentioned that the ordinations must be based on the interest of the patient, if the patient does not want to work with the suggested behaviour there is no point in trying to make them. Therefore, a lot of effort from the nurses goes into making the patient understand the causes of the disease and how to
decrease the risk of complications as much as possible.

Most patients mentioned that they had changed their lifestyle. Some had become more physically active, while others had started to think more about eating healthy. However, more than one of the patients did not have an unhealthy lifestyle to start with. For those patients it was harder to make changes that affected their blood glucose levels.

Most patients said that it was very clear that the most important lifestyle change was to become more physically active. Regarding diet, the patients thought that the ordinations were not specific enough. As already mentioned, many of the interviewees were not overweight, and for them the ordination to eat half a cinnamon bun instead of a whole did not make any change to their lifestyle. The support from healthcare seemed to vary a lot between different caregivers. Some patients were happy with their support, others thought the support was good but that they did not know what to ask. There were also patients who thought the healthcare support was not enough, they did not feel the endorsement they needed to make behavioural changes. Overall it seemed like the patients would have wanted more information and concrete guidance.

All patients went to see their nurse or doctor between one and four times a year. They were also referred to an eye doctor for fondus photography on a regular basis. Depending on the risk level of the patients’ feet, they got their feet examined either by their nurse or by podiatrist.

**Measurements and follow-up**

Most type 2 diabetes patients have their own blood glucose meter, from which they can document their values manually. Some patients have a Continuous Glucose Monitor (CGM), but it is only available for patients with severe type 2 diabetes. There is no standard for how often the patient needs to measure their blood glucose level. Some patients have very stable values and do not need to measure often, while other patients have a greater need for measurement. Other important measurements mentioned by the nurses were weight, blood pressure, food intake, physical activity and waist measurements. One nurse also said that it would be good to be able to choose which parameters to track in a potential application, so that it could be individualised for each patient.

According to the nurses, most patients do not use digital applications for documenting measurements. If the patient is asked to measure their blood glucose levels before a visit to the nurse, they usually just write the values on a piece of paper. The same goes for patients documenting their compliance with
prescribed physical activity and for those who are tracking their food intake during a short period of time before a consultation.

Some patients measure their blood glucose level once a day, others do it up to 7 times a day and some never do it. One patient mentioned using an application for documentation of blood glucose levels, another used a spreadsheet for the same purpose. All patients measured their blood glucose levels to some extent at the debut of diabetes. Some of the patients also documented steps and weight in their phone.

**Digital tools**

All nurses said that their health centre have a chat for communication. The patient could initiate contact with the health centre, either directly with a diabetes nurse or with the health centre in general. One nurse also mentioned that patients could call her, but it was not very efficient because the calls were delayed so that she would get them a day later. She thought it would be good to use chat and email more. Another nurse said her patients could call her during an hour in the morning Monday to Friday and it worked well.

The nurses suggested that measurements such as blood pressure, steps, weight, blood glucose levels could be documented in an application. One nurse said that maybe not all patients would have to come as often as now, if these parameters (especially blood glucose levels) are good. Another nurse stressed the fact that some patients do not have the will to measure anything, while others think it is very interesting. She also mentioned the risk of measurements heightening the stress levels for some patients.

One nurse did not recommend nor did she advice against the use of an application. Another nurse recommended to find an application for tracking food intake and physical activity. The third nurse recommended the application Mysugr, for blood glucose level documentation.

Some features suggested by the nurses were accessing the blood glucose graph before a consultation, warnings when a patient’s levels reach a threshold, both measurable values and psychological state, blood pressure, weight, physical activity and some sort of diary.

According to the nurses, the number of video call meetings have increased during the pandemic. The mentioned positive aspects of video calls were that patients could attend from work or if they were feeling unwell, the meetings could sometimes be more efficient and that all the patient’s questions could be discussed. The disadvantage of video calls were that blood pressure, foot
status and HbA1c could not be measured remotely. Other negative aspects of video meetings are that there is no eye contact and that the nurse cannot see physical changes as easily.

All patients had different opinions about digital healthcare meetings. Some thought that such meetings are good for discussion, while others thought that there were too many disadvantages. Digital meetings can make the contact less personal, which could influence the feeling of security. Some patients preferred video meetings, while others preferred phone meetings. The patients thought that it could be hard to do some of the examinations that are normally a part of a consultation. Examinations mentioned by the patients were foot status, blood pressure and HbA1c.

Most of the patients did not use any digital tool for monitoring their health. Reasons for not using any were lack of interest and not knowing about such tools. One patient used Excel for documentation and visualisation of blood glucose levels and another used an application for the same purpose.

Some desirable features in a digital tool turned out to be blood glucose level documentation, weight tracking, feedback, food intake, reminders, tips, blood pressure documentation, HbA1c measurements and the possibility to ask questions. For the patients to use the application they also said that it needs to be simple, give valuable output, not too time consuming and medically trustworthy.

**Psychological aspects**

The nurses did not use forms for detection of psychological stress or problems. Two nurses thought using such forms could be a good idea, while one nurse thought that she had such good relations to her patients so that she would know if they needed further psychological help. One nurse said that they sometimes used Patient Reported Outcome Measure (PROM) for seeing how the patient was doing and that it could be very good to do that regularly.

All nurses said that to find motivation for self-care, they needed to find what things in life are important to the patient. Such things could be children or grandchildren or simply to live a long and healthy life. To find that motivation all nurses mentioned that they worked hard on telling the patients the risks of not managing their self-care.

One nurse mentioned that they use forms to evaluate how secure patients feel at their health center, but those were not specifically for diabetes patients. However, the same center also arranged patient educations for diabetes patients.
after which they evaluated the patients’ feelings of participation and security. Another nurse suggested that the feeling of security could be elevated by encouraging the patients to think about their well-being over time.

The psychological impacts varied a lot between different patients. Some were not very affected and did not feel any need to talk to someone about the diagnosis, while others were chocked and scared and wanted help to process the notice of disease. Patients were not offered any psychological help. Some patients though this was not relevant, while others stressed that practitioners should be more observant at the debut of diabetes.

Most patients thought that the feeling of security in healthcare came from continuity and competence. Continuity in the sense that the patient sees the same doctor or nurse, so that they do not have to tell their whole story repeatedly. Competence in the sense that the practitioner is a specialist and possesses the relevant knowledge. Some of the motivating factors mentioned by patients were health benefits and awareness.

Education

Two of the nurses said they had patient education until the outbreak of COVID-19 and the third nurse was about to start a patient education. All patient group education got cancelled due to COVID-19. Instead of group education, newly diagnosed patients have been educated during their visits to the diabetes nurses. The nurses have also recommended other sources of information, such as www.1177.se, www.diabetes.se, www.diabeteshandboken.se and various patient associations.

Only one of the patients participated in patient education at debut of disease. The other four had not been offered or had declined to participate. A majority of the patients who had not participated would have accepted an invitation. They thought that it would have been good if the education was provided by healthcare. One patient mentioned that SSDF had educations, but that inconvenient time and costs had been holdbacks.

Almost all patients mentioned Google as a tool for finding information about diabetes. Other sources of information were Facebook groups and books. One patient said that the time with the diabetes nurse was too limited to ask all questions, which is why Google searches became necessary.
Healthcare support

Most patients mentioned www.1177.se as a way of contacting their caregivers. Some patients had the possibility to initiate a chat with their nurse, while others could only initiate contact via telephone. All patients knew how to get in touch with their caregivers, but some thought that it could be very inefficient and that it could take too much time before getting answers. Some patients also mentioned that the nurses and doctors are usually very stressed, which makes it hard to ask all questions during consultations.

4.2.1 Patient Care Flow

The care flow is different depending on the needs of the patients. However, based on the interviews a general care flow for type 2 diabetes patients was created. The care flow can be found in Figure 4.2. This general care flow can be individualised to fit the specific patient.

![Figure 4.2 – Representation of the general patient care flow.](image)

4.2.2 Features From Interviews

The features identified in the interviews are found in Table 4.2. These are features mentioned by nurses or patients, before seeing the list of features from
literature.

<table>
<thead>
<tr>
<th>Practitioner input</th>
<th>Patient input</th>
<th>Feedback/visualisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Care plan</td>
<td>Lifestyle form</td>
<td>Education</td>
</tr>
<tr>
<td>Choose parameters to measure</td>
<td>Blood glucose level</td>
<td>Warnings and notifications</td>
</tr>
<tr>
<td></td>
<td>Weight</td>
<td>Diet feedback</td>
</tr>
<tr>
<td></td>
<td>Waist measurement</td>
<td>Blood glucose graph</td>
</tr>
<tr>
<td></td>
<td>Blood pressure</td>
<td>Chat</td>
</tr>
<tr>
<td></td>
<td>Food intake</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Psychological state/dairy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HbA1c measurements</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2 – Features found in interviews.

4.2.3 Ranking of Features from Literature

All three nurses filled in the ranking sheet. For the first group of features (practitioner input, 3 features) the input was diverse, but the feature with the best rank was "physical activity recommendations". In the second group (patient input, 11 features), the five top ranked features were "blood glucose", "goal setting", "physical activity", "blood pressure" and "diet". The three features with highest rank in the third group (feedback/visualisation, 7 features) were "blood glucose over time", "communication via chat/email" and "patient education".

Four out of five patients filled in the ranking sheet. One patient did not respond despite repeated attempts to get in touch. All patients ranked "overview of care plan" highest in the first group. The answers to the second group were more diverse, but the five highest ranked features were "blood glucose", "goal setting", "weight and Body Mass Index (BMI)", "blood pressure" and "medication". In the last group "patient education" was given the highest rank, followed by "communication via chat/email" and "blood glucose over time".

4.3 Results from Data Analysis

From the results of the literature study analysis and rankings of features from literature, the most relevant features have been compiled into a list which can be found in Figure 4.3. Since the focus of this thesis is the patient perspective,
patient desires are prioritised over practitioners’. The features and their given prioritisation is further explained below.

![Figure 4.3 - Most relevant features from clinical studies, patient desires and usability and patient engagement.](image)

The first item on the list of relevant features is BGL measurements. This was found to be the most important feature for positive outcomes in the clinical studies and the second most important feature for patient engagement. Furthermore, BGL measurements got the highest rank in the patient input category when patients were asked to rank features. Positive clinical results can be argued to be the most important among these three groups, but since the clinical outcomes were in many cases depending on patient engagement, patient education can be seen as the second most relevant feature. Patient education was also highly ranked by patients in the ranking sheet. The third and forth features are data transfer and communication. These were ranked over visualisations both for clinical studies and patient desires. Patients ranked the care plan overview highest in its category and it was also mentioned as a feature that improves patient engagement. Visualisation was prioritised over the remaining measurements in the list because it occurred more frequently in clinical studies with positive outcomes.
4.4 Development

The first task of the development phase was to choose what features to implement. The findings in the data analysis was used as a benchmark for what should be included in the application. Some of the features in Figure 4.3 were already included in the HOPE platform. These features were data transfer from patient to practitioner and communication via chat or email. Due to lack of time, patient education could not be included because it would require an extensive information search and a whole education framework. Instead, two features that were not in Figure 4.3, were included. These features were physical activity and psychological state monitoring. The reason for choosing these features was that they were both raised during the interviews as parameters that are followed up during the appointments with the diabetes nurse. To make the blood glucose visualisation more rich in content, a feature for registering time of food intake was also added. The list of main features chosen to include were the following:

- Care plan overview
- Blood glucose documentation and visualisation
- Goal setting
- Weight, BMI and blood pressure documentation
- Medication reminders
- Physical activity monitoring
- Psychological state monitoring
- Food intake

Each feature takes and returns different types of data. A graphical representation of what data is going into and coming out from each feature are found in Figure 4.4 and 4.5.
Figure 4.4 – Representation what data is going into and out of the features: care plan overview, medication reminders, physical activity monitoring and physical measurements. The input marked with dashed lines are input given by the care provider. All other input is given by the patient.

Figure 4.5 – Representation what data is going into and out of the features: blood glucose documentation, blood glucose visualisation, goal settings and food intake.
4.4.1 Evidence Based Methods for Data Collection

As mentioned in Section 4.4.1, the Swedish healthcare work procedure is built on the evidence based model. Thus, to reach acceptability within healthcare, the features of the tool must be built on evidence. Therefore, after identifying the relevant features, evidence based methods for collecting specific data were found. Evidence based methods were found for mental health and physical activity.

Mental Health

There are several evidence based methods for evaluating mental health. One of the widely used forms is called European Quality of life 5 Dimensions (EQ-5D) [74]. EQ-5D measures the health state in 5 dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. EQ-5D has showed good reliability and acceptable responsiveness for diabetes patients. However, Janssen et al. also concluded that when patients’ baseline scores are close to those of a normal population, the sensitivity of the EQ-5D index might not be high enough to detect relevant changes.

More specifically for diabetics, there is an evidence based questionnaire for evaluation of diabetes distress. This form is called PAID. PAID was not mentioned by the nurses in the interviews, but it is widely used in other countries [75] and the responsiveness of the questionnaire has been proven in several studies [76] [77]. PAID consists of 20 statements, which are graded from 0 to 4 (where 0 is not a problem and 4 is a serious problem) [75]. The total score is multiplied by 1.25 to add up to a maximum of 100. A total score of 40 or more indicates severe diabetes distress and individual item scores above 3 should be addressed in conversations between diabetes nurse and patient.

Physical Activity

Physical activity in disease prevention and treatment (FYSS) is an evidence based handbook for how physical activity can be used for prevention and treatment of various diseases [78]. FYSS includes both a general part and a disease specific part. The diagnosis specific recommendations for type 2 diabetes includes 150 minutes of moderate or 75 minutes of high intensity physical activity a week [79]. According to FYSS, these recommendations have been proven to improve glucose control measured as HbA1c.

FYSS also includes a chapter about how physical activity can be adapted to individuals [80]. In this chapter different ways of maintaining behavioural
change are suggested. One recommendation is to document behaviour through self monitoring. By doing this, the patient can compare their physical activity with short- and long-term goals, which can enhance motivation. The physical activity can be documented in a training diary containing type of activity, frequency, duration and intensity.

4.4.2 Care Plan Overview and Notifications

A general diabetes care plan template was created in HOPE platform. The activities in the care plan were those presented in Figure 4.2. When the template is used for a patient, a care plan overview is created in the application. A screenshot of the overview is found in Figure 4.6. The activities can also be viewed in a calendar view, which can be found in Figure 4.7. Furthermore, the patient can choose to activate push notifications for HOPE. This makes it possible to receive reminders for medication intake, blood glucose measurements, etc. An example of a notification can be found in Figure 4.8.

Figure 4.6 – Activity view: completed tasks are marked with a green box.
Figure 4.7 – Calendar view: activities marked with different colours.
Figure 4.8 – Reminder through push notification: BGL measurement.
4.4.3 Forms

Two types of forms were created. The simple type for input of blood glucose level, weight, waist circumference, steps taken and blood pressure, and more complex forms for lifestyle evaluation, physical activity monitoring, psychological health monitoring and goal setting. An example of the simple form is found in Figure 4.9. An example of a more complex form is found in Figure 4.10, where input lines only appears for steps per week and active minutes per week because the patient has selected these for goal setting.

![Figure 4.9](image) 
Figure 4.9 – Example of BGL measurement form.

![Figure 4.10](image) 
Figure 4.10 – Example of goal setting form.

4.4.4 Automation Code

Handling of Forms

Depending on what type of form was filled out, the automation code handling them was more or less advanced. For simple forms, such as the goal form, the input was only saved to the patient for later use.
**Blood Glucose Level Visualisation**

The blood glucose level over time was plotted in a graph together with the daytime blood glucose level goal value and food intakes. When the patient inputs a blood glucose measurement or food intake, these registrations are automatically plotted in the graph. Because of missing libraries in the current release of the HOPE application, the graph cannot yet be viewed in the mobile application. The graph can however be viewed in the desktop version of HOPE. For the evaluation the graph was sent to the participants at the end of the trial run so that they could give their opinions. An example of the blood glucose visualisation is found in Figure 4.11.

![Blood glucose visualisation graph with symbols for food intake and goal level marked with red line.](image)

**Physical Activity Representation**

The physical activity representation was created according to the training diary mentioned in Section 4.4.1. A weekly representation of physical activity (step frequency, duration, average intensity and distance), cardio workouts (number of workouts, duration, average intensity and distance) and strength workouts (number of workouts, duration and intensity). An example of a weekly summary can be found in Figure 4.12.

**PAID Calculation**

After completing the PAID form, the resulting score, level of distress and problem areas are displayed at the bottom of the form. An example of a PAID from that has been completed is found in Figure 4.13.
4.5 Evaluation

The post-test evaluation questionnaire included 15 multiple choice questions, five questions to further explain multiple choice answers and three open answer questions. For the multiple choice questions, the answers were given on a scale from one to three, from one to five or simply with yes or no. The average numerical scores for the multiple choice questions are found in Table 4.3 and further explained below. The answers to the open questions are also presented below.
Table 4.3 – Average scores for multiple choice questions in post-test evaluation questionnaire.

<table>
<thead>
<tr>
<th>Question</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, please rate how easy or difficult it was to use this application.</td>
<td>4/5</td>
</tr>
<tr>
<td>How easy or difficult was it to navigate the application to accomplish the provided tasks?</td>
<td>4.375/5</td>
</tr>
<tr>
<td>How easy was prioritisation of health activities?</td>
<td>4.125/5</td>
</tr>
<tr>
<td>The notifications were relevant and helpful.</td>
<td>4.375/5</td>
</tr>
<tr>
<td>To what extent did the application make you feel supported by healthcare?</td>
<td>2.65/3</td>
</tr>
<tr>
<td>To what extent did the possibility to open a chat improve your contact with healthcare?</td>
<td>2.5/3</td>
</tr>
<tr>
<td>Did the application make you feel more motivated to practice self-care?</td>
<td>87.5% Yes</td>
</tr>
<tr>
<td>The fact that my input is sent to my care provider encourages me to make lifestyle improvements.</td>
<td>4.375/5</td>
</tr>
<tr>
<td>Using the application took too much time of my day.</td>
<td>4.625/5</td>
</tr>
<tr>
<td>I appreciated the possibility to fill in the PAID form in the application, so that we could discuss my “problem areas” during my visit.</td>
<td>4/5</td>
</tr>
<tr>
<td>I appreciated the possibility to fill in the lifestyle form before my visit.</td>
<td>4.75/5</td>
</tr>
<tr>
<td>How would you rate the graphic representation of Blood Glucose Levels?</td>
<td>4.375/5</td>
</tr>
<tr>
<td>How would you rate the representation of physical activity?</td>
<td>3.75/5</td>
</tr>
<tr>
<td>Would you recommend the application to a newly debuted diabetes patient?</td>
<td>100% Yes</td>
</tr>
<tr>
<td>Could this application help you towards a more healthy lifestyle?</td>
<td>87.5% Yes</td>
</tr>
</tbody>
</table>

The first two questions in the questionnaire, except for which persona was used during the test-run, were about how easy or difficult the application was to use and navigate. The average score for the use was 4 out of 5 (where 1 was difficult and 5 was easy). The lowest score for ease of use was 3 and the highest was 5. For navigation, the average score was 4.275 on the same scale. For this question the minimum score was 4 and max was 5. Furthermore, a question was asked about the ease of prioritising of health activities. The answers to this question were more diverse, with one person finding it somewhat hard to
prioritise, while the other participant found it easy or somewhat easy.

Five out of the eight test participants strongly agreed that the notifications were relevant and helpful, one person agreed and the other two neither agreed nor disagreed.

For the question about support, six out of eight participants answered that they felt fully supported by healthcare, while the other two felt somewhat supported. The participants were also asked if the possibility to contact their nurse via the chat improved their contact with healthcare. Half of the participant group answered that it improved their contact with healthcare much, while the other half said it improved it a little. It is also worth mentioning that the more positive group included the participants that had "contact caregiver through chat" as a task, while the other group had this as an optional task.

Seven out of eight participants said that the application made them more motivated to practice self-care. Reasons mentioned were reminders, satisfaction of getting green boxes for accomplished tasks, seeing how diet and training had an impact on blood glucose levels, seeing improvement in relation to goals and finally also the fact that someone oversees one's lifestyle choices. Furthermore, five participants strongly agreed that the fact that their input is sent to the caregiver encouraged them to make lifestyle improvements. Two participants agreed to the same statement and one did not agree.

Five participants fully disagreed that the application took too much time out of their day. The other three marked the disagree option for the same question.

All participants filled in a form (PAID or lifestyle) before a meeting. Seven out of eight participants appreciated this (indicating fully agree or agree to the question), while the last person indicated neither agree nor disagree.

Three participants indicated that the graphical representation of the blood glucose values was really good, while five indicated that is was good. The improvement suggestions were:

- Add a second goal line, separate goals before and after food intake
- More clear distinction between days
- Include more parameters, such as physical activity
- Make it look more engaging and interesting
The physical activity feature was only used for two personas (four test participants). Out of those, two rated it neither good nor bad, one rated it good and one rated it very good. Improvement suggestions were:

- Simplify registration of strength activities (maybe making it more general)
- Make it possible to fill in daily steps without it being a full physical activity

All participants were asked to mention the two things they liked the most about the application. The answers are summarised below:

- The notifications
- The application was easy to use/user friendly
- The check boxes displayed after completing a task
- Good overview of tasks and measurements
- Explanatory graph
- Makes management of diabetes more fun
- The possibility to chat with a nurse

The participants were also asked to mention the two things they liked the least about the application. The answers for this question were:

- The notification for blood glucose measurements did not lead directly to the registration activity
- Tasks were not marked with colour when not completed, red marks could be used when task is not done
- Lack of gamification/reward system
- Hard to register physical activity
- Not enough notifications
- Not being able to re-open a form that has been submitted
- The fact that date box cannot be left blank
• Missing a spinning wheel for input of date and blood glucose level

To the question if the participants would recommend the application to a newly diagnosed type 2 diabetes patient, all participants indicated yes. Some of the mentioned reasons why were:

• Easy to use
• Good with reminders
• Good way to get structure of what you need to do
• Helps track vital values
• To make diabetes management more fun and manageable
• Great way to learn how to control and live with diabetes, by connecting your diabetes with your lifestyle
• Encourages you to live healthy and strive towards set goals

Seven out of eight participants indicated that the application could help them towards a healthier lifestyle. Reasons mentioned were that reminders, graphical representations and direct nurse contact could be motivating.

The final question was what would make the participant use the application for the first month of disease. The most common answers were the direct support from a nurse, reminders and data tracking.
Chapter 5

Discussion

In this chapter, the results from the previous section are discussed. In the first three sections of the chapter, the areas of the research questions stated in the introduction of the thesis are considered. This discussion is followed by a section covering the methodology of the project. Finally, improvement suggestions and future work are presented.

5.1 Prioritisation of Care Activities

The topic of prioritisation of care activities for diabetes patients was considered both in the interviews, in the evaluation of the developed tool in HOPE and in the literature study. Good prioritisation of care activities means that the patient knows what are his or hers most important tasks to manage their disease. Hence, the patient should know what has to be done and what could be done and why.

In the interviews, several patients mentioned that they did not understand the meaning of their diagnosis or they denied it. It was clear that most patients would have wanted more information from the start, so that they could make the best decisions for their self-care. They also expressed a desire to get stricter ordinations about what lifestyle changes they should have made. The nurses said that the first meeting or meetings with the patient was about sharing knowledge about the disease with the patient. Also, they described how they together with the patient decided what the patient should do. As it seems, the patients and nurses have quite different views of how the first meeting actually is carried out. One explanation could be that there is too much information for the patient to take in and therefore some details get lost. Another explanation could be that not all diabetes nurses have the same
approach, even though the three nurses in the interview study seemed to have similar mindsets. Regardless of which, giving additional information in other forms than oral could help the patient’s understanding. Also, it would give the patient a more deliberate and standardised introduction.

It was also mentioned during the interviews that some of the patients were not aware of their care plan and that they thought it would have been interesting to see it. However, according to the nurses the care plan is usually delivered to the patient in some way. Considering the fact that most patients did not recall learning about their care plan, a care plan overview could probably favour the patients and make them more aware and engaged in their care. Again, information seems to get lost when only delivered to the patient orally. To ensure that the patient perceives the important information, a digital tool could be a good complement. Reminding the patient about what has been said during the meeting through giving the information in the application too could be of great value to the patient.

Considering the results from the post-test evaluation questionnaire, it implies that the overview provided in the HOPE application could help patients in prioritisation. One person in the trial run indicated that prioritisation was somewhat difficult, while all other participants indicated somewhat easy or easy. It is possible that the patient indicating somewhat difficult did not fully understand the structure of the overview. This could be clarified by providing the patients with a more thorough description of the application at start. Furthermore, the application would probably be more easy to understand after actually meeting with a diabetes nurse. That way it would serve more as a complement than a stand-alone tool.

Furthermore, the care plan overview feature was mentioned in three publications in the literature study [45, 54, 56]. In one of these studies, the participants all agreed that a care plan overview was extremely useful for a newly diagnosed type 2 diabetes patient. These results are in line with the ranking sheet filled out by the interviewees in this project, where all patients ranked the care plan overview over physical activity and diet recommendations. These facts further strengthens the statement that such an overview would favour the patient.

In summary, there are indications that a care plan overview could help patients in prioritising. To make this possible, the care plan must be intuitive and easy to understand, while still giving the patient valuable information. It should include clear ordinations from the caregiver and display all care activities with a short explanation of how they are carried out and why. For instance it could be information about the pharmaceuticals the patient has to
take, what they do, their side effects and for how long they must be taken. This way, the patient can learn about their care and take greater responsibility of their own health, which in the end would benefit the whole society.

## 5.2 Self-care Encouragement

As described in Section 4.1.2, the findings in the literature study indicated that greater self-care engagement gives better clinical results. This means that the first step of development must be to create a tool which engages the patient and encourages positive behavioural changes. According to literature, this can be done through patient education and blood glucose measurements, two features that can be included in a digital tool. However, even though these are present, the usage has a tendency of going down over time. This could be handled through having long-term usage in mind during the development and for instance include some sort of reward system to encourage frequent use. Another approach could be to simply make a tool only for newly diagnosed patients. During the interviews it became clear that most interviewees thought a short-term solution would be more realistic, at least to start with, because the most important thing is to learn about how to handle the disease. Learning about the risks of not managing the disease was frequently mentioned as a great encouragement for self-care. It might also be possible to use the same tool for patients with pre-diabetes, to prevent the disease from breaking out. Furthermore, the patients wanted continuity and competence. A communication platform could make it possible to choose other caregivers than the closest one, because more of the care can be handled remotely, which would give the patient the possibility to find the right competence. Also, continuity will be easier to withhold when having continuous communication through the application.

Some of the encouraging aspects mentioned in the evaluation form were that data is sent to the caregiver, reminders, the achievement of accomplishing tasks and seeing improvements. These are features that could encourage some patients, but the problem is that all patients are different. Some patients are simply not driven by goals or reminders and for those patients it is extremely important to find what can be encouraging. This means that no matter how good a digital tool is, the role of the diabetes nurse will still be extremely important to understand patients.

The fact that all patients are different is also important in the selection of which features to implement. Maybe blood glucose measurements and education can be viewed as the most important features, but as already
mentioned all patients are different and thus there must be some sort of flexibility in the digital tool. One nurse suggested that it should be possible to select what parameters to track and this is probably a very good idea. The balance between general solutions and individual patient-centred care is critical in the design of digital health tools. Therefore, developers must understand how general the system can be, while still keeping the necessary flexibility to cover all patients. For some patients, compliance is best reached by letting the patient take part of the decisions made about their care, while other patients prefer to let the caregiver tell them what to do. Either way, it should be possible to use the tool to support the patient in knowing what has been agreed upon or what advice the caregiver has given.

5.3 Patient Acceptance

Making the application individualised is not only important for making the patient feel encouraged, it is also crucial for patient acceptance. The application must give the patient some sort of meaningful output, otherwise they will not use it. The data must be processed and presented in a way that the patient can understand, find interesting and learn from. The interviewed patients said that they would be willing to use the application if it was medically trustworthy, not too time consuming and gave valuable output, which was defined as output from which the patient could make care decisions or learn. This also emphasises the importance of involving patients in the development of applications. Through continuous user tests and feedback, a relevant and useful tool can be created.

The level of interest in technology differed a lot between interviewed patients. A problem raised by some of the patients was that digital meetings could sometimes feel less personal and thus have a negative impact on the feeling of security. However, during the COVID-19 pandemic, important parts of the society has had to become digital. Being forced to use video calls in other areas might make people more comfortable to use them in healthcare too. Still, many of the patients suffering from type 2 diabetes are elderly and might not be a part of the digital society. Therefore, it is important that the first meetings with the nurse are carried out physically. Again, the aim of the tools is to be a complement to the usual care at diagnosis.

Main reasons for not using a digital tool were lack of interest and that the patients did not know they existed. Through the use of a platform for both patients and practitioners, parts of this problem could be solved. In Section 4.1.2, the usability and patient engagement of different studies were
considered. Making the tool easy to use and possible to integrate with everyday life, as suggested in the literature evaluating patient engagement, would probably make it more interesting. From the evaluation in this thesis it was clear that the participants did not find the notifications annoying and the application was not too time consuming. This is one perspective from which the design of HOPE platform is suitable for a diabetes tool.

Furthermore, literature showed that the patients would be more willing to use an application that was recommended by healthcare. To gain the trust of Swedish healthcare, it is important that the tool complies not only with the Swedish laws and regulations, but also with the national treatment guidelines and evidence based approach (further described in Section 2.1.3 and 2.2.3). In this thesis, the features were developed with the national guidelines in mind. Also, work was put into finding evidence based ways to collect data. However, many of the features also builds upon the concept of patient generated health data and the question is if this kind of data is reliable enough to base clinical decisions on. The evidence for positive outcomes from using patient generated health data is still weak, a systematic review from 2019 showed that many of the studies evaluating tools that make use of patient generated health data are still in the development and feasibility phase [81]. Since not many studies concerning the actual impact or outcomes have been conducted, it is hard to argue that this kind of data can be used in an evidence based approach. However, it could be argued that if the quality of the patient generated data can be raised, this data can reach the reliability of data collected in a hospital. The real challenge lies in creating value, that contributes to positive health outcomes, from the collected data.

5.4 Discussion of Methodology

The first phase of the project was the literature study. The main approach in the literature study was to find the most common features of digital diabetes tools described in publications. This approach was chosen because it would give a quantitative representation of which features are relevant. A problem with this approach is that the most common features might not always be the most important ones. It could also be that these are the features developers think are the most important, or simply the easiest to implement. However, the features found in the literature study gave a good overview which was in line with the features mentioned in the interviews, which shows that it was an effective method to find relevant features.

Furthermore, most of the publications did not show what features were
The few studies that presented the extent to which each feature was used revealed that some features were not used at all and in some cases overall usage was low. This makes it hard to draw conclusions even from clinical studies. Therefore, before carrying out clinical testing, one should perform usability testing with diabetes patients to ensure that the usability of the application is high and that the features are relevant. Moreover, an analysis of which features are used should be performed so that clinical findings can be linked to more specific parts of the digital tools. Doing this could contribute to further optimisation of the tools.

The diverse results in the clinical studies included in the literature study indicates that the clinical outcomes can be connected to the design of the application, rather than what features are included. Again, this emphasises the importance of involving the users in the development of the tool. To ensure the usability of the application, the development process should be an iterative process including usability testing with patients and caregivers.

As mentioned in Section 4.2, five type 2 diabetes patients were interviewed. The group consisted of both females and males, and the time since diagnosis ranged between 3 and 16 years. This patient variety gave several different perspectives and insights. For instance, patients who had been living with the disease for a longer time could easily answer what they did not know at diagnosis but know now, while patients with a more recent diagnosis felt they still did not know enough to answer that question. However, it was easier for those patients to describe their feelings at diagnosis because they still remembered it clearly. Interviewing more patients, preferably with even more recent diagnosis and with less motivation to make lifestyle changes, could have given an even more accurate understanding of different patients.

All interviewees participated in the study voluntarily. The problem with only interviewing patients who have signed up voluntarily can be that they are all patients who are interested and want to manage their disease the best possible way. Many of the interviewees said that they did not have an unhealthy lifestyle at diagnosis. These patients might not be the patients who would get the greatest gain from a tool, because changing their life-style would not have any effect on the disease. A great challenge lies in reaching the patients who are not interested in changing their lifestyle or preventing complications. These are the patients that would actually benefit the most from the tool, but they are simply not interested in trying it. To solve this problem, more focus must be put on usability and understanding of the mindset of different patients. Another approach to reach a broader group of patients would have been to send
out the ranking sheet to more patients. The main reason why this was not done was that it would have been hard for patients to rank the features out of context. Possible features were discussed during the interviews, which gave the patients a better understanding of the concept of a digital tool.

In the data analysis, the results from the literature study and interviews were compiled into a list of relevant features. This list was also based on the ranking sheet filled in by the patients. After filling in this sheet, most patients returned it with the note that it was hard to do a distinct prioritisation. It was clear which were the top features, but apart from these the answers were not easy to interpret. Therefore, clinical studies and usability and patient engagement studies features were given more weight than the lower ranked features from the ranking sheet. It would have been preferable to have more patients filling in the ranking sheet to get more reliable data, or to have more evidence from scientific studies specifying which features were used the most. After all it is more valuable to know what features are used, rather than what the patients think that they would use.

The greatest problem faced in the development phase was the time limitation. Due to a delay of the interviews caused by not finding enough participants, the development phase of the project had to be shortened. The result of this was that the development had to be simplified. All planned features were implemented, but with more time they could have been further improved by applying a more iterative process where the application was tested and updated and tested again. Further, the development was somewhat limited by the HOPE platform. The initial plan was to implement a blood glucose representation that could be viewed in the mobile application, but since the required libraries were not in the current release of the mobile phone application it was not possible. Therefore, the representation could only be viewed in the desktop version of HOPE.

Other technical hurdles faced in the development phase were understanding the structure of HOPE and how values from different forms could be accessed and used in a joint output. For example, in the representation of the physical activity, the goal values for active minutes per week and steps per week were included in the summary even though these came from another type of form (goal setting form). A similar challenge was faced with the BGL diagram. At the time, the diagrams in HOPE would only use input from one type of form. Therefore, a way to take in values from the blood glucose measurements form, goal setting form and food intake form had to be found. The main challenge
was to efficiently access the input data from each form, in the correct format.

The evaluation of the tool was performed with fellow students provided with personas as participants. One problem with including fellow students was the risk of bias. It would have been preferable to have participants that did not know who the author was. However, this was a way to get some first user feedback on the application. The participants could give relevant feedback concerning design, usability and integration into everyday life. For further evaluation, type 2 diabetes patients are necessary. Real diabetes patients could give better input on how the application can be used as a complement to traditional care and perhaps raise diabetes needs that were not discovered with non-diabetics. Furthermore, all participants in the evaluation were students of the Royal Institute of Technology, in their twenties and accustomed to using their phone. The typical type 2 diabetes patient is usually older and might not be as comfortable using their phone, making the ease of use even more important. On the other hand, elderly people are becoming more and more used to technology, which is why tools like the ones described in this thesis probably will become more and more popular also for elderly people. Finally, most questions in the evaluation form were answered by indicating a number on a scale. Using more open answer questions might have given a more detailed picture of the usability, but it would also have been harder to interpret.

5.5 Improvement Suggestions and Future Work

Most improvement suggestions mentioned in the evaluation form were changes in the design of the application, such as adding a red box for unfinished tasks, adding a more convenient time date picker (instead of text answer) and make the blood glucose graph more engaging. However, one improvement suggestion raised was different from the others. This suggestion was to include some kind of gamification or reward system. Features like these were also seen in two of the publications in the literature study, in combination with patient education [46, 47]. Both studies described a digital education in which the patient completed quizzes which gave them scores. In one of the studies, high scores was rewarded with their education level being increased. The other intervention rewarded healthy behaviour with health points, which mounted up and finally resulted in water donations for UNICEF. Having such a reward system in which the user gets rewards for registering tasks in time or for registering a certain number of tasks in a row could further encourage the patients to use the application more frequently.
By encouraging users to do regular registrations, more patient generated data can be collected, which can be of great value for improvement of the tool. Using patient generated data, models can be created to learn the patient’s patterns and predict future states. This can for instance be used for warning the patient when approaching hypoglycemia or ketoacidos, so that the patient can take action. Predictions could also be used to see how the patient’s HbA1c will change over time, based on the patient’s current values. A high predicted HbA1c value would indicate a higher risk for complications. Thus, these predictions could work as further encouragement to practice self-care.

To further improve digital diabetes applications, usability must be prioritised. It will not be possible to prove clinical outcomes of such tools before the patients want to use them. Thus, the next obvious thing to do is to keep developing the tool in an iterative process in which the patients and caregivers will be involved. Once the tool has reached high patient acceptance, it should be clinically evaluated. Only then can it be established whether or not digital tools have positive clinical outcomes.

Two important features found both in literature and interviews were diet guidance and tracking, and patient education. These were not included in the tool developed in this project due to lack of time. However, they were found to be important features and thus resources should be put into including them in the design. Again, this must be done in collaboration with patients and caregivers. By involving caregivers in the development, the quality of the information can be secured, which will make the application more trustworthy. Also, integrating patient education into an application will make it easier to spread knowledge to all patients. Providing the patients with a free of charge application would both solve the issue of expensive courses and also it would be possible for the patients to choose time and place for learning themselves.

The focus of this project was the patients. In future work, this application should also be integrated into the workflow of caregivers. Therefore, future work must also focus on considering the desires of the nurses. For them to accept the application, the tool must add something of value. Features that favour the caregivers could be warning systems that could help monitoring the patients’ health data remotely, visualisations of patients’ data registrations and straightforward communication with the patients. Providing healthcare with a usable self-care tool could decrease the time nurses spend on repetitive tasks, such as measuring blood pressure and weight, which the patient can do themselves. Furthermore, if the patients can be monitored remotely, unnecessary visits can be avoided which would decrease the load on healthcare.

During the COVID-19 pandemic the society has become more dependent
on digital tools than ever. Social distancing and other restrictions have forced us to come up with solutions that no one thought were possible before. To improve healthcare, it is important to keep up with the progress of the rest of the society. Digital tools could be of benefit not only for diabetes care, but also within care of other chronic diseases demanding self-care and continuous communication with healthcare. Maybe it is not possible to find a general solution for all hospitals and all diseases. But creating an information platform that is flexible and can be adjusted to fill the needs of the intended care unit would improve healthcare efficiency.
Chapter 6

Conclusions

The task of creating a digital tool for type 2 diabetes patient to increase the security and confidence in their self-care has several dimensions and many aspects to take into consideration. First and foremost, the application must be developed in collaboration with patients and caregivers. This is essential to make the application useful, relevant and easy to use. Moreover, the features of the application must be built on evidence based materials. By following the working model of Swedish healthcare, it will be easier to reach caregiver acceptance, which is crucial for patient acceptance. Furthermore, it must be possible to select the most important parameters to monitor for each individual. Having a care provider monitoring these values remotely, combined with the open communication through the platform, the feeling of security can be increased. Finally, patient education and a continuous dialogue about the disease will increase the patients’ knowledge and thus also their confidence in self-care.

The knowledge and technology needed to build a successful digital tool for type 2 diabetes patients already exists, it only needs to be put together and formulated in a way which is understandable and useful for both patients, caregivers and developers. This thesis contributes to this work by presenting prior work, opinions of patients and caregivers, relevant features and designs suggestions.
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Appendix A

Interview Protocol – Patient

Thesis Description

My name is Ylva and I am currently doing my master’s degree in medical engineering at the Royal Institute of Technology (KTH). For my master’s thesis I am doing a project about a digital diabetes tool. The project is conducted in cooperation with the company ADDI Medical, which has developed the communication platform HOPE. The purpose of HOPE is to automate care processes and to encourage the patient to be more involved in their care. The focus of my project is to increase the feeling of safety and confidence for newly diagnosed patients, by implementing a digital support in HOPE for the first month of disease. To determine which features are relevant and possible to implement in HOPE, I will conduct both a literature study and interviews. By interviewing both patients and care givers I hope to gain a comprehensive view of the requirements from both stakeholders. Thereafter, I will implement the tool in HOPE and finally I will also evaluate how the implemented features can give the patient confidence and guidance.

Confidentiality and Consent

Participation in this interview is voluntary and as a respondent you are always free to withdraw. The answers given in this interview will be compiled into a list of requirements and possible features of a digital diabetes tool. The interview results will be presented anonymously and who said what will not be disclosed. If consent is given, the interview will be recorded, but it will not be shared or published. The collected data will serve as support for the implementation phase of my thesis work. The thesis will be published in DiVa
(KTH’s publication database) and can be sent out to interested participants. If agreeing to participate, please fill in your details below.

Namn:
Signatur:
Datum:

Instructions

First I will ask questions about your first reaction at diagnosis, your care plan and how you view your contact with healthcare. This is to gain better understanding of thoughts and feelings about the first period as a diabetic. Thereafter, I will ask questions about digital tools, to find what diabetics want in such a tool. Finally, I will ask you to rank some of the features found in literature.

Questions

1. Tell me about your diabetes background.
   (a) When were you diagnosed?
   (b) How did it change your life situation?

2. What was your first reaction at diagnosis?
   (a) What was your greatest concern?
   (b) Did you feel supported by healthcare?
   (c) Could you initiate contact with your nurse/doctor? How?
   (d) Did you receive the practical information you needed?
      i. If not, where did you search for information?
   (e) Did you participate in patient education?
      i. If yes, what part felt most important to increase confidence in self-care?
      ii. If no, why not?

3. Did you find it hard to prioritise different ordinances?
(a) Which was the first change you made?
(b) Which was the hardest part of adapting?

4. Did you receive a personal care plan?
   (a) How was it presented to you?
   (b) Were all care activities included (nutritionist, podiatric, eye doctor, etc.)?
   (c) Were you involved in the creation of your care plan?

5. How often are you in contact with healthcare now? Physical/digital?
   (a) Does every consultation feel valuable?

6. Have you used any digital tool to handle your disease?
   (a) What could be desirable features in such a tool?
   (b) What parameters are you controlling today?
   (c) Do you think such a tool could encourage self-care?
   (d) What motivates you to maintain self-care?
Appendix B

Interview Protocol – Practitioner

Thesis Description

My name is Ylva and I am currently doing my master’s degree in medical engineering at the Royal Institute of Technology (KTH). For my master’s thesis I am doing a project about a digital diabetes tool. The project is conducted in cooperation with the company ADDI Medical, which has developed the communication platform HOPE. The purpose of HOPE is to automate care processes and to encourage the patient to be more involved in their care. The focus of my project is to increase the feeling of safety and confidence for newly diagnosed patients, by implementing a digital support in HOPE for the first month of disease. To determine which features are relevant and possible to implement in HOPE, I will conduct both a literature study and interviews. By interviewing both patients and care givers I hope to gain a comprehensive view of the requirements from both stakeholders. Thereafter, I will implement the tool in HOPE and finally I will also evaluate how the implemented features can give the patient confidence and guidance.

Confidentiality and Consent

Participation in this interview is voluntary and as a respondent you are always free to withdraw. The answers given in this interview will be compiled into a list of requirements and possible features of a digital diabetes tool. The interview results will be presented anonymously and who said what will not be disclosed. If consent is given, the interview will be recorded, but it will not be shared or published. The collected data will serve as support for the implementation phase of my thesis work. The thesis will be published in DiVa
Instructions

First I will ask questions about your handling of newly diagnosed patients and the creation of care plans. This is to gain better understanding of the care process during the first period of disease. Thereafter, I will ask questions about digital tools, to find what diabetes caregivers want in such a tool. Finally, I will ask you to rank some of the features found in literature.

Questions

1. What are the first steps you take for a newly diagnosed patient?
   (a) What is done before, during and after the first meeting?
   (b) Does the patient fill in any health declarations manually?
   (c) Is there a general plan? What is included?
      i. Is there a standard plan that I could take part of?
   (d) Is the care plan presented to the patient? How?

2. Which are the most important lifestyle changes the first three months?
   (a) How are these presented to the patient?
   (b) How many meetings does the patient have with healthcare during this time?
   (c) Is there any measurements or data collections that the patient can do themselves, to make every consultation more valuable?

3. How are you using existing tools?
   (a) Are you using any digital tool to create care plans?
   (b) Are you using any digital tool for communication with patients?
(c) Are you using any digital tool for visualisation of patient values, or how are they analysed?

(d) Do you recommend your patients to use any application?

(e) What parameters are interesting for the patient to track?

4. Are there any routine controls of psychosocial health? Forms or so?

5. Do you think a digital tool can improve patient confidence in self-care in the beginning of disease?

6. How do you think self-care can be encouraged?

7. Do you have any additional thoughts that you would like to discuss?
Appendix C

Feature Ranking Template

Features for Practitioners

Rank the following features 1 - 3, where 1 has the highest priority and 3 the lowest.

- Recommendations for physical activity (input training as activity)
- Overview of care plan (with scheduled activities and appointments)
- Diet

Features for Patients

Rank the following features 1 – 11, where 1 has highest priority and 11 has the lowest.

- Glucose measurements (manually or automatic)
- Diet diary
- Training diary
- Weight and BMI
- Emotional diary
- Personal goals (diet, weight, long-term glucose, etc.)
- Blood pressure
- Medication intake
- Sleep
- Ketones in urine
- Preparation form for consultations

**Feedback/visualisation**

Rank the following features 1 – 7, where 1 has highest priority and 7 has the lowest.

- Blood glucose visualisation over time
- Physical activity (e.g., steps taken) visualisation over time
- Messages for motivation and reminders
- Patient education
- Communication (chat/mail) with caregivers
- Guidelines from the National Board of Health and Welfare
- Links to external resources
Appendix D

Post-test evaluation questionnaire

1. What was the name of your persona?
   *Jane, Cathy, Josh, Frank*

2. Overall, please rate how easy or difficult it was to use this application.
   *Easy, somewhat easy, neither easy nor difficult, somewhat difficult, very difficult*

3. How easy or difficult was it to navigate the application to accomplish the provided tasks?
   *Easy, somewhat easy, neither easy nor difficult, somewhat difficult, very difficult*

4. The notifications were relevant and helpful.
   *Strongly agree, agree, neither agree nor disagree, disagree, strongly disagree*

5. How easy was prioritisation of health activities?
   *Easy, somewhat easy, neither easy nor difficult, somewhat difficult, very difficult*

6. To what extent did the application make you feel supported by healthcare?
   *Fully supported, somewhat supported, not supported at all*

7. Did the application make you feel more motivated to practice self-care (physical activity, healthy eating, regular BGL measurements)?
   *Yes/no.
   Why/why not?*
8. The fact that my input is sent to my care provider encourages me to make lifestyle improvements.
   *Strongly agree, agree, neither agree nor disagree, disagree, strongly disagree*

9. Using the application took too much time of my day.
   *Strongly agree, agree, neither agree nor disagree, disagree, strongly disagree*

10. I appreciated the possibility to fill in the lifestyle form before my visit (instead of doing it during my visit) / I appreciated the possibility to fill in the PAID form, so that we could discuss my “problem areas” during my visit.
    *Strongly agree, agree, neither agree nor disagree, disagree, strongly disagree*

11. How would you rate the graphic representation of BGL?
    *Really good, good, neither good nor bad, bad, really bad*
    How could it be improved?

12. How would you rate the representation of physical activity?
    *Really good, good, neither good nor bad, bad, really bad*
    How could it be improved?

13. What are the two things you liked the best with HOPE Diabetes?

14. What are the two things you liked the least with HOPE Diabetes?

15. Would you recommend the application to a newly debuted diabetes patient?
    *Yes/no.*
    Why/why not?

16. Could this application help you towards a more healthy lifestyle?
    *If yes how?*
    If no, why not?

17. Did the possibility to open a chat improve your contact with healthcare?
    *Yes/no.*

18. What would make you use this application for the first month of disease?
Appendix E

Personas and Tasks

Project information

For my master’s thesis, I am doing a project about a digital diabetes tool. The project is conducted in cooperation with the company ADDI Medical, which has developed the communication platform HOPE. The purpose of HOPE is to automate care processes and to encourage the patient to be more involved in their care. The focus of my project is to increase the feeling of safety and confidence for newly diagnosed type 2 diabetes patients, by implementing a digital support in HOPE for the first month of disease. To determine which features are relevant and possible to implement in HOPE, I have conducted both a literature study and interviews. By interviewing both patients and caregivers I gained a comprehensive view of the requirements from both stakeholders. Thereafter, I implemented the tool in HOPE and now I will evaluate how the implemented features can give the patient confidence and guidance.

The trial run will last for five days, during which all participators are asked to act like one of the provided personas. Each persona will be represented by two individuals. Further information about each persona is provided below.

At the end of the trial run, each participator should have performed all tasks stated for their persona. After completing the trial period, a usability evaluation will appear as a questionnaire in the app. The evaluation form will be the same for everyone. All participators are asked to fill in the provided form based on their experiences of the app.
Instructions to participators

• Read through the description and tasks of your persona
• Download the HOPE app
• Choose Demo ADDI and then Demo X-jobb
• Choose “parkoppling” and enter your provided code

When you have logged into the app you will see your scheduled activities. If you click on an activity such as a physical meeting, you can mark it as done. If you click on a form, you can fill it out and depending on the type of the form, different things will happen.

You can also see your activities in the calendar view. Different types of activities are marked in the calendar with different colours.

In the middle of the menu bar at the bottom, you find the chat function. Here you can choose which caregiver you want to contact. Here you can write questions, both medical and about the app.

Under “mer” you can find additional information about the functionalities of the app.

Finally, you can click “min profil” where you can change your details, find further information, etc.
Jane

“I wish healthcare could make use of all the health data I generate and based on it help me find what works for me. I also want to understand how different behaviours can have an impact on my blood glucose levels.”

Jane was diagnosed with type 2 diabetes after having her first child. She is working full time as an engineer in computer science and thus she knows a lot about different technical solutions for healthcare. On her spare time, Jane enjoys spending time with her family and friends, as well as going to the gym or out running. She uses an app to track her physical activity and she also takes daily notes of her dietary intakes. Now that she needs to start measuring her blood glucose levels, she wants to share all her health data with her diabetes nurse to get help interpreting it. She wants feedback from her input so that she can learn how to handle her disease.

Jane has had her first meeting with the diabetes nurse. She found out that she was in the risk group for foot complications and therefore she will be sent to a foot specialist. Furthermore, Jane was also provided with Metformin (pharmaceutical that reduces new formation of glucose in the liver and improves glucose uptake in the muscles), which she must take 500mg of twice a day.

Challenge
Jane wants to use only one app for all her data collection. She wants continuous feedback, both personalized and general. To get the best possible feedback, she thinks it is important to record as much of her behaviour as possible, especially at the debut of disease. She is quite anxious and does not have the best experiences with healthcare. Thus, it is important that her data is sent to and reviewed by caregivers on a regular basis.

Tasks for Jane

On-time tasks:

- Input goal values for:
  - Average BGL (reasonable values are between 7 – 8.4 mmol/l)
  - Daytime BGL (reasonable values are between 6 – 8 mmol/l)
  - HbA1c (reasonable values are between 42 – 52 mmol/mol)
  - Steps (pick a reasonable value)
  - Active time (at least 150 min)
- Complete PAID form before next meeting with nurse

Repeated tasks (might only be done once during demo run):

- Input physical activity daily
- Input BGL values when notified (pick a value 4 (before eating) – 10 (after eating) mmol/l)
  - Check BGL graph
- Input meal or snack at the time of the event
- Read info/notifications
- Mark visits done

Optional tasks to try:

- Take contact with caregiver through chat
Cathy

“I want to follow the recommendations from healthcare with the smallest effort possible. I want to know what I must do, but I do not feel motivated to change anything else in my life.”

Cathy was not surprised when diagnosed with type 2 diabetes. Her mother was diagnosed with the disease several years ago and she had been experiencing some of the typical symptoms. Having the disease in the family makes her less anxious and she has a good trust in healthcare. However, Cathy is rather young and not living a very unhealthy life, thus, she does not feel motivated to make any lifestyle changes. Instead, she wants to control her disease with small efforts.

Cathy has always been an active person with a varied diet. She likes to cook her own food and has a healthy mindset, she does not eat much sugar, but she does not refrain completely either. Cathy likes long walks and occasionally she also takes class workouts at the local gym. Cathy has two grandchildren and spending time with them is a great motivation to stay healthy and avoid complications.

Cathy is having her first meeting with the diabetes nurse this week.

Challenge
Cathy wants a time efficient tool. She does not want to be too involved and she trusts that if she inputs her values, healthcare will react if something is wrong. She wants to know the most important activities but does not want notifications. Instead, she wants to decide for herself when she wants to use the app. She does not need the tool to motivate her, she already has the motivation to stay healthy. Instead, she wants the tool to make her selfcare smoother and to give her a feeling of security. Cathy’s small technical interest requires clarity in tasks. If something is not clear, she will not put too much time into trying.

Tasks for Cathy

On-time tasks:
• Input goal values for:
  • Average BGL (reasonable values are between 7 – 8.4 mmol/l)
  • Daytime BGL (reasonable values are between 6 – 8 mmol/l)
  • HbA1c (reasonable values are between 42 – 52 mmol/mol)
  • Complete lifestyle form before meeting with nurse

Repeated tasks (might only be done once during demo run):
• Input BGL values when notified (pick a value 4 (before eating) – 10 (after eating) mmol/l)
  • Check BGL graph
  • Measure blood pressure when notified
  • Read info/notifications
  • Mark visits done

Optional tasks to try:
• Take contact with caregiver through chat
Josh

“The diagnosis was a chock and a wake-up-call. I need support to change my lifestyle and become healthier. For me, it is important to feel the mental support from healthcare, it makes me less vulnerable.”

Josh is a hard-working man, with not much time to cook healthy food or go to the gym. After work he usually goes home and order take-out, some nights he goes out for a beer with friends. Josh lives alone and has plenty of time outside work. The reason Josh went to the doctor was that he had been feeling very tired and had a constant headache. When starting treatment for type 2 diabetes, Josh will hopefully have more energy for physical activity and other selfcare activities.

Josh was not aware of his risks factors for diabetes and was very chocked at the type 2 diabetes debut. He has the will to improve his lifestyle, but he needs guidance from healthcare. Josh does not have much knowledge about diabetes, which makes him quite anxious. He thinks that a good application can make him feel more confident in his disease and he highly value the possibility to initialize contact with his diabetes nurse in a simple way.

Josh is having his first appointment with the diabetes nurse this week.

Challenge
Josh wants a tool that can tell him what to do when. He wants the app to remind him of his self-care tasks and he wants to be able to track improvement. Seeing the results of his efforts is a great motivation for him. It is also important for Josh to have constant contact with healthcare, to make him more confident in his selfcare.

Tasks for Josh

On-time tasks:

• Input goal values for:
  • Average BGL (reasonable values are between 7 – 8.4 mmol/l)
  • Daytime BGL (reasonable values are between 6 – 8 mmol/l)
  • HbA1c (reasonable values are between 42 – 52 mmol/mol)
  • Steps (pick a reasonable value)
  • Active time (at least 150 min)
• Complete lifestyle form before meeting with nurse

Repeated tasks (might only be done once during demo run):

• Input physical activity daily
• Input BGL values when notified (pick a value 4 (before eating) – 10 (after eating) mmol/l)
  • Check BGL graph
• Input meal or snack at the time of the event
• Measure blood pressure
• Measure weight
• Take contact with caregiver through chat (at least once)
• Read info/notifications
• Mark visits done
Frank

“Healthcare contact is always stressful, and I do not feel like I get any support at all. I want guidance without having to put too much time into handling the disease, I have so much more in my life that I would rather do.”

Frank is very social and outgoing person who recently retired from his job as a store owner. His son is now running the store, but Frank stills helps him every now and then. When he is not in the store, he likes starting projects in his house. He also loves spending time with his wife and their children and grandchildren.

Frank will never let his diabetes stop him from anything. He does not have very good experiences from healthcare and thus he did not take it very seriously when they told him he must make lifestyle changes. Instead, Frank has decided to keep living his life as usual. He will do the activities he is assigned, but he will not put too much time into trying to interpret his data himself.

Frank has met his diabetes nurse once. He has also had his eyes examined and will soon have his revisit to the nurse for follow-up. Frank was also provided with Metformin (pharmaceutical that reduces new formation of glucose in the liver and improves glucose uptake in the muscles), which she must take 500mg of twice a day.

Frank is not very interested in being involved in his disease. However, his technical interest made him agree to use the application. Frank wants an application that can allow him to keep living his life without major changes. He wants reminders to take his medication and to measure his blood glucose values.

Challenge
Frank is not very interested in being involved in his disease. However, his technical interest made him agree to use the application. Frank wants an application that can allow him to keep living his life without major changes. He wants reminders to take his medication and to measure his blood glucose values.

Tasks for Frank

On-time tasks:
- Input goal values for:
  - Average BGL (reasonable values are between 7 – 8.4 mmol/l)
  - Daytime BGL (reasonable values are between 6 – 8 mmol/l)
  - HbA1c (reasonable values are between 42 – 52 mmol/mol)
- Complete PAID form before next meeting with nurse

Repeated tasks (might only be done once during demo run):
- Input BGL values when notified (pick a value 4 (before eating) – 10 (after eating) mmol/l)
- Check BGL graph
- Measure blood pressure
- Read info/notifications
- Mark visits done

Optional tasks to try:
- Take contact with caregiver through chat