Utrecht University

ChipSoft

ACCESSIBLE CLINICAL PATIENT GROUP DATA FOR MEDICAL DOCTORS

Business Internship Report

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Content

1 Executive summary

If medical specialists in the hospital could easily view clinical data on groups of patients, they could easily understand how their patient population is doing. This could contribute to the quality of care. For example, by enabling to see which complications are most common, so that the doctor could point out to his colleagues how to improve their care. They could also easily select patients with a certain diagnosis who are eligible for a pilot study with a new, promising drug, so that he can quickly determine whether eligible patients are available for this study. There are more examples of why a doctor should have independent and fast information about groups of patients at his disposal. It can contribute to the quality of care, to (scientific) research, or just be fun for a doctor who is excessively interested in the statistics of 'his' patients. Easy accessibility for medical doctors into clinical data of patient groups can therefore contribute to society, because the healthcare provided is improved.

Aim

In this project, the aim is to find out what requirements a product must meet to be used by doctors as a tool for providing insight into clinical data on groups of patients. With this information, the first steps in product development can be made. Due to the complexity of their work process and work context, clarifying the user requirements of doctors as end users is very complex. Therefore, it is good to do this in cooperation with end users, i.e. the doctors.

Business context

This project took place in the context of the company ChipSoft. In the Netherlands, ChipSoft is the largest supplier of hospital information system software with electronic medical record functionality included. The product, called HiX, helps physicians and healthcare workers to register their healthcare activities and to view individual patient records. One module of HiX, which can be bought separately, is called ChipSoft-Datawarehouse (CS-DWH). It is a business intelligence (BI) solution, which, among other things, provides insight into management information. A new information mart (IM) focuses on clinical data rather than management information, as it can also show clinical data from HiX. This module is designed to show information on the level of patient groups rather than on the level of individual patients, which is what HiX is designed for.

CS-DWH fulfils multiple functions within a hospital because it can show information on different subjects relevant in a hospital setting. It can provide information on healthcare production in the hospital, which is relevant for the finance department. But it can also inform planning staff to assure that resource capacity is efficiently used. The quality of healthcare is checked annually by government inspections, but this can be monitored throughout the year with CS-DWH. This makes it possible for quality staff to intervene more quickly.

Many technological developments influence CS-DWH. An important trend is self-service BI. This gives end users the freedom to extract and interpret data from the system themselves, without the need for a technical background. Another important factor that influences the CS-DWH module and acts as a precondition is privacy, specifically the AVG legislation. Medical data is enormously privacy-sensitive, so it is important that, depending on the role of the hospital employee, they can only see information they are allowed to see by the General Data Protection Regulation (GDPR).

According to strategy researcher Michael Porter, profitability in a market is determined by five different forces: competitive rivalry, the bargaining power of customers and suppliers of the market players, the threat of potential market entrants and possible substitutes for the product or service. Each of these factors is influenced by different factors. The most important forces for the HIS/EMR market in which ChipSoft operates with HiX are competitive rivalry and the power of suppliers. Transition cost, so the resources and effort to change from one HIS/EMR product to another, is an important factor in this market. The use of the HIS/EMR is intertwined with the work process of a hospital's healthcare provision, so the risks and costs of changing the complete work process are very high. These high transition costs result in less competitive rivalry among market players. It also results in less bargaining power of customers compared to the market players. Research by the Dutch Consumer & Market Authority, which supervises fair competition in a market, shows that there is a vendor lock-in on the Dutch HIS/EMR market, to which ChipSoft contributes as a supplier. A vendor lock-in means that after choosing a supplier, it is very difficult for a customer to switch suppliers, and often large costs are involved.

The vendor lock-in does not apply to CS-DWH, as a separate module from HiX, because the transition costs are much lower for a hospital. What does play a greater role in profitability in the BI market for healthcare are industry growth and product differentiation. The BI market is still relatively new and many technological developments, such as self-service BI, are on the horizon. In healthcare, technological developments are generally adopted somewhat slower, so at this moment the market can still grow reasonably. As a result, there is less competition between market players. Product differentiation is high. For example, CS-DWH is built on HiX and is therefore well integrated with HiX, something which other BI tools cannot offer. This lowers the competition on the market and is also used as a strategy.

Strategic challenge

Another strategy of ChipSoft is to improve the product through collaborative innovation with customers. Because ChipSoft will always have less knowledge of the user requirements than the customer itself, i.e. the hospital, it loses out in this. Because of this, the bargaining power of customers is higher. In addition, the knowledge of the work process of doctors and other healthcare workers is tacit, which makes it difficult to communicate. ChipSoft responds to this by developing and innovating its product together with its customers. An example of this is the Innovation Platform. This includes user groups, in which end-users come together to come up with joint solutions and new ideas on various subjects. From practice and from literature, CIC has been proven to be beneficial for firms in product development. Therefore it was also used in this project.

Methods & results

To map out the users' needs, interviews were held with various doctors. This provided enough background information to analyse the requirements indicated. The most important requirement was user-friendliness, next to independent use, freedom of settings and privacy for both doctors and patients. In terms of content, doctors want to be able to select a patient group. They want to be able to combine different types of clinical data from this patient group, such as the most frequent complications plotted against the operations. To be able to interpret the data, they want to be able to compare it with each other.

With this information, a first prototype was designed. The focus was on putting usability into practice in a tool specifically designed to select a patient group based on multiple criteria, namely diagnoses, operations and medication. The prototype was demonstrated during another round of interviews with doctors, asking for their feedback. In general, doctors were able to use the prototype independently quickly, with buttons for navigation being an important feature. The main recommendations are that although selecting patient groups and combining clinical data was possible, being able to compare data is an essential requirement for doctors. In terms of operational features, the biggest lack was a smart and intuitive search engine that makes relevant suggestions, like a search engine such as Google.

Conclusions & relevance

These results show that the most important aspect is user friendliness, which was also expected. However, it has now been concretised in discussions with doctors and a first step has been taken in product development. This helps to achieve the goal of having three specialists using IM Medical by 2022. It also clarifies where within CS-DWH resources can best be spent. Intensive contact can also contribute to the creation of a distribution channel, which increases the chance that an enthusiastic doctor will recommend the product to his colleagues. For ChipSoft, this project contributes to the strategic challenge of improving its knowledge of user requirements. Because of this, ChipSoft gets a better position relative to its competition, which makes it possible to attract more customers and to increase the long-term profitability.

2 Introduction

This thesis captures, from a business perspective, the process of a product development project at ChipSoft, which took place in the department Datawarehouse. I first describe the context of the market and the company, and from that the strategic challenges for the company emerge. This project falls within one of those challenges, so that is the assignment description / research question. This is followed by a description of the approach and the results of the project and then a discussion to place this small piece in the larger picture.

2.1 Business context

Description and history of ChipSoft

ChipSoft is a healthcare IT company and develops among others software for keeping an electronic medical record (EMR). This software is used in most Dutch hospitals. In recent years, it has also expanded to hospitals in Belgium and to other types of healthcare institutions, such as GP practices and mental healthcare institutions. Healthcare institutions that provide specific care, such as oncological care, are also served.

An electronic patient record (EMR) is a software application in which medical patient data is recorded and stored digitally. This makes the patient data easily available. HiX also functions as a hospital information system (HIS) in which information for hospital operations is kept. This information supports the logistics of the healthcare process and the billing process. HiX is therefore not a personnel or accounting system but is limited to function as a HIS as well as an EMR system.

In 1986, ChipSoft was founded by Gerrit Mulder. He worked as a surgeon in a Dutch hospital and was annoyed about the cumbersome way of registration. Together with his son Hans Mulder, he founded ChipSoft to automate healthcare registrations. At the beginning of the nineties, half of the Dutch specialists worked with the software. Over the years, the product has expanded to become a full HIS that supports the entire healthcare process in the hospital.
Since 2013, the programme has been called HiX, which stands for healthcare information exchange.

ChipSoft's ambition, as stated on its website, is as follows:
"The primary ambition of ChipSoft is to continue to develop innovative software that supports and facilitates every healthcare provider to deliver the right healthcare to the patient at the right time. To realise this ambition, ChipSoft continuously investigates possibilities to make healthcare even more efficient, so that scarce time and resources can be optimally used for the benefit of the patient. Our secondary ambition is to further expand our national and international market share to enable as many patients and healthcare providers as possible to benefit from the very best healthcare ICT." (ChipSoft, n.d.-a).

In 2009, ChipSoft had a dominant market share in the Dutch hospital HIS/EMR market (Care Vision, 2009). This share has increased in the past decade. As market leader, ChipSoft currently holds about 70% of the Dutch HIS/EMR market (M&I Partners, 2021b).
The product HiX is characterised by its focus on the work process of the physician and other healthcare providers. Depending on the function of the healthcare providers and their task at that moment, relevant information is presented. This ensures user-friendliness for end-users, who use this during their day-to-day tasks. In addition, it is a fully integrated software system,

as it is designed as an internal core system with various integrated modules. Previously, hospitals still used partial software for, for example, agendas, patient lab results and imaging results. Consequently, patient information was not always up to date, so different doctors did not always have access to the latest patient data. Some systems were even unable to communicate with each other. Nowadays, thanks to integrated HIS/EMR systems, most of the information is stored in one integrated system, which means that the information about patients is always as recent as possible.

HiX consists of different modules that can be purchased by a healthcare institution in different compositions or as an all-in-one package, called "All-you-can-HiX".
One of these modules is ChipSoft-Datawarehouse, which can be implemented as part of the "All-you-can-HiX" package or a hospital can choose to pick another supplier for this functionality. Since the subject of this thesis evolves around one part of the Datawarehouse module, it will be explained in more detail below.

Datawarehouse

One of the modules is the CS-Datawarehouse (hereinafter referred to as Datawarehouse or CS-DWH). This is a business intelligence (BI) solution that enables analysis and visualisation of enormous quantities of data. For example, business management information such as key performance indicators (KPI) can be displayed in dashboards. Or business analysts in a hospital can analyse hospital-specific information using cubes, which is data stored in a suitable way for analysis purposes. Information that can be visualised includes throughput times at the radiology department or peak loads at the emergency department, for example.

Next to business management information, clinical patient data can also be extracted from registries in HiX. This is enabled through IM Medical, a Business Intelligence product that makes this clinical HIS/EMR data accessible. In addition to collecting the data, IM Medical filters the data, provides it with meaning and places it in in the correct medical context.

For example, patient diagnoses, treatments, or complications can be analysed. This information can be viewed on a patient group level using the Datawarehouse module, rather than on the level of individual patients in providing insight into the most common diagnoses, for example, or which complications occur most frequently with certain treatments.

The Datawarehouse module consists of several parts, which differ in the required technical IT knowledge and flexibility for the end user. A dashboard is a ready-made overview with graphs and other visualisations around a subject, which is suitable for healthcare staff without technical knowledge, but gives little or no flexibility. A hospital can also build its own information facilities on the foundation of the Datawarehouse. This requires a great deal of technical knowledge, but the flexibility means that it can be fully tailored to the hospital's needs.

2.2 Social context

It can be beneficial for society to enable access in clinical data of patient groups. Because all actions must be registered, there is a wealth of information available in the HiX HIS/EMR about all patients and treatments in the hospital.

2.3 Structure of report

The context of this thesis is first thoroughly discussed. In Chapter 3 and 4 the forces influencing the market are analysed, where first macroenvironmental forces are discussed, followed by a thorough analysis of competitive forces. A business analysis is conducted in Chapter 5 to contextualise and substantiate the conducted research. This leads to the aim of the research described in Chapter 6. This is followed by the applied methods in Chapter 7, the results in Chapter 8 and the interpretation, strengths, and limitations of the research in Chapter 9. Throughout the report, abbreviations are used which are listed in Chapter 10. The referenced literature can be consulted in Chapter 11 and the Appendices are available in Chapter 12.

3 Market analysis with PESTEL analysis

A PESTEL analysis is done to analyse the macro-economic influences on a market. PESTEL is an acronym which stands for the categories of forces that are analysed: Political, Economic, Social, Technological, Ecological and Legal forces. These forces can influence the decisions made by companies operating in the market concerned. Therefore, it is important to obtain a complete picture of the market and which forces influence its profitability.

3.1 Political forces

ChipSoft is the biggest player in the Dutch HIS/EMR market for hospitals. In addition, Epic, a company originating from the US, also has a significant share of the Dutch market. Together, they serve most of the market, where Nexus and Cerner hold smaller shares (KPMG Advisory N.V., 2022).

In its role as independent market regulator, the Netherlands Authority for Consumers and Markets (ACM) seeks to contribute to well-functioning markets, by assuring fair competition between business (Autoriteit Consument & Markt, n.d.). For healthcare ICT markets specifically, it aims to safeguard public interests such as accessibility, quality, and affordability of healthcare, thereby protecting consumers' interests. After investigating the functioning of the markets for information systems of healthcare institutions and digital data exchange in healthcare, the ACM concluded that there is vendor lock-in on the Dutch HIS/EMR market and that ChipSoft plays a role in this as HIS/EMR supplier (Autoriteit Consument & Markt, 2021a; van Lonkhuyzen, 2022).

Vendor lock-in means that once a customer has opted for a particular supplier, it is difficult to switch to another supplier, and often only at great expense. This is a frequent problem in ICT markets (Autoriteit Consument & Markt, 2021a). This applies specifically to enterprise resource planning (ERP) markets, such as the HIS/EMR market, because this type of software forms the user's work process. Switching to a different supplier necessitates major changes in the organisation, leading to excessive costs (Buxmann et al., 2013). The findings of ACM, constituting of a specific account of the vendor lock-in and possible solution approaches from a competition perspective, has been made public by the ACM in two publications (Autoriteit Consument & Markt, 2021a, 2021b). The research has already caused a stir in the news.

As part of the investigation, the ACM commissioned consultancy firm KPMG to conduct a market survey on the demand and supply side of HIS/EMR systems. Because it concerns an investigation into vendor lock-in on a market, this may have negative consequences for the reputation of the suppliers. This was also acknowledged by the court in preliminary relief proceedings, which led to the decision that, for the time being, only the management summary may be published (College van Beroep voor het bedrijfsleven, 2022; KPMG Advisory N.V., 2022).

Despite the temporary halt to publication of the report, the research has received media attention in a national newspaper (van Lonkhuyzen, 2022). The major criticism is that players in the HIS/EMR market supply healthcare organizations, which fulfil an important role in society. Therefore, HIS/EMR suppliers are blamed for making excessive profits over the back of publicly funded healthcare organizations. As a response, political figures have also entered the discussion (Monterie, 2022). ChipSoft reacted to this stating that profits are used within the organisation to secure continuity and innovation. A major irritation about ChipSoft in the ACM

report is the limited 'openness' of the system when it comes to exchanging data and especially the extra licences that need to be purchased to enable patient data exchange. Other suppliers do not charge extra for data exchange and make it easier for hospitals. ChipSoft endorses that patient data exchange is an important matter. They have been involved in the data exchange between the first two hospitals that exchange the relevant treatment data digitally when referring patients (Tjongerschans Ziekenhuis, 2022).

This development is in line with a new Dutch law called Wegiz (Wet elektronische gegevensuitwisseling in de zorg) that will come into effect next year. The Act will regulate the mandatory electronic exchange of medical data between healthcare providers (Rijksoverheid, 2021). In addition, similar European legislation is also being prepared under the name European Health Data Space. This is considerably more comprehensive than the Wegiz, but in practice this European variant will not come into effect until 2026 (Kiers, 2022).

3.2 Economic forces

There have been many rounds of budget cuts in healthcare over the past decade. This effectively means that healthcare institutions have had to cope with the rapid rise in healthcare costs (Koolman & Wouterse, 2021). However, this has had little or no impact on the expenditure that hospitals have made on their ICT infrastructure. On the contrary, these ICT costs relative to turnover have increased in recent years (Gerla & van Luxemburg, 2021). The cutbacks in healthcare therefore do not seem to have affected budgets spent on ICT in healthcare. This is also evident in the numbers of hospitals and other healthcare institutions that have become ChipSoft customers in recent years. It seems that other factors, such as the digitalization across the society of the last few decades, have had a bigger impact.

3.3 Social forces

Due to the ageing population in the Netherlands, the demand for healthcare is increasing. As a result, hospitals and healthcare institutions are providing more healthcare. The volume of provided healthcare is expected to increase about 4 percent per year (Zorg voor Beter, 2021). Since ChipSoft bases its prices for healthcare institutions on, among other things, the number of beds in the hospital, this is indirectly linked to the healthcare production of a hospital. The ageing of the population therefore has an indirect effect on ChipSoft's revenue.

A general trend in society is that all actions of a doctor must be traceable and verifiable. This means that healthcare providers must record every action in the EMR, due to quality requirements that must be met. These are imposed by controlling government bodies, such as the Healthcare and Youth Inspectorate (IGJ) (Inspectie Gezondheidszorg en Jeugd, n.d.) and healthcare insurers (Zorgverzekeraars Nederland, 2022). This increased registration pressure means that healthcare providers spend increased time registering their actions in the patient's electronic medical record (EMR). As a result, the HIS/EMR plays an increasingly key role in the work process of healthcare providers and ChipSoft has a bigger role to play as an HIS/EMR supplier.

A very important topic in hospitals is quality of the provided healthcare. The results of hospitals in this area are monitored by national governmental bodies, including annually by the Health and Youth Inspectorate (Dutch: Inspectie Gezondheid en Jeugd or IGJ). This required the submission of a strict set of quality indicators, with quality data on various specialisms. Since

quality registrations within hospitals themselves have improved enormously in recent years, the IGJ believes that the next phase has now begun (Inspectie Gezondheidszorg en Jeugd, 2021). In this phase, the focus is shifting from fixed indicators to looser improvement goals, in which a risky theme is central. The emphasis is now more on improving and learning. This means that hospitals are freer in their interpretation of what qualitatively good healthcare looks like, and how they can improve it. Therefore, less standardisation is desirable in the reports delivered to clients, so a different approach needs to be taken in development.

Another important topic is data-driven healthcare, where data is used to make decisions. This trend has unfolded in recent years and plays a role in virtually every company, including healthcare organizations.

3.4 Technological forces

New technical developments affect the HiX product portfolio. Examples are the use of the HIS/EMR on mobile devices, in an app. Within HiX, HiX Mobile has been developed for this purpose (ChipSoft, 2022). This allows healthcare providers to enter certain registrations on, for example, a mobile phone or tablet. For example, a nurse can enter measurements of a patient while standing at the patient's bedside.

Voice recognition software is another development that can help in the work process of a healthcare provider. In this way, the healthcare provider can quickly speak his findings for registration instead of typing them in. A HiX module has also been developed for this.

Artificial Intelligence (AI) is playing an increasingly significant role in healthcare. For example, AI can help with speech recognition to record a conversation between doctor and patient and record it correctly in a patient's file (Nuance, 2021). These are examples of incremental innovation, which extend or improve the functionality of an EMR.

Another important development affecting ICT in healthcare, and ICT in general, is the transformation to the cloud. The main advantages for healthcare institutions to choose cloud solutions are lower costs for IT infrastructure and servers, better performance, up-to-date software, and easier collaboration, from any location (Chauhan & Kumar, 2013). Research by consultancy firm Quint has shown that for care and cure healthcare institutions, increasing flexibility and decreasing IT management are the main reasons to migrate to the cloud (Consultancy.nl, 2021). HiX is also increasingly being used in the cloud by healthcare institutions, particularly smaller healthcare facilities such as GPs and rehabilitation centres.

For Datawarehouse, an important technological development is the rise of PowerBI. This is part of a broader development in which end users want more flexibility in their business intelligence solutions. This allows them to adapt the content of a report to the context of their specific demand at that moment. A significant difference is that end users usually have no or less technical BI knowledge. As a result, BI solutions that focus on self-service BI are more simplistic and faster than traditional BI solutions (Johansson et al., 2015). A well-known example of a software application that focuses on self-service BI is PowerBI from Microsoft. A major difference from its predecessor (Microsoft SSRS) is its user-friendliness. Less technical knowledge is required to design a report. Besides, the use by the end user is different, as the

report can be modified by an end user with just a few clicks, instead of only being modified by the IT department.
This results in a different way of use by the end user. Minor changes can easily be made yourself, making the IT department or the internal BI department in the hospital unnecessary (for such matters). This will also change the development of standard reports from Datawarehouse for hospitals.

Many other trends in the field of business intelligence might impact healthcare in the future. Trends such as natural language queries to extract flat text from the HIS/EMR and AI will start to play a role in healthcare in the (near) future (Gartner, 2021). However, the healthcare industry is known slowly adopting new technological applications, so this might take some years (van der Zijpp et al., 2018).

3.5 Environmental forces

Because ChipSoft makes software, there is little to no environmental impact or influence from environmental organizations. However, the use of servers and databases does, of course, consume energy, though it is more efficient and safer for patients compared to all the paperwork from the past. Also, using a lot of paper is not environmentally friendly either.

What does have an impact is the increasing role of Corporate Social Responsibility (CSR) for companies. CSR is defined as "an organisation's responsibility for the effects of its decisions and activities on society and the environment". ChipSoft delivers its services in the healthcare sector. In the Netherlands, the healthcare sector is paid through taxes and health insurance paid by all Dutch inhabitants. Because of this social payment system, there are certain expectations of suppliers of healthcare organizations, regarding its functioning and operations (Collins, 2010).

A few years ago, journalists covered a story on ChipSoft in a popular research program on TV (Eikelenboom, 2019). Their criticism was the enormous power of ChipSoft in the design and development of the software. The wishes of the end users were not met, or only at an extremely late stage. There was also criticism of ChipSoft's high profit margin (Eikelenboom, 2019). The profit margin in 2018 was 46 percent (€52 million gross profit on some €112 million in revenue). Competitor Epic had a turnover in the Netherlands of €43.5 million in 2019, and with a gross profit of some €12.7 million, Epic arrives at a profit margin of about one third. As a result of the recent judgment in the preliminary relief proceedings concerning the publication of the report by the ACM, there is renewed media attention for the high profits of ChipSoft in the general media (van Lonkhuyzen, 2022). Following this, some healthcare executives express their opinion on the matter, arguing that the high margins are socially inexplicable (Zuil, 2022).

3.6 Legal forces

Quality standards such as the NEN and ISO are principal factors that play a role in ChipSoft's business operations and the HiX product. The ISO 13485 standard focuses on the quality of the organisation. The requirements for a quality management system are specified. An organization needs to demonstrate its ability to provide medical devices and related services that consistently meet customer and applicable regulatory requirements (International Organization for Standardization, 2016). In case of ChipSoft, this concerns patient safety and

customer satisfaction, which must be considered in all parts of the organisation. Risks must be identified and demonstrably mitigated. Furthermore, business processes should be evaluated and always improved.

The Conformité Européenne (CE) certification is important, as it concerns the quality of the product. Medical devices are divided into classes according to their 'intended purpose', based on the risk to the patient. HiX falls under class IIb, as do anaesthesia machines, for example. Although most EMRs fall under class I, as do plaster casts, HiX falls under class IIb because it also contains software modules that function as medical devices. This is the case for Class IIb including ChipSoft-Medication and/or patient data management system (PDMS). This software can, for example, administer infusions or medication to a patient, with amounts depending on calculations based on the patient's weight.

There are multiple important legislative and regulatory issues that have a significant impact on ChipSoft. The most important, and which has received the most attention from society in recent years, is the General Data Protection Regulation (GDPR; AVG in Dutch). This concerns the privacy of patients, as their, very privacy-sensitive, clinical data are stored and consulted in ChipSoft's product HiX. HiX has been designed to always ensure privacy, with the principles of 'privacy by design' and 'privacy by default'. Privacy by design" means that products and services are designed to ensure that personal data are properly protected. “Privacy by default" means that the default settings of a product or service are privacy friendly (Autoriteit Persoonsgegevens, n.d.). ChipSoft has a privacy team and a Data Protection Officer, as required by the Dutch GDPR, to address this issue.

Besides registration, consulting personal and medical data is an important function of HiX. Various healthcare staff can consult such data, but they are not all allowed to view all data of registered patients. This depends on whether they have a treatment relationship with the patient. Based on this, they are authorised to view certain files or certain types of data (Patiëntenfederatie Nederland, 2022)). The setting up of these authorisations and the assignment of rights to HiX users is done by the healthcare institution, whereby the default setting is as privacy friendly as possible and fully compliant with the Dutch GDPR.
If there is a treatment relationship, the HiX user, e.g., the attending specialist, is allowed to view the person's clinical data. If there is no treatment relationship, there is a block and the HiX user cannot access the file. A pop-up automatically appears, a so-called "break-the-glass" procedure, after which the user is obliged to specify the reason for viewing, so that in emergency situations he can still view the file. For example, if a patient comes into the emergency room, but is not conscious. Or if a healthcare worker in the hospital needs acute healthcare because of an accident. In fact, all actions and clicks are logged in HiX, so that they are transparent to the healthcare institution. The importance of this became clear when many healthcare staff wrongfully investigated the medical file of a Dutch celebrity and the hospital found out because everything was logged (Bukman, 2018a). Insight into these logs can also be requested by patients themselves because they are entitled to inspect them (Patiëntenfederatie Nederland, 2022).

Privacy also plays a significant role within Datawarehouse. The display of data in reports must always comply with the Dutch GDPR. Depending on the level of detail in the report, this plays a major or minor role. Many reports have a detail page, where data is displayed at the patient

level, with a patient number. In most healthcare facilities, this patient number is not directly traceable to a specific patient on the report itself. However, the user can usually click on the patient number to navigate to the patient's file in HiX. If there is no treatment relationship, the user is also prompted to provide a reason for viewing. Other reports contain much less detail. For example, a report on the number of outpatient appointments or the number of admissions per speciality.

What can play a role here is the privacy of doctors and other healthcare workers. However, this is an issue within the walls of a healthcare institution, as they can authorise certain HiX users for specific reports.

Before software can be delivered, it must first be extensively tested for quality and functionality. For this test work, test data is required. It is important to test with representative test data. Preference is given to real data (copy of healthcare institution) instead of generated fake data, as this ensures better software quality (Datprof, n.d.). However, it is difficult to get hold of these, because hospitals are, quite rightly, careful with the patient data they hold. There are possibilities to pseudonymise the data, and in this way the privacy of patients is guaranteed.

4 Market competition with Porter's five forces

The idea that competition in a market is believed to be shaped by the collective of five different forces was introduced by revolutionary Michael E. Porter back in 1979 (Porter, 1979). The five forces are direct competitors, the bargaining power of both customers and suppliers of the market players as well as potential entrants to the market and threatening substitute products or service. Together, these forces influence profitability in a particular industry. It is important to understand these forces, so a firm can develop a strategy to ensure long-term profitability.

These five forces are discussed in the context of the Dutch HIS/EMR market, with special attention to the situation of ChipSoft. Where relevant, some more detail is given when a force differs specifically for CS-DWH.

4.1 Competition

The main factors driving competition in the Dutch HIS/EMR market are the competitors, transitions costs, the growth of the Dutch HIS/EMR market and product differentiation.

Competitors

There are only a few players left in the Dutch HIS/EMR market. ChipSoft serves about 70% of the market, Epic about 13%, Nexus 10%, and Cerner about 7%, in 2021. The shares of ChipSoft, Epic and Nexus are increasing, and the share of Cerner has decreased in recent years (M&I Partners, 2021b). So, there are quite significant differences in the market shares. However, Epic has about 1300 customers worldwide and is thus much larger than ChipSoft. As a result, Epic and ChipSoft are both seen as dominant players in the Dutch HIS/EMR market (Bukman, 2018b). They therefore often compete in tenders, although Epic focuses on a specific type of hospital and thus mainly serves UMCs and large hospitals (Autoriteit Consument & Markt, 2021b). Because there are only a few dominant players left, the chance of takeovers is small, and therefore the role of competition is moderate in influencing profitability (Porter, 2008).

As for CS-DWH, multiple players exist in the hospital business intelligence market. Important players are Conclusion, Performation, IllionX, among other smaller players. Most players are approximately the same size, with no huge market leaders now.

Transition costs

The switching costs for hospitals to switch to another HIS/EMR supplier are extremely high (Autoriteit Consument & Markt, 2021a). This is because the use of the HIS/EMR is intertwined with the work process of a hospital's healthcare provision. Moreover, when switching, all employees must learn to work with the new system, which costs a lot of time and therefore money. The switch is also technically complex, because all data, such as patient records and employee data, must be transferred. It is important that this is done without errors because patient data must not be lost. The Personal Data Authority applies a mandatory retention period of 20 years for medical files (Rijksoverheid, n.d.). Selection and implementation of an HIS/EMR takes about 1.5 to 2 years on average, so it also takes a lot of time (KPMG Advisory N.V., 2022). Because of these reasons, hospitals will not easily decide to change HIS/EMR supplier.

Concerning Datawarehouse, the most important aspect for a successful business intelligence implementation is not so much the technology, but the practice and people within an organisation. In a change of the BI tooling are therefore especially capable people important. It is therefore an impactful change, but not impossible. This is exemplified by a recent retraction of one of the clients of ChipSoft from the CS-DWH-module. Compared to transition of a HIS/EMR system, changing BI tooling has a much smaller impact on an organization.

Industry growth

Over the past 10-15 years, nearly every hospital switched to an integrated hospital-wide EMR, whereas previously they often used many departmental and process-specific systems (Nienhuis, 2021a). The Dutch HIS/EMR market is currently regarded as saturated (Autoriteit Consument & Markt, 2021b). As a result, there is a great deal of competition between the players on the market to gain market share when a hospital issues a call for tenders, both in the Netherlands and in other countries.

As for CS-DWH, the role of business intelligence in hospitals is still increasing. According to a report from 2015, the basic role of business intelligence in providing KPIs was okay. However, the actual use of the numbers from reports lagged, data is fragmented across multiple systems and often the business intelligence unit in a hospital was perceived as a cost item for external accountability, towards health insurers (M&I Partners, 2015).

Most hospitals have implemented some form of business intelligence tool that supports internal and external responsibilities. However, there is still a world to be won when it comes to data intelligence. As was mentioned in the PESTEL analysis, a recent development in business intelligence is self-service BI. Most vendors of business intelligence tools in healthcare focused on business intelligence in the form of KPIs, so the market for more intelligent use of data is still growing in the Netherlands (M&I Partners, 2021a). So the industry of business intelligence tools in healthcare is still growing, so

Product differentiation

Broadly speaking, the functionalities of different HIS/EMR products are the same, namely the registration and retrieval of clinical data and the support of processes in the hospital. There is some difference in the functional depth between the available products (KPMG Advisory N.V., 2022). The form is different, too. ChipSoft is known for its Standard Content, which is a standardised configuration based on a template (M&I Partners, 2021b). Epic, on the other hand, offers more self-build, and thus focuses on a specific customer segment (Autoriteit Consument & Markt, 2021b). In addition, there is a different degree of completeness. The Nexus HIS/EMR is still partly under development, as it does not yet contain a fully-fledged medication module. As a result, it is seen by the market as an incomplete EMR, which means that the HIS/EMR must be linked to a specialist sub-product (KPMG Advisory N.V., 2022).

Part of the product is in the service that is provided. This is expressed in support during the use of the product and for a large part in the implementation. Often, external parties specialized in guiding implementation processes are hired by hospitals to assist in the implementation. The extent of successful implementations differs per supplier. For example, a few years ago one HIS/EMR implementation was stopped prematurely due to disappointing results, resulting in a lack of trust (van Dorresteijn, 2015). Thus, a solid implementation plan is

being rated higher, and an HIS/EMR that has already proven itself in the Dutch HIS/EMR market is chosen more often (KPMG Advisory N.V., 2022).

There is a difference in the degree of contact between suppliers and customers, to find out what customers want in terms of further development of the product. ChipSoft has intensive contact with its customer group through so-called 'User Groups' (Gebruikersgroepen in Dutch) (ChipSoft, n.d.-b). Epic is a large American company and stores the medical records of around 225,000 patients in the US. Consequently, its broad research agenda, which relies on the input of large clients in the US, is hardly influenced by non-US clients (Jennings, 2021).

As for CS-DWH, firms that operate in the business intelligence market in healthcare have various forms of product-service mixes. Some focus more on the back end of business intelligence, whereas other focus more on providing services to implement and adopt business intelligence tools in a hospital (M&I Partners, 2021a). This means that the products differ quite a lot from each other.

Fixed costs

The proportion of fixed costs is high because of high cost of research and development (R&D) of the product. Partially, this is because of changes in legislation, and the software needs to support the most current regulations, since hospitals must comply with these. Next to this, the products in the market are still developing towards more functionality, which is why investments in R&D are done (Nienhuis, 2021b). Therefore, R&D costs are high, due to personnel costs. High fixed costs can lead to price competition, but this has little influence in the HIS/EMR market.

Exit barriers

Depending on whether the player also has a market share abroad, and whether it also sells other types of products, the barriers to exit differ. When barriers are high, companies are forced to stay in the market even though profit margins are decreasing (Porter, 2008). Epic and Cerner have many customers in other countries, but ChipSoft only recently started to enter markets outside the Netherlands. When companies are active on multiple markets, be it different products market or several geographical markets, it is less catastrophic when they exit a market. Therefore, its exit barriers are lower in that case Also, most players have focused on serving only hospitals the healthcare sector, which makes an exit from the HIS/EMR market difficult (Autoriteit Consument & Markt, 2021b).

Conclusion

Because the products are broadly the same, yet differ in details and service, there is a fair amount of competition in the HIS/EMR market. These factors decrease profitability of this market overall in the context of competitive rivalry. As for business intelligence in hospitals, there is also a fair amount of competition. Lower transition cost, more product differentiation and more industry growth play large roles in the competitive rivalry.

4.2 Power of customers

Transition costs

As mentioned before, the transition cost for a hospital switching to another HIS/EMR is enormous, because switching is technically complex and work processes must be adapted. As

a result, substantial investments are required form hospitals if they switch. So the power of hospitals as customers in the HIS/EMR market is negatively affected by the high transition costs (Autoriteit Consument & Markt, 2021a). The product, although broadly similar, is still quite heterogeneous due to the hospital's wishes in terms of design, further increasing the transition cost for hospitals (Autoriteit Consument & Markt, 2021b).

Knowledge of customers

Research by the ACM has shown that hospitals cooperate to a limited extent when it comes to exchanging experiences about their purchased HIS/EMR systems (Autoriteit Consument & Markt, 2021b). The prices charged by different HIS/EMR suppliers are not always transparent to hospitals (KPMG Advisory N.V., 2022). Furthermore, hospitals have less technical knowledge of the product, which means they cannot make the switch themselves without the help of suppliers (Autoriteit Consument & Markt, 2021a). It is also not a core activity of hospitals. Some hospitals that previously had their own EMR, such as Erasmus MC, decided to choose an HIS/EMR from an HIS/EMR supplier (Furore, n.d.).

As for CS-DWH, the knowledge of customers regarding business intelligence is very high. Opposed to the supplier of business intelligence tools, the business intelligence team in a hospital has a much deeper understanding of the specific information that is demanded inside the organization. They know the organization inside out, and have more contact with the end-users. This means that they know what content is necessary in the reports that they provide end-users with. In most cases, the business intelligence team at the hospital are seen as the direct competitor of the business intelligence tooling firms. However, not all hospitals have the technical knowledge inhouse to make the reports themselves. Often, the larger hospitals have more resources for business intelligence and therefore have workforce with more technical skills to build and maintain the reports supplying business information. Therefore, the knowledge of business intelligence teams in hospitals plays a major role in the power of customers regarding business intelligence market in hospitals.

Size of orders

Also, the purchase of an HIS/EMR is usually done individually by a hospital. Although there are some examples of hospitals cooperating in a purchasing process, (Bukman, 2020; van den Elsen, 2016; van der Beek, 2014) most hospitals conduct their own selection process (Autoriteit Consument & Markt, 2021b). As a result, the size of the contracts is low, which gives customers less power on the market in relation to the suppliers.

Price sensitivity of hospitals

The implementation of a new HIS/EMR is expensive for a hospital. The cost of implementing a HIS/EMR system can amount to around 15 to 20 million euros, depending on the size of the hospital (Bukman, 2019). Next to this, there are costs on an annual basis, for updates and maintenance. The share of turnover that a hospital spends on ICT annually is on average 5.7%, half of which is spent on the HIS/EMR (Gerla & van Luxemburg, 2021). This is therefore a fair proportion of the turnover. As the profit margins of hospitals are only around 0-2%, it is important to keep costs down (Zuil, 2022). Thus, price can influence the selection process of hospitals. For example, Nexus' costs were about half those of other market players when the Groene Hart ziekenhuis in Gouda selected an EMR. The hospital's Chief Medical Information Officer (CMIO), who is a medical doctor advising the hospital on ICT issues, stated that reduced

cost was one of the reasons for choosing Nexus as a supplier (Bukman, 2019). Because the proportion of HIS/EMR costs in relation to total revenue is reasonable, and profit margins for hospitals are low, hospitals can be sensitive to price in their HIS/EMR selection.

However, since hospitals depend on the quality of the HIS/EMR for their operations, as errors can have far-reaching consequences, certain minimal requirements must be met. For example, a hospital recently lost many documents from medical patient files due to an error. These documents can never be retrieved again if a patient needs his medical records in the future. This explains why hospitals in general are quite risk-averse, and why they are less price-sensitive when they can prevent quality related issues, as can be expected from their low profit margins.

4.3 Power of suppliers

Microsoft provides software programs with which ChipSoft's software is written. Also, the OS which is used is only Microsoft Windows. For projects and document exchange, Microsoft Sharepoint is used. Slowly, more hospitals start looking into transferring their data to the cloud, which is supported by Microsoft Azure. Because of this, the customers of ChipSoft, so hospitals and other healthcare institutions, are indirectly also customers of Microsoft.
As an independent software vendor (ISV) on the Microsoft platform, ChipSoft brings in thousands of users for Microsoft, which is why ChipSoft is considered an official 'Microsoft ISV-partner (ChipSoft, 2020)

There are few other suppliers offering these services and the transition costs for ChipSoft to switch to other programs, platforms and software is also incredibly high. Next to this, the HIS/EMR market is only a small share of the markets served by Microsoft. As a result, the threat from Microsoft as a supplier is high.

There are alternatives to Microsoft as a supplier, for example open source. But security is a disadvantage here. Microsoft's product is very standardised because Microsoft does not adapt it for ChipSoft. Also, the chance of forward integration of Microsoft is minor because Microsoft's product is in fact already passed on through ChipSoft's product, as ChipSoft is an independent software vendor. This is one of the largest sources of revenue for Microsoft (Popp, 2011). So, the overall threat of the supplier to ChipSoft is small.

Because the supplier of the tooling that is used for developing the CS-DWH module is also Windows, with most important software programs being Visual Studio, SSRS and PowerBI, the power of suppliers regarding the CS-DWH is equally low as for ChipSoft overall.

4.4 Potential entrants

An important influence is that of scale on the demand side of the market, also called network effects. This occurs when a customer is willing to pay for a product when there are more other customers (Porter, 2008). This is a common phenomenon in the software industry (Buxmann et al., 2013). In the HIS/EMR market, this manifests itself as a greater incentive for hospitals to choose a supplier if surrounding hospitals have also chosen this supplier. This is because hospitals are better able to cooperate and exchange data if they use the HIS/EMR of the same provider (Autoriteit Consument & Markt, 2021b). By increasing the number of customers, the value of the product also increases, thus reinforcing the network effect, a positive feedback loop (Buxmann et al., 2013).

Also, the transition costs to another supplier are extremely high for hospitals, as already described. There are strict rules and legislation that a company and its product must comply with, as described in the PESTEL analysis. In the past, hospitals used to make their own HIS/EMR software. But the developments are too quick to keep up with and the scale is not large enough. But, in favour of current HIS/EMR market players, this reduces the likelihood of new entrants. This also contributes to the capital investment required to enter the Dutch HIS/EMR market, making it difficult for companies to enter this market. Investments necessary to ensure that the product is compatible with the Dutch healthcare system, with its financial DBC (Diagnose-Behandel Combinatie; English: Diagnosis-Treatment Combination) system, are not even included here. According to consultants for HIS/EMR software selection for hospitals, firms that are not active in the Netherlands no longer even respond to requests for quotations (van Lonkhuyzen, 2022). Current market players also invest a considerable part of their turnover in the further development of the product. This varies between about 14-16% at Cerner to about 36-38% at ChipSoft. This is partly explained by the complex landscape of government programmes around ICT and digital healthcare (KPMG Advisory N.V., 2022). As a result, large scale is needed to recoup the investments for the Dutch market. Only when a large scale is reached can the supplier recover its costs. This makes it difficult to enter the market (Porter, 2008).

Because all hospitals have now chosen an EMR, their processes have been adapted to work well with the HIS/EMR system. This gives the established suppliers an advantage over potential market entrants. This played a role, for example, in the choice of Nexus by the Groene Hart Hospital (Bukman, 2019). In addition, there are now few all-new implementations, as most hospitals have already opted for an EMR. As a result, the only way for new players to enter is by conquering current suppliers. This makes entry difficult.

Access to distribution channels also influences potential market entry (Porter, 2008). In the Dutch HIS/EMR market, a European tender is usually issued (van Dorresteijn, 2013). This is transparent, enabling suppliers to enter the market.

Regarding CS-DWH, the main influences on threat of entry to the business intelligence market in healthcare are the lack of necessary economies of scale on the supply-side, the modest switching costs and capital requirements and limited accessibility of distribution channels.
Economies of scale are not necessary on the side of the supplier, as quite some BI tool vendors start with providing services to hospitals as their main source of income. The fact that switching costs are comprehensible for a hospital has been discussed before. The limited capital requirements and accessibility of distribution channels are exemplified by the fact that most firms are in some way, or another involved in working together on a project which is funded by a health insurer, or as part of a pilot inside a hospital, thereby not dependent on heavy investments (Wilman & Ahli, 2018). Therefore, a considerable force can be expected as a threat of entry from scale-ups.

4.5 Substitutes

Substitutes perform a similar function as products of the industry, but does so by different means (Dobbs, 2014). A topical example is that of videoconferencing, which can be substituted by travel. The price sensibility of hospitals, switching costs and profile of the buyer affect the threat of substitutes. As mentioned before, the switching cost for hospitals are very high.

Besides, hospitals tend to be risk avoidant and the price sensibility for HIS/EMR systems is moderate, so this results in a low threat of substitutes. However, the force also depends on the trade-off to the substitute's industry product. The better the relative of the substitute, the lower is the potential of the HIS/EMR market.

For CS-DWH, the price sensibility and switching cost of the hospitals is lower, so this results in a somewhat higher threat of substitutes for the business intelligence market in healthcare.
Changes in other industries may make them more attractive substitutes than before. For example, improvements in plastic materials might make them a good substitute for aluminium, even though the industries might seem unrelated at first. The other way round also holds true, so a change in the current industry might be in favour of an industry (Porter, 2008).

5 Business analysis

5.1 Customer segment:

ChipSoft's customer base consists of healthcare institutions. The majority are hospitals, serving about 80% of the Dutch hospital market as a supplier for HIS/EMR software.
As this market is almost saturated, they have expanded their customer base in several ways.
Firstly, next to hospitals, other types of healthcare institutions are now being served, such as home care, maternity care, nursing homes, clinics, nursing homes, rehabilitation centres, mental healthcare institutions, GPs, and pharmacies. These healthcare institutions also need software to support the healthcare process and to store medical information about patients. However, the work processes are different, so HiX needs to be set up differently. Another substantial difference is the scale of the organisation. Hospitals are usually much larger organisations than other healthcare institutions and provide healthcare in many different specialties.

In recent years, new markets have been opened abroad. Initially, customers were sought in the Flemish market in Belgium. It also participated in a tender for a large hospital in Ireland, but unfortunately lost and ended as the runner up behind Epic. So, ChipSoft is actively seeking opportunities to tap into new foreign markets.

ChipSoft acts here as a centralised exporter. This is particularly effective in countries that differ little from the home country. This is the case in the Flemish part of Belgium, where the cultures are relatively close and, more importantly, the same language is spoken. An increasing number of employees are active from Belgium for customer support functions, namely implementation and support, which is typical for a centralised exporter. In Belgium, ChipSoft can build on the strengths of HiX by taking the firm-specific advantages abroad without modifying them. This allows ChipSoft to take advantage of economies of scale, as the product is standardised, and can be sold abroad with a few adaptations.

Datawarehouse

Large hospitals have a larger business intelligence department, so usually more knowledge of BI. In small hospitals, there are usually only small BI staff. As a result, they have different requirements for how the information should be made available to end users. Small hospitals usually use standardised products (standard content), and the BI specialists maintain this and help end users within the hospital to use it. Large hospitals use standard content and often also have self-built reports.
Besides, the information needed in a hospital varies depending on its specialisation. In the Netherlands, there are general, categorical hospitals, which for instance specialise in cancer healthcare, and teaching hospitals, which often provide specialist healthcare and conduct academic research and education. Due to the differences in the provided healthcare, the information needs are different.

Description of end user

The end users are doctors working in a hospital as medical specialists. In general, medical specialists are seen as highly skilled people who have the interests of their patients at heart. It is for a reason that they must swear in their doctors' oath that "I put the patient's interests first and respect his views" (Kleijne, 2019). Many doctors have a tremendous drive to help people. After a long training period, they often work long hours and work evening, night, and weekend

shifts. As a result, practice is often less rosy than one would have imagined when choosing to study medicine (Bustraan et al., 2019; Saris, 2022). The medical profession is described by a philosopher and lecturer in medical ethics as "rather sectarian". He explains: "It is something you see in every profession where people perform work with social significance, which is so specialised that you are not interchangeable, and where you have a high degree of autonomy. In such professions you have initiation and socialisation processes. " (Kleijne, 2019). Then again, the hospital is a workplace that offers a quite different environment from the average office job. The workload is enormous due to the administrative burden and pressure on care, while there is less and less time for the patient (Federatie Medisch Specialisten & VvAA, 2017).

There is also an old-fashioned working culture in the hospital world. It is characterised by long working hours and a hierarchical relationship between experienced and junior doctors. This work ethic and anything but feminist culture also leads to difficulties in starting a family. This culture, combined with doctors who have a great inner drive, ensures that their altruism is exploited and drives the healthcare system to extraordinary effort. Added to this is the general idea that you must be able to stand anything. If someone cannot, it is not the system but the person (Kleijne, 2019).

Although young doctors more often express that their identity is more than their job, and their world bigger than the hospital. Research has shown that a disrupted work-life balance is the most cited reason for trainees in hospital-based specialty training (in Dutch: Arts in opleiding tot specialist; AIOS) to quit their training (Bustraan et al., 2019). Most do continue to work as doctors, but outside the hospital. So, the current healthcare system has a lot of influence in how doctors do their work. As a way of dealing with that system, many doctors have developed the same traits: they are often stubborn and headstrong. This means that doctors tend to have a lot of influence in a hospital organization, often resulting in them getting their way. For CS-DWH, this means that the requirements of doctors are very important and must be incorporated into the product.

5.2 Value Proposition

First a general description of the structure of the product HiX is given as background. Following this, the strategic challenges for ChipSoft and specifically for CS-DWH are discussed. Lastly, the method to overcome the strategic challenge that is dealt with in this project is explained.

HiX is a modular product. A different composition can be sold per customer. Some modules are standard, however, such as CS-Patient, which forms the basis of HiX, as this is where the registration and recording of patient data such as name, address and place of residence takes place. Other modules are optional for customers, such as CS-Datawarehouse. However, by default, ChipSoft sells the product merged into 'All You Can HiX'. They can choose not to take this module and to choose their own solution for this. Sometimes, several years after the original implementation of HiX, a customer decides to add an optional module. The end user does not experience that HiX consists of separate modules but uses everything from one environment.

Overall, hospitals have the same tasks in providing healthcare, but the work processes are still quite different. A work process can be different within a hospital, for example between different specialisms, as well as within the same speciality between different hospitals.

In the past, ChipSoft used to make the architecture the same, but the exact design was determined during an implementation process with the relevant customer based on the wishes of that hospital. In the past years, the choice was made to standardise the layout, so-called 'Standard Content'. However, in some areas, the wishes of customers are so different that there are still different flavours.

Strategic challenges

The principal way in which ChipSoft developed its strategy, aiming to increase profitability, is based on the market forces of competition and the bargaining power of customers. Below is discussed how these strategic choices are reflected in the product/service that ChipSoft offers.

In its competitive rivalry, it focuses on new product development and service improvements. Its product, i.e. the software program, contains a total package of functionalities for all treatment and registration processes with role- and task-specific content for every healthcare worker. Not all competitors can deliver this (KPMG Advisory N.V., 2022). Through standardization, i.e. its so-called Standard Content, it can drive down cost of software development. The standardization enables ChipSoft a more uniform product since all clients use the same software. This reduces R&D cost for software development and other fixed costs, such as solving bugs.

Standardization of software also improves the efficiency and reliability of implementations at hospitals because it becomes more of a routine with a fixed phasing. As a result, ChipSoft can promise future clients an implementation project within time and budget. This can be a determining factor in a HIS/EMR supplier selection process, as implementations by other firms have proven to be unpredictable at times, causing them to exceed budget and/or time restraints or the whole project to be cancelled (Furore, n.d.; van Dorresteijn, 2015). Its Dutch origins make ChipSoft perfectly adapted to the DBC system, which is the Dutch financing system for healthcare.

When it comes to the force of customers, ChipSoft has a relatively good position when compared to other types of industries, as was discussed before. Its clients have a decision-making unit which consists of multiple people in various roles, as is often the case in organizational buying (Fahy & Jobber, 2015). So, not everyone has the same type of knowledge and amount of knowledge in the buying process. The healthcare professionals who are involved in the purchasing process of a HIS/EMR typically do not have a deep understanding of the day-to-day use of the product. This can result in a distance between the daily users and ChipSoft, which designs the software. This is strengthened by the fact that the software is made by software developers, who usually think in a different way compared to the medical doctors who use the software daily in their work processes. So, a gap in knowledge needs to be overcome.

ChipSoft does this by facilitating user groups, under the title of the Innovation platform (NL: Innovatieplatform). Primarily, software innovation and development take shape through different user groups. User from various healthcare organisations from the country are brought together to share expertise on the content. In that way, the standard content can jointly be enriched in consultation with end-users (ChipSoft, n.d.-c). As a result, ChipSoft can overcome

its lack of knowledge in user requirements concerning new innovations and at once assure joint decision-making by their clients.

Datawarehouse

CS-DWH focuses on product differentiation to compete with other players in the market. Because it is a module of HiX, it can exploit its tight integration with HiX. Among the advantages of this is that the product can be reached from same interface as HiX, which is easier for end-users. The integration also enables CS-DWH to build on the authorization structure of HiX, which allows only authorized users to access the HIS/EMR of an individual patient when clicking on a patient number in a report.

As far as new entrants are concerned, ChipSoft does have easy access to distribution channels. When implementing HiX, it will have contact with its clients, thereby enabling entry to the business intelligence department of a hospital. Also after implementation, account managers from ChipSoft keep in close contact with their clients, to stay on top of any changes in requirements from clients. This provides an advantage compared to other current or new market players.

The power of CS-DWH as a supplier is not nearly as much compared to the power of ChipSoft as a HIS/EMR supplier. Adding to this, the transition cost of switching BI tools is lower compared to a HIS/EMR. Therefore, CS-DWH must pay more attention to its provided service in order fulfil the clients' needs. This is an interesting difference in the approach of the CS-DWH department towards clients compared to ChipSoft.

In line with the lack of knowledge regarding the EMR, the internal BI department at the hospital has a more precise understanding of what end users want regarding reports than ChipSoft-DWH. Therefore, to streamline its product development with the requirements of end users, ChipSoft stays in close contact with them. It should be noted, however, that every client has slightly different requirements. This means that it is virtually impossible to develop a product that exactly fits all needs of every client. So, the challenge for ChipSoft is to develop a product that as closely as possible meets the requirements for as many hospitals as possible.

Because of the lack of knowledge on users' needs in a product, one of the challenges for the product development of IM Medical is to find out what end users want concerning clinical information on patient groups. This is especially the case for the needs of medical doctors at the hospital. Medical specialists are extremely busy, so it is challenging to keep in close contact with them. Next to this, they are usually unaware of the technical possibilities. Although they might act as influencers in the buying process and impose their choice criteria on decisions, they are not the decider in the buying process (Fahy & Jobber, 2015).

Collaborative innovation with customers

An open form of innovation is called collaborative innovation with customers. This can be defined as the processes by which firms and customers engage in mutual innovation (Greer & Lei, 2012). More open innovation has been adopted by firm since the last few decades because it helps them develop successful products (Chesbrough, 2003).
Generally, working with customers is seen as beneficial, especially for complex or radical innovation. One of the indicated driving factors of pursuing collaborative innovation is the

depth of knowledge of customers (Greer & Lei, 2012). This is indeed the main driving force for ChipSoft to innovate collaboratively. In this context, the software development is for knowledgeable customers, which explains why collaborative innovation works well in this industry (Nambisan, 2002) . Furthermore, when the customers' needs are tacit, this means that their need information is difficult to communicate across individuals or organizations (Subramaniam & Venkatraman, 2001). The knowledge of medical doctor's needs is tacit and difficult to explain to non-doctors because context is necessary to understand the exact work process of medical doctors within the hospital. Therefore, interaction, preferably as close as possible, is favourable in communicating the customers' needs. This improves the quality of information sharing, with customers more likely to provide necessary contextual knowledge helping to convey their tacit needs (Cui & Wu, 2016). For these reasons, innovation in collaboration with customers is helpful in product development for ChipSoft.

5.3 Revenue

The revenue of ChipSoft is ascertained by its long-term contracts. These contracts are mostly around 5-10 years, and at the end can be extended by another 5 years. The contracts consist of two types of income. Firstly, the cost concerning the implementation process. Secondly, the yearly license cost for the software and maintenance and service costs. If a hospital wants a tailored piece of software, which is specifically designed for that client, then a separate order with its own contract can be agreed on.
Sales are made through winning public tenders that hospitals call when they seek a HIS/EMR supplier. These tenders comprise long selection processes, which vary in length. For hospitals, they take a few years up to eight years for the selection process in Ireland.

5.4 Organisational structure

Centralisation of decisions is clear characteristic of the organisational structure at ChipSoft, as decisions are taken very centrally. The managing board takes many decisions, even on relatively minor subjects. This is exemplified by the frequent meetings and demos in the product development of IM Medical with of top management, namely the Manager R&D and the Division Manager R&D Netherlands. This centralisation contributes to the coherence of the product. Furthermore, a centralized organisation can make a change in its overall direction because its tight command-and-control structure enables it to impose.
A disadvantage of a centralized firm might be that all decisions need to be passed up the hierarchy to top management, which takes time. However, ChipSoft is a rather flat organization, with only a few levels of management, as can be noted from the organogram (Figure 1) This helps to speed up decision-making, even if decisions need to be made centrally by the board members.

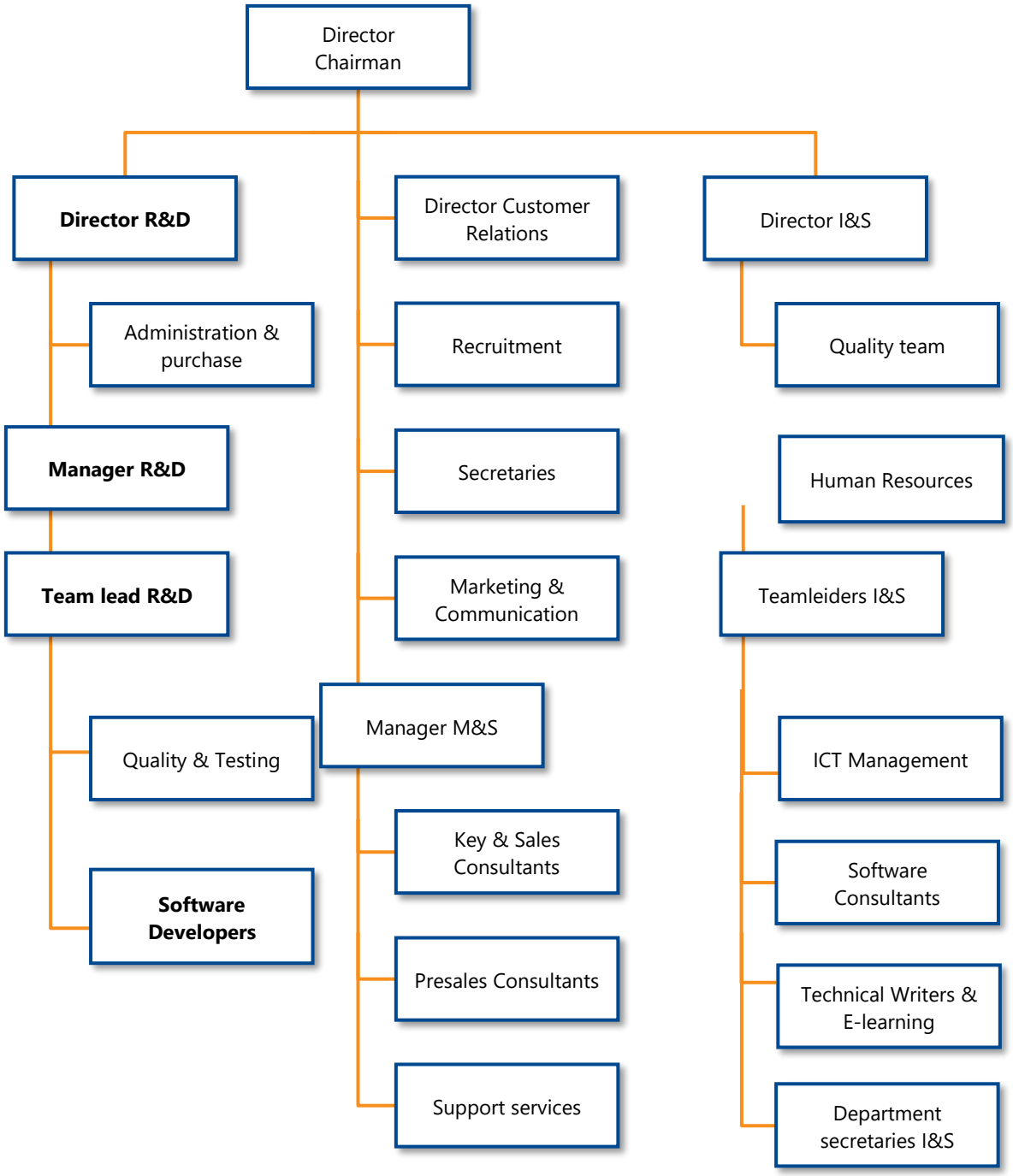

Figure 1 Organisation chart of ChipSoft.

5.5 Work process

The work process within ChipSoft is streamlined along the whole R&D department, as products are developed and innovated through scrum. The process consists of cycles, called sprints, that take two weeks, followed by a release with the new development in an update called a Hotfix. This process, which is common in the software industry, makes development faster and more flexible, by breaking up the product into many features that are built and released quickly (Schilling, 2020). This allows for constant, incremental improvements of the product.

A major advantage of agile development, rather than large product development projects, which can only be assessed by clients at the end of the project, the aim is to demonstrate a minimal viable product (MVP) as early as possible. The key here is that feedback early in the development process can shape the direction of development and the developers can make early adjustments. This helps to reduce risk and makes it clearer which part of the product does or does not work.

Datawarehouse department

The structure of the teams at the Datawarehouse department is slightly odd compared to the other departments. Usually, the R&D teams, which develop the software, are separate from the I&S teams, which implement the product at the hospitals. At the Datawarehouse department however, the developers as well as the project consultants that implement the product at the clients, are all together in one department, working closely together.

Among the developers, there is a further distinction. A team of software developers is devoted to developing the back- and frontend of the software, so the product is correctly built in the overall product HiX. Another team assures that the data is correctly extracted from the source database, which is HiX, and prepared to enable quick and efficient analysis. Yet another team, the so-called BI team, develops the actual reports and dashboards through visualisation of the data in tables and graphs. This is what is released to the clients of CS-DWH. The hospitals can use the reports independently, and next to that the project team with project consultants who implement the product at clients, in fact also act as clients of the BI team.

Because the CS-DWH module is a separate module and works separately from the rest of the product HiX, there is a fair risk that hospitals might choose another supplier for a BI tool (which was also pointed out in Porter's five forces analysis). The intensive collaboration within the Datawarehouse enables better streamlining between the product development and implementation of the product, resulting in better retention of current HiX clients and more new sales made during current contracts with HiX clients.

6 Aim of the study

As was pointed out before, one of the main strategic challenges for ChipSoft is its lesser knowledge of the user's needs. This accounts for ChipSoft and the product HiX as a whole, but even more so for the CS-DWH, since the internal BI departments at hospital will have a deeper understanding of the users' needs in management information.

Involving the end-user in product development has been proven to increase the likelihood of a successful product being made (Greer & Lei, 2012). The fact that ChipSoft does not always develop software that suits users' needs has been a source of criticism too. Another reason to invest in user involvement is that reports have been developed and are currently available at CS-DWH but are barely used by any clients. This indicates that these reports do not meet the user's need, be it in lacking the right information or another reason. Lastly, in new product development large investments in R&D are done. This increases the risk for a company, which makes it even more important that a product fits the user's needs.

As was pointed out in the PESTEL analysis, there has been a shift from static report sets to more 'self-service BI' in recent years. This means that an end-user, without technical background knowledge, has more freedom to set parameters, enabling him/her to analyse and interpret data himself/herself. With just knowledge of the business side, they can even build whole reports themselves. This makes the end-user less dependent on an organisation's ICT department (Bhat, 2020). And there is an increasing need for doctors to have insight into clinical data.

From all these developments, together with feedback from ChipSoft's customers, the idea for a new product arose, which makes medical patient information accessible. IM Medical, a Business Intelligence product that collects and filters clinical data from HiX and then the data is given meaning and placed in the correct medical context.

The user group can be segmented based on technical knowledge of the end user. A medical specialist is an end user with little or no technical knowledge, little time to spend and a great interest in the information, because of their responsibility as a doctor in the hospital, as their primary task is to care for the patients.

Little is known about the wishes of medical specialists as end-users regarding the use of medical patient data at group level for various reasons, which have been discussed before. This makes it difficult to design a product that meets their needs. Because users or future users are a valuable source of information when designing new products it is important to gain more insight into the requirements and wishes of medical specialists regarding the use of patient data at group level. Defining and prioritising the requirements and wishes of medical specialists in the use of patient data at group level is the aim of this study.

Several types of information questions can be answered with IM Medical, namely both recurrent questions and exploratory questions. Recurring questions include indicators that must be supplied annually to inspection bodies, health insurers and federations such as the Netherlands Patients Federation (Patiëntenfederatie Nederland) or the Dutch Association of Hospitals (Nederlandse Vereniging van Ziekenhuizen) to guarantee high-quality healthcare. An example of an indicator is the number of reoperations of a hip fracture, which is carries out

after complication in the first operation. This indicator says something about the quality of healthcare concerning hip fractures, where a low number of reoperations is a sign of high quality of healthcare. Furthermore, exploratory questions can be answered. For example, more insight can be gained into the patient population within the hospital. This information can be used to better coordinate the supply of healthcare with the hospital's catchment area.

Correlations between medical interventions and clinical interventions can also be examined. If such types of information are offered in an accessible way, medical specialists can use it themselves. This allows a medical specialist to retrospectively gain more insight into the consequences of certain interventions in a patient population and to act if necessary.

To summarize, the objective of this study is to investigate the needs of medical specialists at hospitals, in the context of information regarding clinical data about patient groups. This will result in a clear overview of the requirements of medical doctors. The result of this preparatory research is then used to develop a first prototype. This prototype is demonstrated to medical specialists to receive feedback, which is converted into recommendations for ChipSoft to further develop the product.

The following sections will, in this order, address the methods, describe the results, and lastly interpret the results.

7 Method

7.1 Purpose

Mapping of requirements and wishes of medical specialists regarding information requests about groups of patients is necessary as input for product development of IM Medical for medical doctors. Due to time constraints, this study was limited to investigation of the requirements of doctors and retrieving feedback on a first version of a prototype which was designed.

The aim was to gain more insight into what a medical specialist considers important. It was a descriptive study, as an accurate and in-depth profile was obtained. This input was necessary to be able to make a product that meets the wishes of medical specialists. Interviews with end users were chosen because more depth is possible in interviews compared to surveys with fixed answers (Hennink et al., 2020). Depth is important because it enables us to really understand the users. This is important to be able to make a product that meets the needs of the end user (Mahr et al., 2014). In market research, users are asked what they find important in the product. Because of this user involvement, this is a form of collaborative innovation (Schilling, 2020).

7.2 Research participants

It was decided to interview multiple doctors so that a mixed picture would be presented. The research population for this research is limited to medical doctors working at Dutch hospitals. So, general practitioners, company physicians, psychologists, dentists, and other types of medical doctors were excluded, because the basis of IM Medical has been specifically designed for use in hospital setting.

Because this is qualitative research, a purposive sample was used (Hennink et al., 2020). This means that the sample size is smaller, i.e., five doctors, which allows for a detailed understanding and the possibility to go into depth. Also, a purposive sample gives the opportunity to determine the characteristics of the sample.
The participants were approached personally. Two of them are medical specialists and have a position as medical advisor at ChipSoft. In this function, they advise software developers from a physician's perspective. Another participant is a doctor and has been working at ChipSoft for a few weeks. This enabled her to give her view as a doctor as well. The latter two were approached to participate from within the researcher's own network.
Due to time constraints, only two of the five participants were approached for feedback on the prototype.

7.3 Participants demographics

The doctors who participated in the study all gave a distinct perspective on the issue. They all had a different speciality within medicine, so they provide diverse types of healthcare to patients and their patients encounter different things during a healthcare process.
The interviewed doctors were at various stages of their careers. Three of them were medical specialists, one was trainee in hospital-based training (Dutch: AIOS) and one doctor finished medicine but was not in hospital-based training yet (Dutch: ANIOS). This made it possible to gain insight into any differences depending on the doctors' positions. As the study focused on hospitals only, it was decided to select only doctors who work or have worked in hospitals, and not in other types of healthcare institutions, such as nursing homes or GP practices.

The doctors are/were working at different hospitals. Different hospitals may have different work processes. This may affect the way they obtain information about their patients. Another significant difference between the selected doctors is that they are currently working with different HIS/EMR systems. All doctors have also had experience with HiX during their career, except for one doctor. The latter will also switch to HiX in the autumn of 2022, once the hospital where he works has implemented it. Regarding the gender of the participants, there was an even distribution (two female, three male).

7.4 Data collection

A semi-structured interview was chosen because it is an exploratory study (Hennink et al., 2020). Therefore, a certain degree of standardisation and focus is desirable, as it concerns a specific subject. However, it should also be possible to discuss related topics that are suggested by the participants (Rubin & Rubin, 2012).

The structure of the interview guide was designed based on literature (Hennink et al., 2020). Before starting the interview, a very brief introduction was given, explaining the project and the purpose of the interview. Permission for recording was also sought, and the participant was asked if they had any questions. See Appendix 1 for the interview guide.

To start the conversation smoothly and to get more context, it was decided to ask the participant about his/her background first. Then some questions were asked to get to the heart of the research question. Participants were asked what questions they have about groups of patients, what the goal is of such questions. Next, they were asked about how they retrieve such information, and what information is missing. The last questions addressed what they find important about a means of obtaining clinical information on patient groups. After these core content questions, a short demo was given. The first part of the demo was done in the same way as this is done for ChipSoft customers, by using slides. This gave the participants already a short impression of how a product could look like. Secondly, a short demo was given with the product itself, which is much closer to the real version of the product. Here a dashboard was shown in PowerBI, so that the participant could experience a demo version in a realistic way. Finally, a so-called 'fade-out' question was asked to bring the interview to a close, by asking the participants how they see retrieval of clinical data on patient groups in the future.

All questions are formulated as open-ended questions, so that they are not leading and do not direct the participant in a certain direction (Rubin & Rubin, 2012). Also, a main question was always asked, which was followed by a follow-up question. This follow-up question was only asked if the answer to the main question was not sufficient or not detailed enough.

The semi-structured interviews took place partly during physical appointments and partly via online interviews. The preference was for a physical appointment because it makes it easier to gain more depth in the conversation, and this is also referred to as the 'golden rule' for in-depth interviews (Hennink et al., 2020). However, this was not always possible in practice, due to distance or time-related reasons.

The interviews lasted 68 minutes on average, with a range between 65 and 91 minutes. This was longer than the previously calculated 60 minutes per interview. Of all interviews, audio was recorded with two devices. After the interviews, it was determined which of the two devices had the best audio quality, whilst the other functioned as back-up. This was important for automated transcription.

The transcription was automated to speed up the process. Special transcription software called Trint was used (Trint, n.d.). After the automatic transcription, in which the audio is converted to text, the audio file can be run through again. A cursor then indicates which text belongs to the current part of the audio file, so that corrections can be made manually. This is necessary because, for example, names of people or companies were not recognised properly, or if a person spoke too unclearly or the audio quality was not good enough.

All interviews were transcribed word for word. It is up to the researcher to determine with how much detail an interview is transcribed, depending on the purpose of the study (Hennink et al., 2020). The first interview was transcribed with details such as stop words ('uhm' and 'euh') and short repetitions ('... like, uhm, like...'). Since this does not contribute to the purpose of the study and prolongs the transcription process very much, it was decided not to do this again for the remaining interviews.

7.5 Data analysis

The interviews were coded using the program NVivo. This is qualitative data analysis software (QSR, n.d.). The use of this programme made it possible to assign codes to the text, and to easily reconcile the texts that had been coded.

It was decided to use a mix of inductive and deductive strategies for code generation, because with only deductive strategies for code generation there is a risk that the data will not be able to 'speak for itself'. As a result, some matters that become known during an interview may be missed, whereas that is precisely the aim of a qualitative study (Hennink et al., 2020).

The analysis was done based on grounded theory, which means that the coding was divided into several phases, namely open coding, axial coding, and selective coding (Corbin & Strauss, 1990)). We started with open coding, in which the codes were formed based on the data. There was little interpretation and basic themes were described in the name of the code (Hennink et al., 2020). Here is a more detailed explanation of how this phase was conducted:

First, using the interview guide, some codes were created based on the topics that were asked in the interview (see Appendix 1). Several codes were also created based on prior knowledge, which had emerged from conversations with professionals at ChipSoft. These strategies are deductive ways of coding. The resulting codes form a starting point in coding the data.

Next, inductive strategies were used. Here, active reading was used, reading the interviews, and critically examining the meaning of the saying on the topic being questioned (Hennink et al., 2020). Here codes were assigned to (parts of) sentences, or short paragraphs, which briefly

summarised what the interviewee said. Many codes were created, to ensure that there was not too much interpretation, and detail and sentiment were retained. If the interviewee said something in diverse ways but meant the same thing, this was coded as often as possible using the same code. In this way, repetition of a subject can be recognised. Repetition of a topic often indicates that the topic is important to the interviewee (Hennink et al., 2020).

The next phase was axial coding. In this phase, connections are made between the components of the data, by means of categorising the codes that were created during the open coding (Corbin & Strauss, 1990). The codes created for the subjects in the interview guide were also used as a steppingstone. Sometimes a new code was also created, which represented an abstract category. Any codes that were coded in different interviews, but had the same meaning, were merged.

All data were also read actively once more based on the codebook. This involved checking whether codes from the codebook still appeared in the data, to see whether certain themes had been skipped, and to add them.

In Appendices 2 until 5, the code trees for the various topics can be seen. In each of these Appendices, the themes are stated on the left, the categories in the middle and the separate codes on the right. Using the classification of the categories, the results will be discussed in Chapter 8.

The final stage was selective coding. Here, the central theme is defined. Because the research was done within a business setting, it was decided to do this in the form of a format that was supposed to be used.

7.6 Project programme

This is a document that is used as a guide for project planning. Part of it is to clearly define the project, describing the reason, target group, problem, demarcation, stakeholders, and dependencies. Next, a so-called project programme is drawn up. This describes the content of the project. Within CS-DWH at ChipSoft, this often concerns new functionality in the software. This is also the case in this project, so the project programme is the output of the previous research.
The output is divided into the following categories:

- Purpose and target group: For whom and with what purpose are you developing content? If this is not yet clear from the project brief, you will need to do additional research. It is important that you clarify this for yourself before you start the design phase. This must be a refinement of the problem definition and target group from the project brief, based on the interviews with stakeholders. Guiding questions are: What is the purpose of the content to be developed? / What process do you want to support? What is the target group for the content? / What type of user (e.g., doctor)?
- Operational requirements: These requirements are aimed at the use/management of the product and are set by the target group, users, customers, and other parties with

an interest in it (such as administrators). Guideline question: What requirements are there to be able to put the product into use.

- Preconditions: These are requirements that the project result must satisfy unconditionally; they cannot be influenced by the project, so in principle not even by the line manager or customer. For example, due to legislation and regulations, safety restrictions or the organisation's policy (such as only collaborating with parties for which the organisation has a framework contract).
- Design constraints and performance requirements: These requirements come from us as developers or from the department or organisation and have to do with the realisation of the project itself. Remember that a useful design constraint prevents 'reinventing the wheel'.
- Functional requirements: These requirements indicate what the project result should be and what it should be able to do to solve the problem of the target group or to achieve the intended goal. Guiding question: What functions or characteristics should the project result have?

7.7 Prototype

The answers to the questions in the project programme were used as a basis for proposing an idea for a prototype for a product. The idea for a prototype was developed in cooperation with other team members. This was chosen because other team members have more knowledge about what exactly the existing product of Datawarehouse and the existing product (HiX) of ChipSoft already contains and has in terms of functionalities.

With the idea of the prototype, we started to make it in PowerBI. This amounts to a simple dashboard, which meets the requirements defined as well as possible.

This prototype was presented to three doctors for feedback. This was done during a conversation. During the meeting, which was a physical meeting for all three doctors, they were encouraged to use the prototype independently. The doctors did all the talking while very minimalistic notes were taken. These notes are worked out in Appendix 8 and summarized into recommendations in Chapter 8.

The prototype will be presented through screenshots in this thesis. Due to its nature, a PowerBI file, it cannot be presented as is in this thesis.

8 Results

The first section describes the results of the interviews. Then the processing of this information into a prototype product is discussed.

8.1 Interviews

Based on the questions in the interview guide, the answers are discussed below.

Which medical information questions about patient groups

The most frequently mentioned information questions, by all doctors, related to healthcare production, and are therefore not necessarily questions of medical content. Examples are numerical matters that a medical group puts in its annual report, such as numbers of patients seen, how many patients with condition X we have seen. Also, for example, in relation to government requirements on minimum numbers of operations to be performed annually. Capacity issues were also raised. Furthermore, many issues were mentioned by way of examples. These have been categorised into the following types of questions:

8.1.1 Purpose of the information request

One of the topics from the interview guide was the purpose of the information (see Appendix 1). Various goals emerged that physicians pursue with the use of information they have about patient groups. Through analysis of the interviews, many codes emerged that described a purpose of an information request about patient groups. These codes have been analysed to arrive at larger themes. See Appendix 2 for the categorisation of the codes which were the basis for the themes.

Improving quality of healthcare

To be able to improve the quality of healthcare, it is necessary for doctors to have insight into the outcomes of healthcare. Doctors also need to be able to guarantee patient safety; related to this is that they want to check whether they comply with the guidelines, which are drawn up nationally or by a scientific association of medical specialists within a specialism. Another goal is to benchmark results with other hospitals. They would also like to adjust policy based on group data if, for example, the number of complications is rising. Or they want to further improve the quality of healthcare.

A doctor said in one of the interviews that if a problem is identified, for example an unusually high number of complications, data at group level is needed to determine the cause. A cause could be an error made by doctors or other healthcare providers, which you would like to be able to correct as quickly as possible. But it could also be comorbidity, where there are one or more (chronic) conditions in addition to the main diagnosis, which can lead to more complications.

Research

This means research in the broadest sense of the word. It may involve selecting patients to participate in research. It may also involve evaluating a hypothesis, for example if a doctor has a hunch about a patient population based on experience. This feeling can be substantiated or refuted with data, as illustrated by a doctor with the following example.

"*Sometimes you see a few people in a short time and you get the impression that you have intoxication with a certain group of medicines. You should then be able to enter that and make*

it transparent. And then you think: oh, it's going completely wrong. Or it's not that bad, because then you see it in an overview and it's still far below the national average (Interview 2).

Direct patient healthcare

This includes determining a treatment for patients, i.e., determining the right treatment for a patient based on knowledge at the population level, filtered by patient characteristics (e.g., age, gender). Or it is about informing the patient, i.e., explaining risks of treatment to patient based on knowledge based on patient populations the same patient characteristics.

"*Data is also widely used in oncology. They look at the group level to see what the best individual treatment is. I think that data would also allow you to show very clearly what your considerations are as a doctor, to choose that treatment. I think it's good to have a bit more insight as a doctor.*" (Interview 4)

Positioning

Through policy, a department or hospital can determine which treatments they want to and can offer or strategically choose to expand a particular healthcare path.

"*You see more and more concentration of medical treatments. Especially a small regional hospital, they cannot offer all treatments. But you do now have insights into exactly what treatments we do: How many times a year do we do them? Is this still feasible? And what are we good at? What are we going to focus on? And I think that data can help a hospital to make a kind of objective. This is what we are good at, these are the core activities. This is what we are going to do. For example, by saying: we're good at fitting pacemakers, but the ICD* [Implantable Cardioverter Defibrillator], *that's a bit too complex. Yes, we'll leave that to a top clinical hospital or a university hospital."* (Interview 4)

Personal interest

A doctor himself may also be interested in a certain patient group and certain statistics thereof.

"*I do remember that when I was on the Corona ward last December, for example, that we wanted to know: How many patients are vaccinated and how many are not? But that was more out of interest.*" (Interview 1)

8.1.2 Current way of consulting medical information patient population

The doctors were asked during the interviews how they currently find out information about groups of patients (see Appendix 1). See Appendix 3 for the categorisation of the codes which were the basis for the themes.

The general tendency among the doctors was that it is possible, but takes a lot of time, often days, and is difficult because not all patients surface during the first search. Also, the doctor often needs help from other hospital staff.

An example was given: "*I did that myself once, but then I had to look at people with a lot of blood loss who I got out of the system myself. Then I had to look up their patient numbers and give them to the lab with the message: Can you examine the blood transfusions here?*"

When a doctor wants to select patients for examination, he often has a hunch/idea. He cannot count how many patients meet certain criteria, because filtering by a certain piece of data in the file is not possible, only filtering by speciality. Let alone filtering on a combination of data. He also does this by counting on paper which patients who come to the outpatient clinic might be suitable and how many of them there are. So, there is no systematic way. Nowadays, a doctor can also manually add patients to a list in the EMR and save them. It is sometimes difficult to find patients; searching by name gives too many results. However, a doctor can search by patient number, linked to a contact moment.

During a complication discussion, it is general and only the exceptional cases are highlighted and discussed in detail to learn from them. For example, the complications related to surgery are not available. Some things are still recorded manually in an Excel file, such as the number of incidents in the department.

Some general overviews are available for doctors. But these cannot be flexibly adjusted by a doctor himself. The ICT staff, who can do this, only adapt overviews for (very) specific purposes. Furthermore, the way DBCs are registered differs per hospital, which makes comparison difficult. Hospitals also use different EMRs, which also makes it more difficult.

If a search is made in the EMR, it must be manually checked for accuracy in the plain text of the EMR. The following example was cited to illustrate how difficult it is to extract medical information about groups of patients from an EMR.

"*The hospital in Spijkenisse was actually closed at the time because, supposedly, there were more deaths among the cardiology patients in that hospital. The health insurer then immediately decided to close the hospital. At the time, there was an entire investigation into whether this decision was justified: is it really the case that more patients died in that hospital, or in other words that their healthcare was of poor quality, which the cardiologists were accused of. I believe this investigation took a year or even 18 months. But it turned out that they were either the same or slightly below the national average. Those cardiologists have all fallen into the financial abyss and the hospital has now been converted into a kind of day hospital.* "(Interview 2)

Since the output of the research related to product development was put in the form of the project programme, this distribution was also kept to this.

8.1.3 Preconditions

Separate from the user needs of doctors, some requirements are preconditions for the product rather than wishes or 'nice-to-have'. Without these, the product cannot be released for all CS-DWH clients to use.

The quality of the data recorded in the source (the input) is especially important because it determines the quality of the information coming out of the analysis. Inferior quality data results in useless information. Hence the commonly used expression 'rubbish in, rubbish out'.

Next, it is important that the data is easy to order. This means that it should not be recorded in plain text, but in a structured way (Shah & Khan, 2020). Only then is it searchable by a computer.

The medical diagnosis field is important to be mandatory in the EMR, too. This is not always mandatory now, as now only the DBC diagnosis field is mandatory in some EMRs. Also, data is sometimes registered in the wrong place in the EMR, causing the data to be incorrect. Or an incorrect DBC is linked to a patient with a certain medical diagnosis. Finally, it is good to realise that the method of registration differs per doctor, per professional group, per field and per hospital. Everywhere, a slightly different method is used. This makes it difficult to use data in the same way across the board. Also, the layout of the EMRs differs slightly between the professional groups and hospitals, also because of the divergent ways of working.

Compliance with the General Data Protection Regulation (AVG) is a precondition of the project because it concerns legislation. But it was also mentioned several times by doctors, so they consider it important. Patient privacy was cited by all doctors, physician privacy by two out of five doctors.

8.1.4 Content requirements

The categorization of the codes concerning functional requirement are visible in Appendix 4. The information that doctors would like to have available are the following categories: diagnosis, patient characteristics, DBCs, operations, complications, medication, patient history. It is important that this information is available at various levels, from the specialty level to the patient level. When information is viewed at the patient level, they also want to be able to view a patient's record to get more context about the specific patient.

Selection of patients

Doctors need information on a selection of their patients. They then want to be able to select patients based on various criteria, such as diagnosis, treatment, patient characteristics, laboratory results, complications. They also want to filter patients based on the healthcare provider, for example on a speciality or by the treating doctor.
In addition, they want to be able to filter based on time. They want to be able to select patients who meet a criterion within a certain time. They also want to be able to filter on a time component that is dependent on another time, for example, a time determination of recovery after a certain treatment. Filtering by time must be possible within a patient's record, to see the progression of a piece of information over time.

Combination

Combining patient data is also a requirement for a tool. The following combinations were mentioned:

- Combination of complication and patient characteristics
- Combination of diagnosis and behaviour
- Combination of diagnosis and patient characteristics
- Combination of diagnosis and operations
- Combination of complaints and diagnosis
- Combination of outcome and patient characteristics
- Combination of complication and operations

Comparison
Without context, individual numbers do not give any information. They only give information if they can be compared to other numbers. Numerous ways of comparison were given as examples:

- Set and compare patient populations, e.g., patients living in postal codes area A and area B
- Comparing one data set, for example the number of complications after a particular treatment, with the national average for that data set.
- Compare a parameter, e.g., compare the outcome after treatment with drug A and B.

8.1.5 Operational requirements

These requirements are necessary to put the product into service but are not dependent on the content of the product. The categorization of the codes concerning functional requirement are visible in Appendix 5.

Most important: user-friendliness

User-friendliness is the most important feature. Several doctors mentioned this first when asked what a tool should be. During the discussion it was specified in what way a tool is user-friendly. User friendliness can be divided into several topics, based on thematic analysis of the interviews. The doctors mentioned that a software programme should be easy to use, fast and require few mouse clicks.

"*Yes, of course, any software system works best if you don't need a manual, is my philosophy. Because then it will be used completely.*" (Interview 3)

Independent use

A few requirements can be categorised as independent use. The doctors mentioned that the programme should be easily accessible on their computers. They also want it to be interactive, so that they themselves have more flexibility in what information is visible. For this, it must have a logical, intuitive layout so that they can easily find the information they are looking for. A smart search function, for example a Google-like search engine, would also help to find the right diagnoses easily. Finally, it was also mentioned that the information must be easily shareable with colleagues, if for example it is to be used in a departmental meeting.

Freedom

Different content questions should be able to be answered with the tool. Freedom of settings is also important, as different doctors have different information needs. As a doctor, you must be able to ask questions of the tool, so that any question you think of at that moment can also be answered immediately. A few clicks are allowed if it is logically (functionally) arranged.

Privacy & GDPR

Privacy of the doctor is important. It depends on the granularity of the data what exactly is insightful, and on the user accessing the information. Because the user is decisive, work contexts are important. A manager may see fewer details about patients than the doctor in charge. And a doctor may see his own data on patient complications to compare it with the average of his colleagues. But it is not desirable for a doctor to be able to see the precise complication data of his individual colleague.

8.1.6 Impeding operational characteristics

The most frequently mentioned fact was that a separate application is a hindrance to the user, especially if it is difficult to find. Also, too much effort to use it correctly, and too many clicks to get to anything, is a hindrance. It should not cost the doctor extra time but save time. In terms of content, too much general information was indicated to be experienced as a limiting factor, when exact numbers are not displayed.

8.1.7 Not all doctors are the same

Through the interviews it became clear that doctors working as ANIOS & AIOS do not need this information daily. Their work consists of patient contacts, and they are less likely to be involved in monitoring groups of patients. Therefore, they do not need information about groups of patients during their work. The training of an AIOS pays attention to data available on patient groups, so it could still be interesting.

It is important to realise that not all doctors are the same and do their work in the same way. They often have different interests within their profession or see the provision of healthcare to patients in varying ways. Apart from direct patient healthcare, the (outpatient) clinical work, they often have additional tasks, within or outside the hospital's professional group. For example, some doctors are more involved in making policy, within the hospital or nationally, or in (scientific) research or other matters. A different degree of enthusiasm is also noticeable among physicians. Because of these differences, not all doctors are equally interested in information about patient groups. It is important to keep this in mind when implementing the product.

8.2 Determining form and content of product

Inspirational dashboard

As part of the IM Medical product, periodically a new dashboard is released. This dashboard is a report which are ready to use for hospitals or can function as inspiration to design a dashboard by themselves based on the template dashboard.

These inspirational dashboards were a good opportunity to make a first start with the preliminary results of the interview, which were available at that time. It was chosen to design a dashboard which provides in comparison of two patient populations, because this is something that had not been done in previous dashboards. Furthermore, a new house style had been developed at the CS-DWH department, so it was also chosen to incorporate this in the inspirational dashboard. Lastly, it was clear form the first impression of the interviews, that selecting a patient population will always play a role when using data about patient groups. So this was reason to improve the intuitiveness of selecting a patient population, though keeping enough freedom in the choices that can be made by an end user.

These choices resulted in the inspirational dashboard, of which a screenshot can be seen in Figure 2.

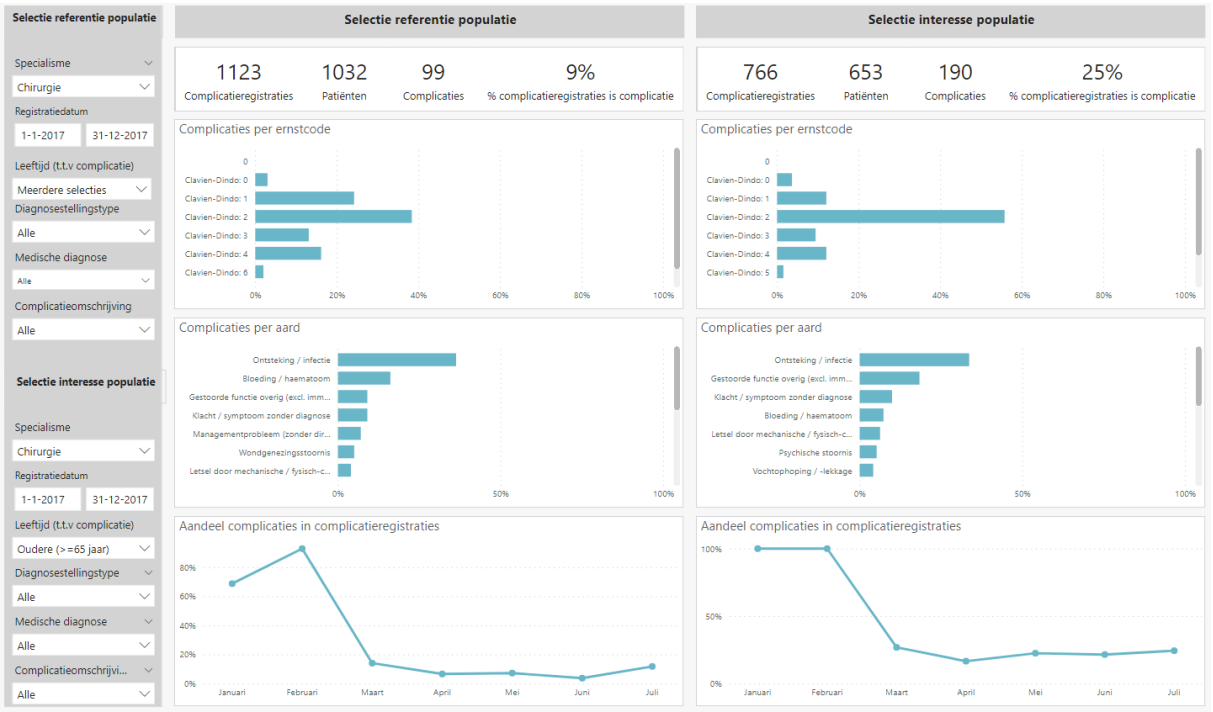

Figure 2 IM Medical dashboard: Complication comparison in patient populations. This is a fictional example for the registering specialism 'Surgery', met registration date in 2017. Complications are compared between patients under 65 years old (left side) and over 65 years old.

Because this inspirational dashboard was released for use by clients, it had to pass through the usual process of software development to secure quality. This meant that it first a prototype was designed. This prototype was critically reviewed by the team and comments were given as feedback. This feedback was incorporated into the end-product. This product was reviewed during a so-called code review. A code review is a meeting where the product is presented to BI developers at the CS-DWH department, whereby it is important that these people have not seen the product before. This assures that they can take a fresh perspective on the product and critically review it. The received feedback is then processed. When fully ready, the product needs to be thoroughly tested to assure there are no bugs of mistakes in the product. This is done in two rounds: by the developer who designed the product and by yet another designer, preferably someone who has not seen the product before. The testing is done according to test cases, which need to be checked. These test cases have been drawn up before the development process, where every detail of the product is listed and needs to be checked before release is possible. This extensive process of testing is necessary to prevent bugs in the software, so it is important that this is process is structured and neatly followed through.

At release, the product is provided with release notes, where features of the product and/or updates of the software are explained in language that is understandable for end users. Furthermore, the users' manual of the IM Medical product is updated with the new additions (see Appendix 7).

Sparring with team about prototype

Together with the team, we looked at what came out of the interviews. The aim was to propose idea that could be used for a prototype. The pain points and wishes of doctors were discussed.

Some rough sketches were made on a board to propose an idea together and make it visual for each other (Figure 2).

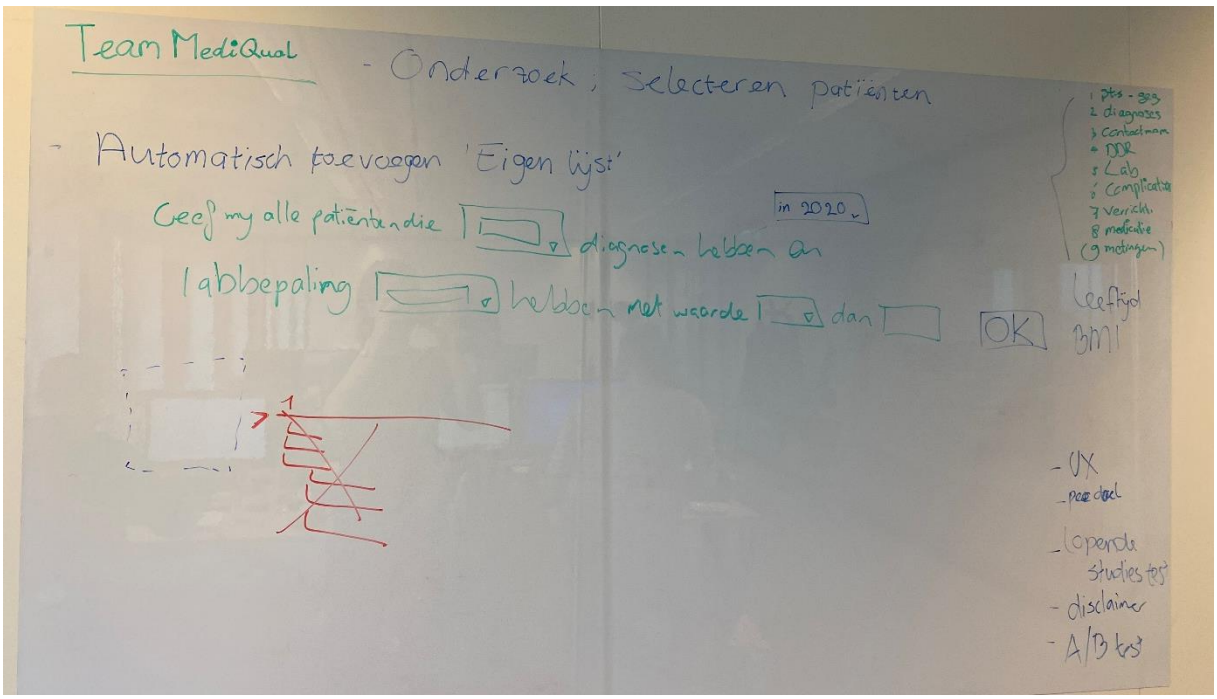

Figure 3 Picture of whiteboard after discussion of content and form of the prototype

The result of the discussion is used as input for the prototype and is discussed below.

Product and service

Because of the trade-off between user-friendliness and freedom of settings, it was chosen to focus on one goal. So, the purpose of the product will be to select and save patients based on various criteria. The user can step by step enter these. The output will be in the form of a table with relevant patient data, which the user can save for later use. The product is created in PowerBI.

Benefits (Gain creators)

The focus in this product is usability. This means that the physician must be able to use it without having a technical background and/or knowledge of the back end of HiX or the Data Warehouse. User-friendliness is a requirement for physicians and was also mentioned most often in the interviews.

Another requirement is that the doctor must be able to use the product independently, without help from other healthcare staff or technical staff in the hospital. This also leads to an easier and faster process for the doctor, which lowers the threshold for use.

The product also offers freedom in institutions, as different doctors often have different interests. Current dashboards, which are already available to doctors and other healthcare staff, show, for example, a certain part of the healthcare production or quality. However, this is done in a static way, where only a few parameters can be adjusted, such as the date range that is looked at.

The purpose of the product is the selection of patients for examination, so that doctors themselves can filter on patients. This gives doctors easy insight into their patients. An

important prerequisite for them is the combination of data, which will also be included in the product.

Pain relievers

Now, it takes a long time and is a laborious process to get answers to information questions about groups of patients. This was mentioned as the most important pain point among doctors. The product solves this by allowing the doctor to work independently, without dependence on other hospital staff. As a doctor now does not have to count patients on paper during outpatient visits, he can conduct counts outside the outpatient appointments. The product facilitates patient counting within a selection. It is now also possible to combine certain types of patient data, such as a diagnosis and a treatment. This was previously not possible or only with difficulty.

8.3 Prototype

The prototype was designed with as many desirable characteristics incorporated as possible, given the restricted amount of time that was available. Table 1 below shows the characteristics of the prototype that were chosen to focus on. If applicable, an explanation for a certain choice is given.

Table 1 Characteristics identified from the interviews and their presence, including explanations for the choices when applicable.

Category	Characteristics	Present
Functional requirements	Selection of patients	Yes
	Combination of patient data	Yes
	Comparison of patient data	No
User-friendliness	User-friendliness	Yes
	Fast	Yes
	Easy to use	Yes
	Few mouse clicks necessary	Yes
	Easy to access in system	N/A for prototype; accessibility from HiX possible
	Easy to share with colleagues	Partially, screenshots of the report can be exported as PDF and shared
Independent use	Easily accessible on doctor's computer	N/A for prototype, accessibility from HiX possible
	Interactive	Yes
	Flexibility in parameters	Yes
	Logical, intuitive layout	Yes
	Smart search function	No
	Easy sharing with colleagues	Yes
	Understandable	Yes
	No technical background necessary	Yes
Freedom	Freedom of settings	Partially, settings were chosen to match doctor’s interests when goal is selecting patients

	Spontaneous questions can be answered	Prototype was tailored for selection of patients only
	Logical arrangement of settings	Yes
Privacy & GDPR	Privacy of doctors is secured	No
	Privacy of patients is secured	Yes
Impeding characteristics	Too much effort	No
	Too many clicks	No
	Cost too much time	No
	Too general information	Yes

Regarding the accessibility of the prototype and the characteristics 'Easy to access in system' and 'Easily accessible on doctor's computer', it should be noted that this is already technically possible. But this prototype is still in early development and the doctors consulted were not in a hospital environment, so it was chosen to present it outside of HiX.
As for the ability to share with colleagues, screenshots of the report can be exported as a PDF file, but this does not contain all the information from the prototype. So sharing with colleagues is partially possible, but not including all information in one file.

As for two characteristics in the category freedom, namely 'Freedom of settings' and 'Spontaneous questions can be answered', they are not completely incorporated in the prototype. The reason for this is that, in this prototype, it was chosen to develop a tool which helps doctors achieve one of the goals that they expressed during the interviews. Therefore, several settings that are relevant for the doctor in selecting patients were included, for example sex and the specialty of diagnosis. But this was kept limited, to assure user-friendliness and understandability of the prototype.

Screenshots of the prototype are included in Figure 3a until 3h. Since the prototype was designed for the Dutch market, the language of the product is Dutch.

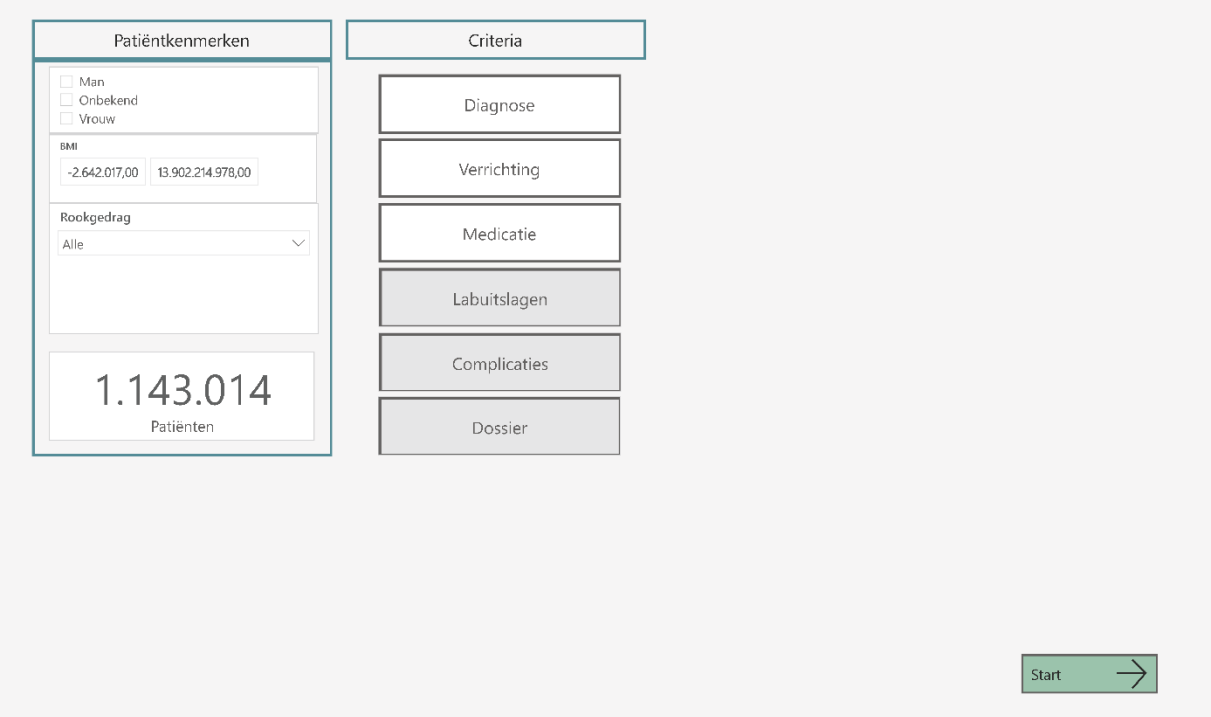

Figure 4a Screenshot of prototype - Home page

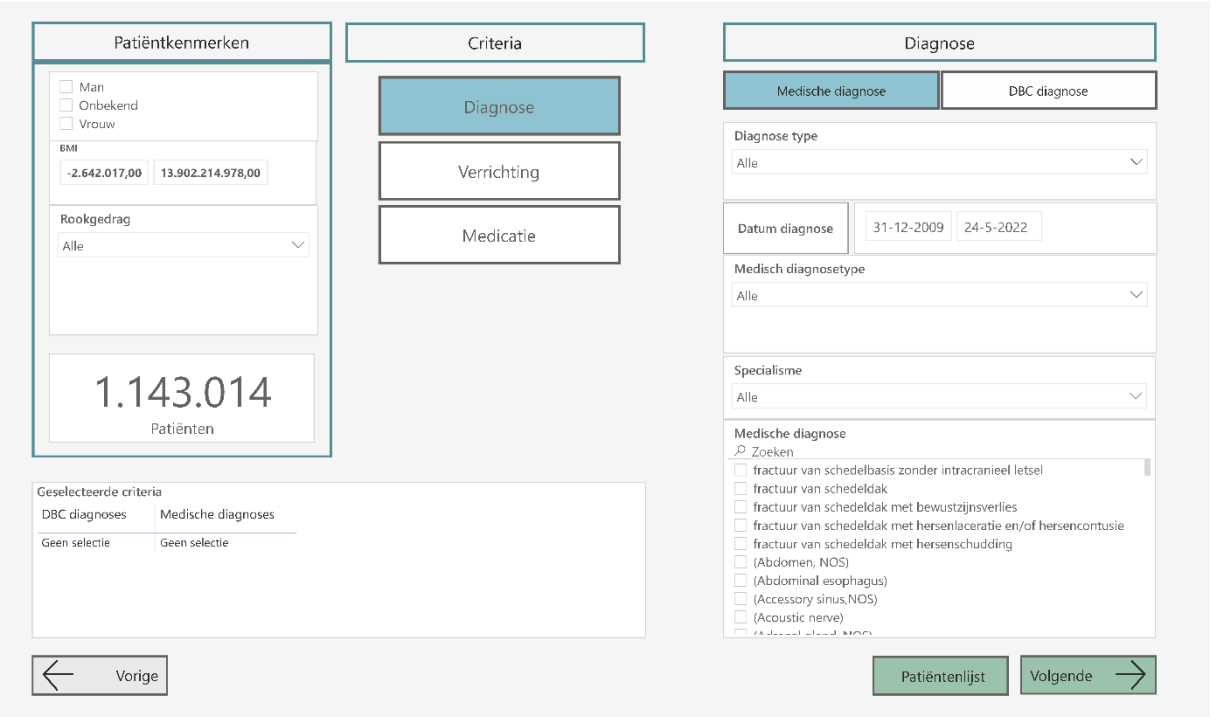

Figure 4b Screenshot of prototype - Diagnosis page tab medical diagnosis

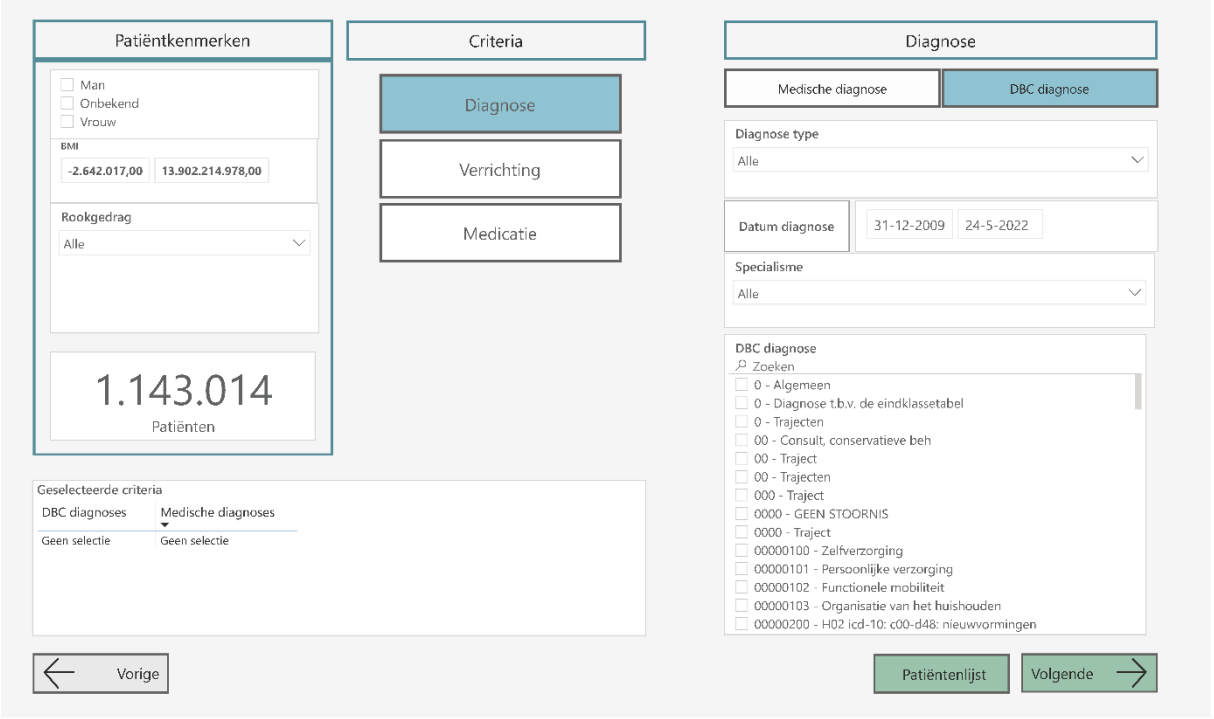

Figure 4c Screenshot of prototype - Diagnosis page - tab DBC

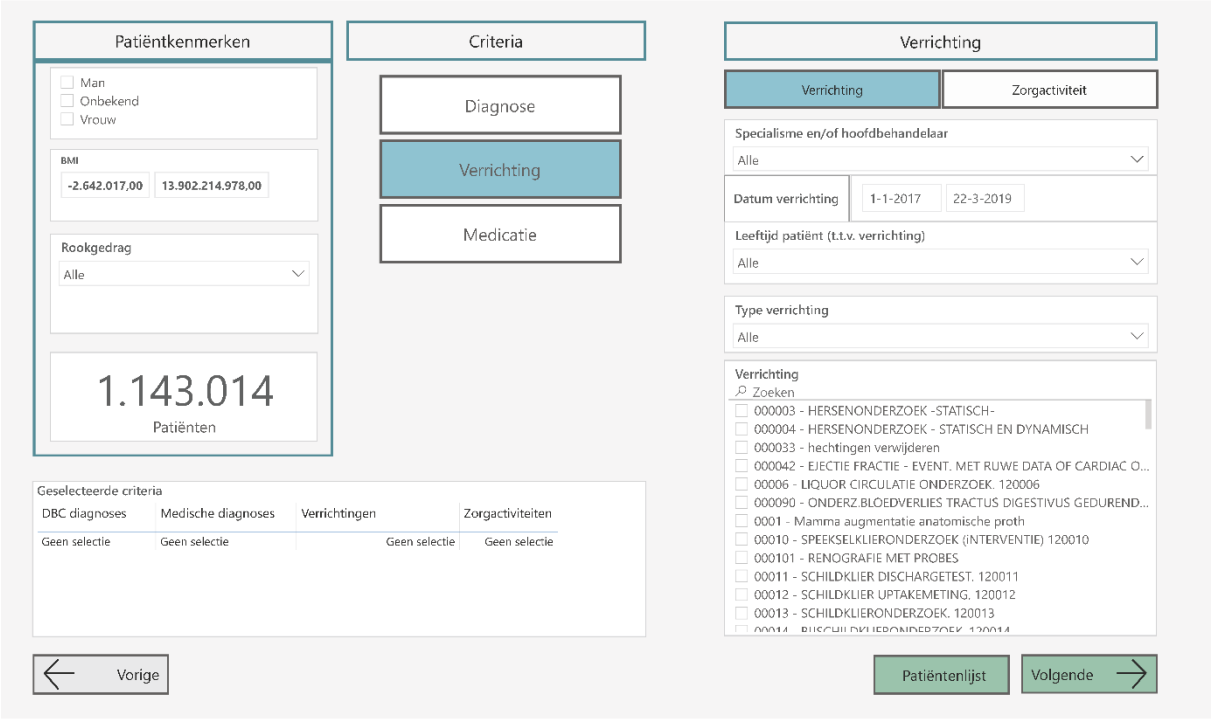

Figure 4d Screenshot of prototype - Intervention page - tab intervention description

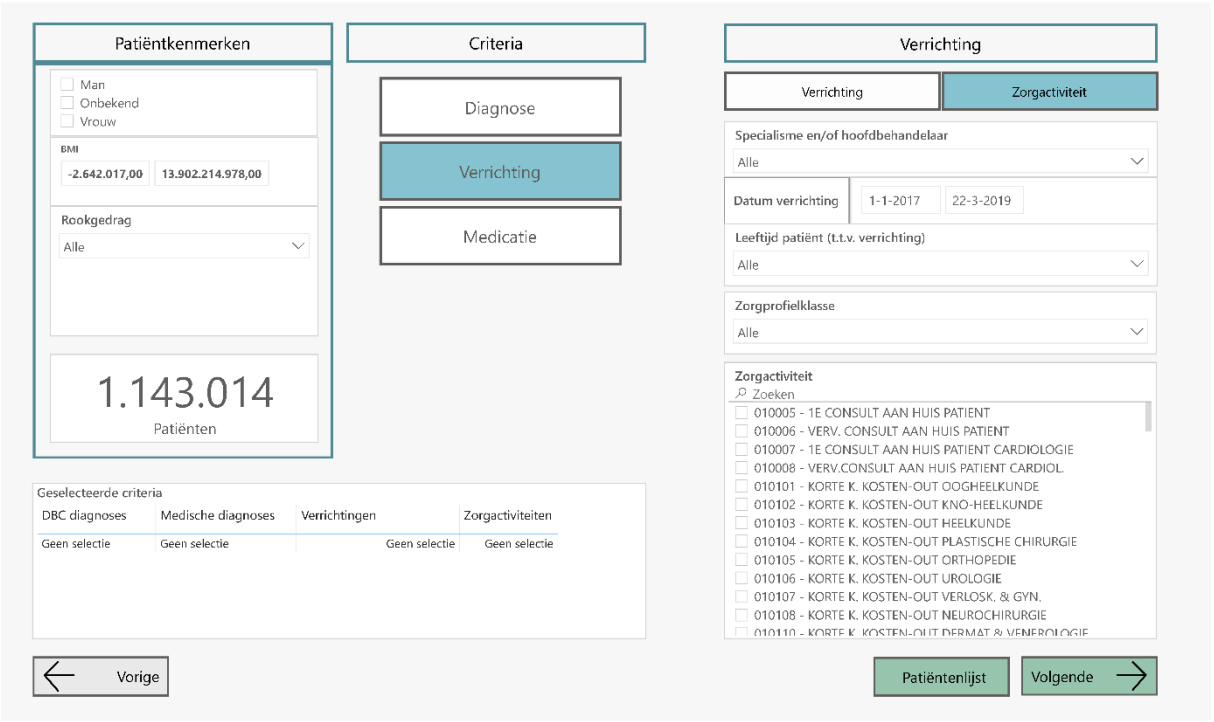

Figure 4e Screenshot of prototype - Intervention page - tab healthcare activity

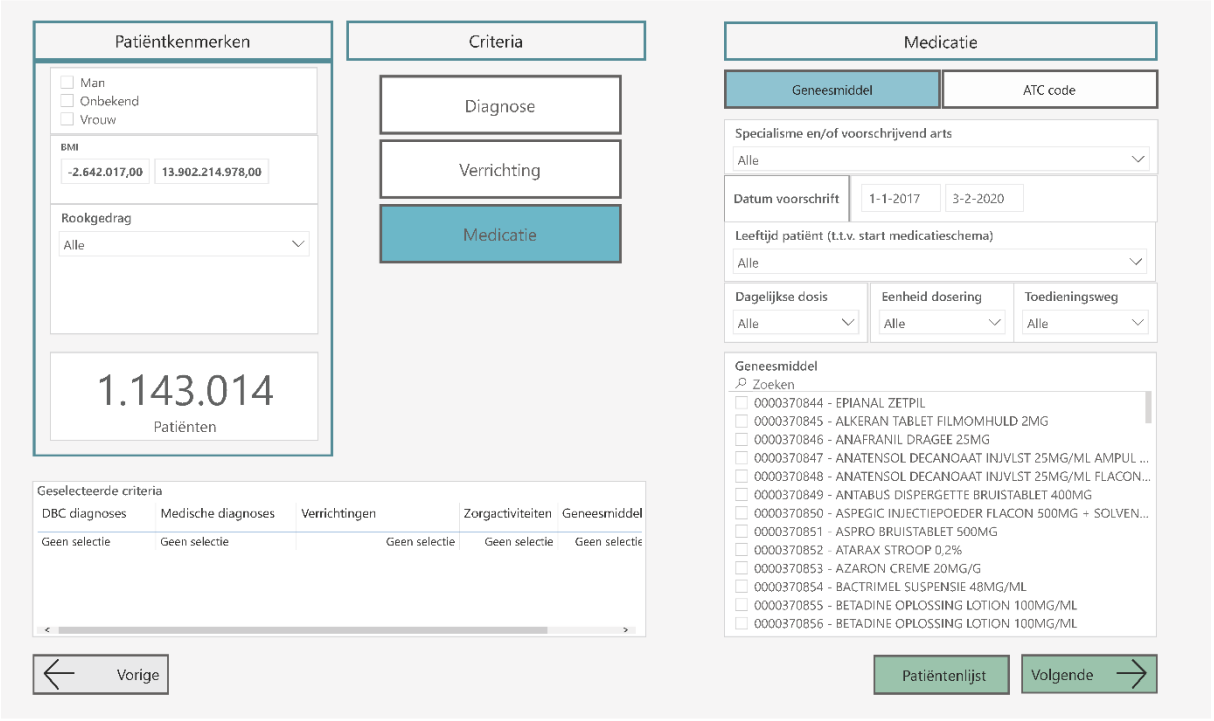

Figure 4f Screenshot of prototype - Medication page - tab drug name

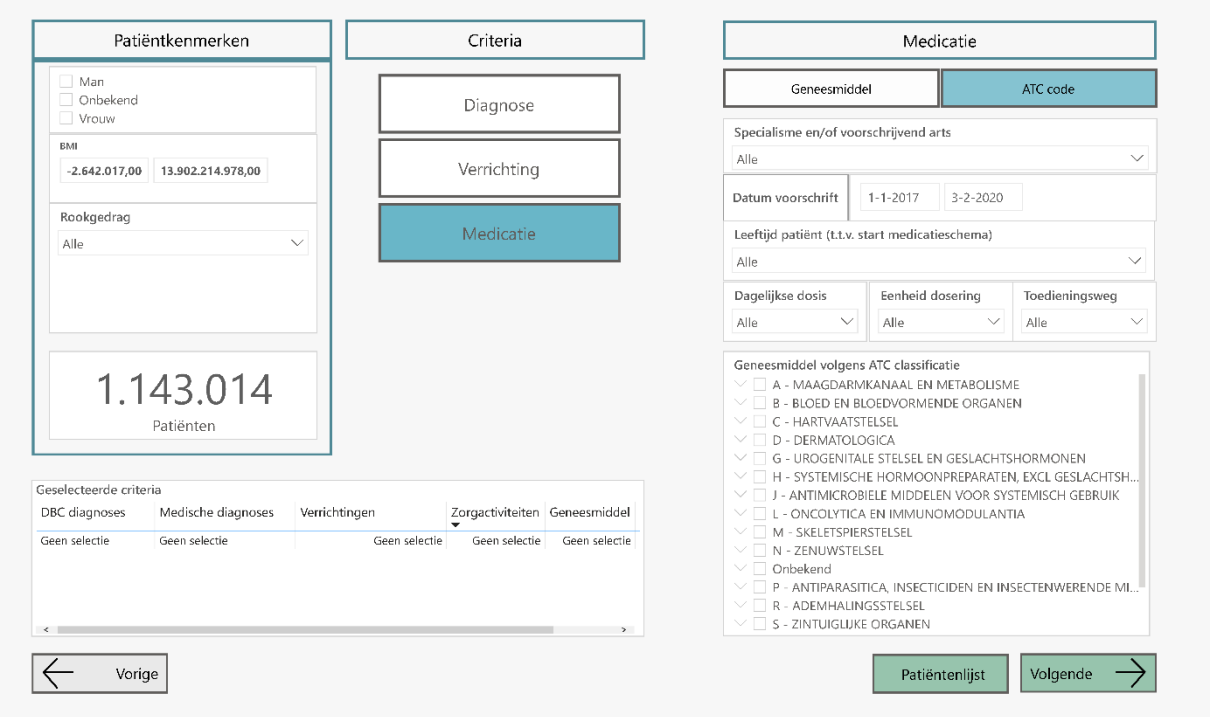

Figure 4g Screenshot of prototype - Medication page - tab ATC codes

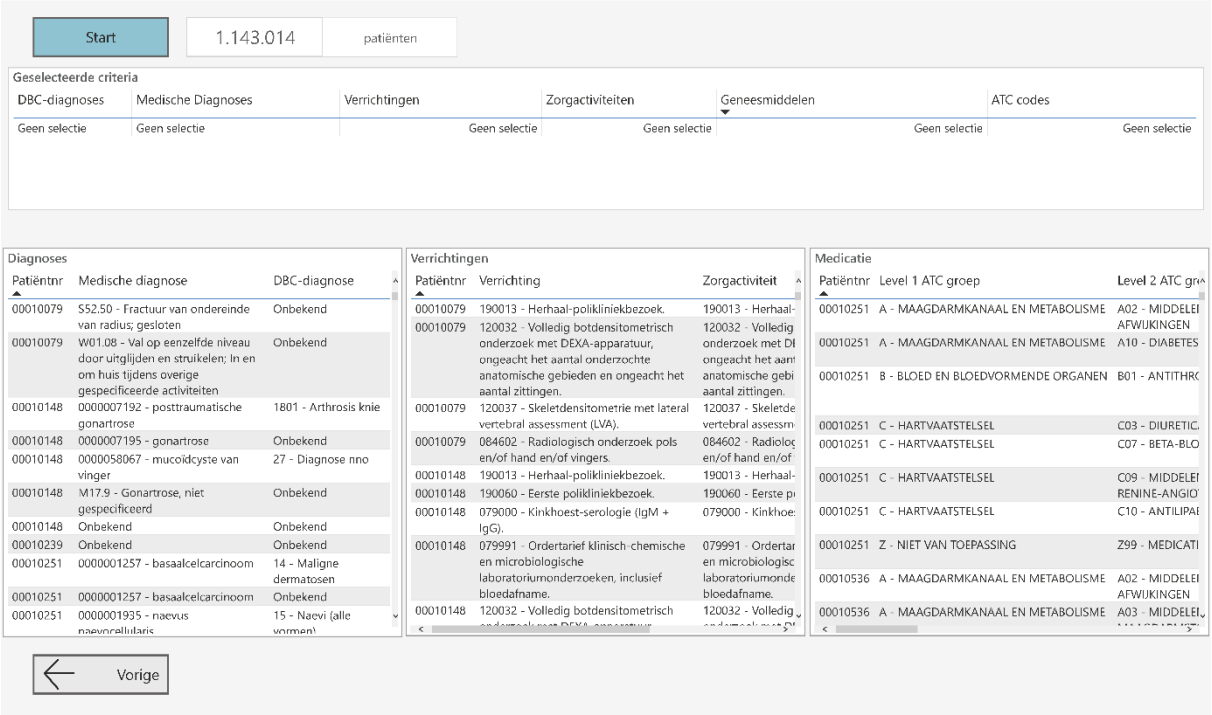

Figure 4h Screenshot of prototype - Output page

8.4 Feedback on prototype

Notes that were made during the demonstrations with the doctors were worked out right after the session in an overall story, categorized by topic. These can be read in Appendix 7.

General features

Overall, the prototype was received as quite intuitive. Especially the buttons were very helpful to navigate through the prototype. Also, the card showing the number of patients which were selected at that moment was used frequently. It was used in two ways: to check how many patients there are left within the selected parameters. This important key number was used on every page of the prototype. The other way it was used was to check if all filters had been reset. If the number of patients was 1.14 million, then all the filters were indeed correctly reset. To accomplish this, the button available in the online PowerBI service called 'reset to default' was used multiple times. However, when opening a PowerBI report from HiX, this button is not available, so another solution would have to be sought.

Searching & filtering

The search option for look for diagnosis, operations or medication was used all the time, so this is an important feature. Unfortunately, when the search query does not exactly match the available search results, they will not appear. So when a diagnosis is misspelled or searched through a synonym, the searched for result will not appear.

Some filter options that were presented were not used by any of the doctors. Most importantly, the tab with DBC diagnosis and healthcare activity were not used. They are relevant in the financial processes of delivered healthcare, so are not relevant in the medical perspective of a doctor.

Regarding general patient characteristics, most useful filter options were included. Current age was deliberately excluded as a patient characteristic but added as filter options on the operations page and medication page. The reasoning behind this choice was that if doctors look at data from a few years ago, patients are today a few years older than they were at the time of the registration. Interestingly, a doctor commented that current age is indeed relevant. From a medical perspective, it matters if a patient is 20 years old or 80, but a difference of a few years will affect a medical judgement as much. Therefore, it would be good to add current age as a filter option.

Another general critique was that lists of options or search results are listed alphabetically. It would be helpful if they are categorized according to specialism with subcategories based on functionality. So, diagnoses are categorized according to specialisms, and these lists are then categorized based on sub-specialisms. For example, within a category of lung diseases, options such as asthma types, lung cancers and infectious respiratory diseases are presented.

Output

Regarding the output of the selection tool, this can be improved too. Now, the output consisted of three separate list of patients within the set parameters. The lists contain only patient numbers for privacy reasons, and give for each patient the diagnosis, operations, and medications. So if a patients had multiple medications prescribed, multiple rows with that patient number would appear in the medications table (see Figure 4h in the table on the right).

Also the number of patients that are included in the set parameters is useful information for a doctor. But doctors preferred that they could further investigate the selected patients on other dimensions.

Discussed above are the most important recommendations. More detailed recommendation can be found in Appendix 7, where all comments and ideas for improvement are listed.

9 Discussion & conclusions

In this Chapter, the methods and results are discussed, and conclusions are drawn in general and in context to ChipSoft and CS-DWH.

9.1 Interpretation of results

The results are largely in line with the hypothesis that the most important aspect of a tool for specialists, who have no or little technical ICT background, is to make a solution that is user-friendly. This was evident from the fact that it was always mentioned first by the doctors who were interviewed, because if issues are repeated within or across texts, this may signify an important issue for participants.

As a result of this research, the requirements for doctors are clearer, because the interviewed doctors articulated their needs clearly. Also, the prototype showed how some characteristics were easy to develop. But feedback on the prototype made clear that some characteristics will be harder and require more effort to develop such that the needs of doctors are met.

One of the main critiques in the feedback was that doctors do need to be able to select patients, as well as combine types of clinical data and compare data before it is usable for them. So all three functional requirements can be classified as a 'must-have'.

9.2 Relevance for CS-DWH

From here on, the prototype can be developed further in cooperation with clients, such that IM Medical can be used by medical specialists. One of the goals for 2022 is that IM Medical is used by at least three specialists, within at least two healthcare institutions. For this, the functionality must be improved, so a tool must be made that is suitable for specialists. For this, it is necessary to know what is important for specialists, so that it is known what needs to be developed and a planning is considered.

One approach is talking with specialists, which was done in this project. From there, several requirements were incorporated into a first prototype. Recommendations emerged during discussions in which the prototype was demonstrated. These are used in the further development of the prototype. During this further development, other customers can also be involved in providing feedback. In addition, dashboards for other subjects are being developed in cooperation with customers. Here, the list of characteristics desired by doctors can be kept as a guide in the development or improvement of dashboards. User-centred software requirement are known to improve chances of a successful implementation and use of the product in the healthcare domain (Teixeira et al., 2012).

From a business perspective, this information will help Datawarehouse on what to spend their resources on. Because it was investigated what is important in developing an IM Medical tool for specialists, decisions on what to spend resources on, thus time and money, are better informed. It will also help with adequate prioritization of projects and tasks.

Also, contact with end-users in the development process can act as a distribution channel, increasing the chance that the involved doctors will actively promote the product within their hospital. This lead can ensure that the product is embraced in the hospital. Because the doctors are already familiar with it and because doctors often have a lot of influence in a hospital. By

using this contact as a distribution channel, CS-DWH positions itself better towards potential entrants in the BI tools market in the healthcare sector. This can reduce the threat of entry (Porter, 2008).

All in all, good dashboards can set themselves apart and increase the overall quality of the CS-DWH module. This justifies that the price of the entire CS-DWH module has increased, due to the addition of IM Medical. The additional value of this content makes up for this price increase. This is beneficial for CS-DWH regarding its turnover.

9.3 Relevance for ChipSoft

As was mentioned in the PESTEL analysis, one of the critiques that ChipSoft received from its clients is that they do not listen enough to their users in developing software (Eikelenboom, 2019). This is one of their main strategic challenges too. In this research, exactly this was done by talking with the end users of this product. So, this is a step in the right direction in facing this challenge. Ultimately, this helps ChipSoft in its main ambition, which is to make healthcare even more efficient, such that scarce time and resources can be optimally used for the benefit of the patient.

More knowledge of users' needs and thus more adequate decision-making in managing resources on product development will lead to a better positioning of ChipSoft relative to competitors. As mentioned before in Chapter 4 in Porter's five forces analysis of the profitability of the HIS/EMR market, new product development can be a strategy for competitive rivalry on a market. Investing in product development can set a product apart, differentiating oneself from its competitors. Thereby, a firm can charge higher prices that its competitors and maintain long-term profitability.

9.4 Strengths and limitations of methodology

An important aspect of interviewing in research is that the participants are invited to share their perspectives. This enables gaining a detailed insight into the research issue from the perspective of the study participants (Hennink et al., 2020). This helped in really understanding what their job is and what their day-to-day tasks and work process is. This created more empathy for what problems they currently encounter when gathering and using clinical data on patient groups. With this background information, it is easier to imagine what their requirements for software are.

A limitation of interviews is the smaller number of participants, that is possible to collect data from due to time restrictions. Other methods such as surveys could have retrieved answers from a larger sample. An advantage of a larger sample is better generalisability across the whole population. However, for this exploratory research, one extensive conversation could yield more background information from the interviewees' experience than a survey with standardized questions. Furthermore, the experience during the interviews was that a proper and exact introduction into the subject was necessary to assure that interviewees understood the subject matter. A good understanding by the interviewees of the subject matter was considered more important than a large sample, therefore the choice for interviews is justified.

Participants sample

A strength of the sample was that each doctor had experience at another hospital. This is important because at every hospital, a different work process is used. All the interviewed doctors could therefore provide their own experience. This ensured a mixed and well-balanced view on the subject matter. However, an aspect that might be considered a weakness of the research is the ties to ChipSoft of the interviewees. This could have introduced bias in the results because these people tend to have an above average in ICT and its opportunities.

Data collection

Because the interviews were semi-structured, this allowed for the interviewed doctors to come up with lots of subjects themselves. Interestingly, every doctor came up with new aspects that were important for the subject. The topics from the interview guide ensured that all subjects of the research issue were covered. Semi-structured interviews turned out to suit this research well, as all doctors ended up talking a lot more than expected, thereby providing a lot of input. This results in a higher quality of the data, improving the output of the study.

During the interviews, no notetaking was done because the audio was recorded. Therefore the interviewer could focus all attention on the conversation without distraction. This resulted in lively conversations with the interviewees, encouraging them to share all their ideas and considerations about the subject at hand.

As the last part of the interviews, the participants were given a demonstration of an inspirational dashboards for IM Medical that has been released. This demonstration is also given at clients to pique their curiosity. This might have influenced the direction of the requirements that were expressed after the demonstration. However, during analysis, it was considered at which moment during the conversation the demonstration was given. A differentiation was done to assure that the answers were not pushed into a certain direction. In any way, most doctors expressed themselves for the most part in providing examples of (un)desirable situations. Besides, the demonstration helped them in concretising and expressing their requirements, as they were encouraged to say their thoughts aloud when viewing the demonstration. Therefore, this issue has been tackled as much as possible.

Data analysis

Data analysis was one of the most extensive parts of the project, because the interviews were thoroughly analysed. As a result, a lot of information was categorized and conceptualized. Because of the inductive strategies chosen as a first round of analysis, the data could really speak for itself (Hennink et al., 2020).

As stated above, the data analysis was carried out very thoroughly. This meant that it took a considerable amount of time of the project's duration. One could argue that this time could have been used more useful. Especially in a business context, where the primary goal is not to analyse the conversations precisely to conceptualize the research issue. Rather, the goal is to extract the necessary requirements and start working with these as quickly as possible. However, a structured approach to data analysis helps to capture all the ideas present. Because the conversation is recorded and transcribed, it also prevents bias from the interviewer in remembering the meaningful details of the conversation.

10 Layman's summary

What if a medical doctor could easily access the clinical data of all patients at the hospital, to gain insight into information at a group level? A cardiologist could see what the most frequent diagnoses are among his patients. He could get insight in what causes severe complications after treatments or compare the effects of two types of medication to see which one works better. Because doctors and other healthcare workers are obliged to register every action in the patients' medical record, the data is registered anyway. However, for medical doctors, it is difficult to easily access these data on a patient group level, because a lot of ICT knowledge is necessary.

In the Netherlands, ChipSoft is the largest supplier of electronic medical record (EMR) software, called HiX. HiX supports medical workers in their daily work processes with software to register and see medical records for individual patients. A separate module of HiX, called ChipSoft-Datawarehouse (CS-DWH), can access data at the level of patient groups. Hospitals need to provide data about quality of healthcare to governmental authorities. Monitoring these numbers helps hospitals maintain high quality healthcare throughout the year.

In the HIS/EMR market, ChipSoft excels at developing software for hospitals. Yet, its main challenge is to develop software meeting (or exceeding) the needs of end users. Designing software for medical specialists is difficult. They are busy thus hard to reach, tend to be stubborn and are unaware of the technical ICT background. So, ChipSoft relies on open innovation and collaborates with hospital staff in developing new software. This project also used this type of innovation, aiming to develop a prototype product as part of the CS-DWH module, especially for medical specialists.

To get a thorough understanding of medical doctors' needs, multiple doctors were interviewed. They talked about if and how they currently use patient group information. And what information they need from the EMR, and their opinion on what a product should look like. They also shared their view on the future of clinical data retrieval on patient populations.

After thorough analysis of the interviews, there was a clear picture of the doctors' needs. Currently, it is difficult and time-consuming for doctors to gather patient groups information from the EMR. They expressed the need of a software tool supporting this. The doctors wanted to select patient groups, combine diverse types of information and compare data from patient groups. For example, they want to see complications after a specific surgery in different patient age groups. On the form of the product, doctors rated user-friendliness most important. Independent use is also important, avoiding reliance on a hospital's ICT workers. With this information, I developed a prototype and the doctors provided feedback. The conclusion was that a good start at developing this product has been made. Especially the chosen interface was intuitive, as they could find their way quickly.

This project contributes to the development of CS-DWH by providing a clear overview of doctors' preferences. By that, ChipSoft faces its strategic challenge, as lesser knowledgeable compared to its customers in end-users' needs. These steps in product development led the way to give doctors access to clinical data on patient groups, which can lead to improved quality of healthcare, so is beneficial for society.

11 Abbreviations

ACM	Autoriteit Consument & Markt (Netherlands Authority for Consumers and Markets)
AI	Artificial intelligence
AIOS	Arts In Opleiding tot Specialist
ANIOS	Arts Niet In Opleiding tot Specialist
AVG	Algemene Verordening Gegevensbescherming (General Data Protection Regulation)
BI	Business Intelligence
CE	Conformité Européenne
CMIO	Chief Medical Information Officer
CS	ChipSoft
CS-DWH	ChipSoft-Datawarehouse module
DBC	Diagnose-Behandel Combinatie (Diagnosis-Treatment Combination)
EMR	Electronic medical record
ERP	Enterprise Resource Planning
GDPR	General Data Protection Regulation
GP	General Practitioner
HIS	Hospital Information System
HiX	Healthcare information exchange
ICT	Information and Communications Technology
IM	Information Mart
ISO	International Organisation for Standardization
ISV	Independent software vendor
KPI	Key performance indicator
MVP	Minimal viable product
NEN	Nederlandse Norm (Dutch Standard)
PDMS	Patient Data Management System
R&D	Research & development
Wegiz	Wet elektronische gegevensuitwisseling in de zorg

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13 Appendices

13.1 Appendix 1: Interview guide

Introduction/Background information

Good morning/good afternoon. First, I would like to thank you for taking the time to talk to me today. My name is Aniek Verschuuren, and I am doing this project for the BI team at ChipSoft, as part of my graduation project for the Master of Science and Business Management.

As you know, a lot of clinical data is recorded on patients. For each patient, every contact, every action, every diagnosis, medication is written down.
But it is not always easy to access this data at the level of groups of patients. ChipSoft has developed a new module within HiX Datawarehouse called IM Medical. With this module, it is possible to view medical information, which is extracted from the EMR, on groups of patients or patient population in an accessible way. In other words, you can answer information questions that relate to multiple patients.

I look at how doctors use information about a patient population in their work and how they obtain this information. So, I am curious to know how you do this now, what information you already have and what you would still like. I would like to know how IM Medical could help with this. The interview takes about half an hour.

Recording consent
Before we start, I would like to ask your permission to record this interview so that I can focus all my attention on our conversation.
Everything you say will remain anonymous and confidential. If you wish, we can stop or pause recording at any time. Do you give us permission to do so?
Do you have any questions before we start?

Opening/background questions

1. Would you like to introduce yourself?
    a. What do you do in your work?
        i. What does a typical workday look like?

Interview questions

2. During your work, you register all kinds of information about the patients, and that is always per patient. Consulting medical information is also done per patient. You do this in the HIS. But what questions do you have about **groups of** patients?
    a. Can you give examples?
3. What do you do with that information?
    a. What is the purpose(s) of that information?

4. How do you get medical/clinical information about groups of patients?
    a. What means do you use?
        i. What software?

5. What information about groups of patients would you like to see, but you cannot?

a. Can you give examples of information requests?

6. What do you consider important about a means of obtaining medical information about patient groups?
    a. What would make you use a tool?
    b. What would stop you from using a tool?

7. Example of inspiration dashboard PPT
   What do you think about the use of this dashboard?
   Why should you use this dashboard?

Fade-out question

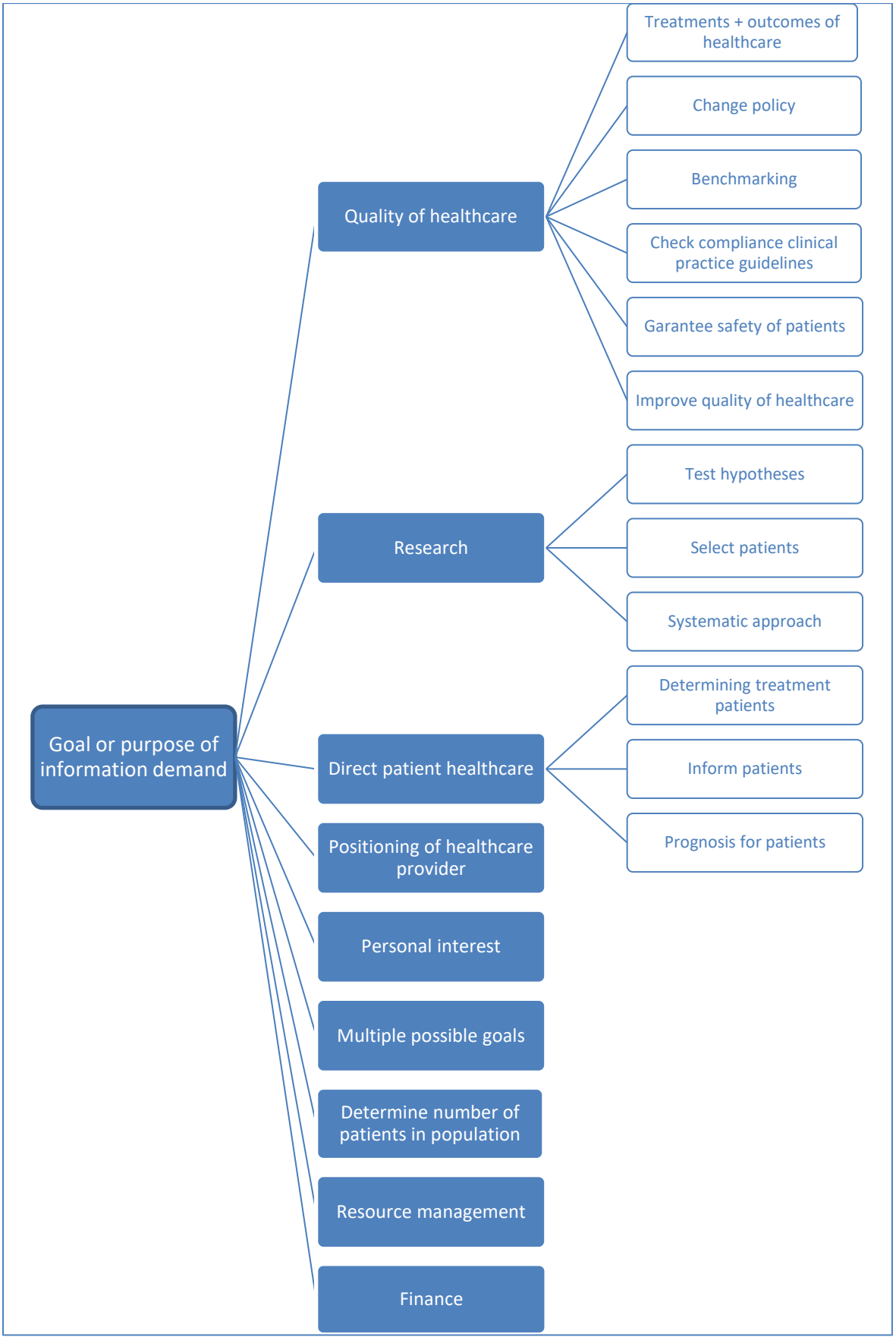
8. How do you see the use of clinical data on patient groups within the hospital in the future?

Completion

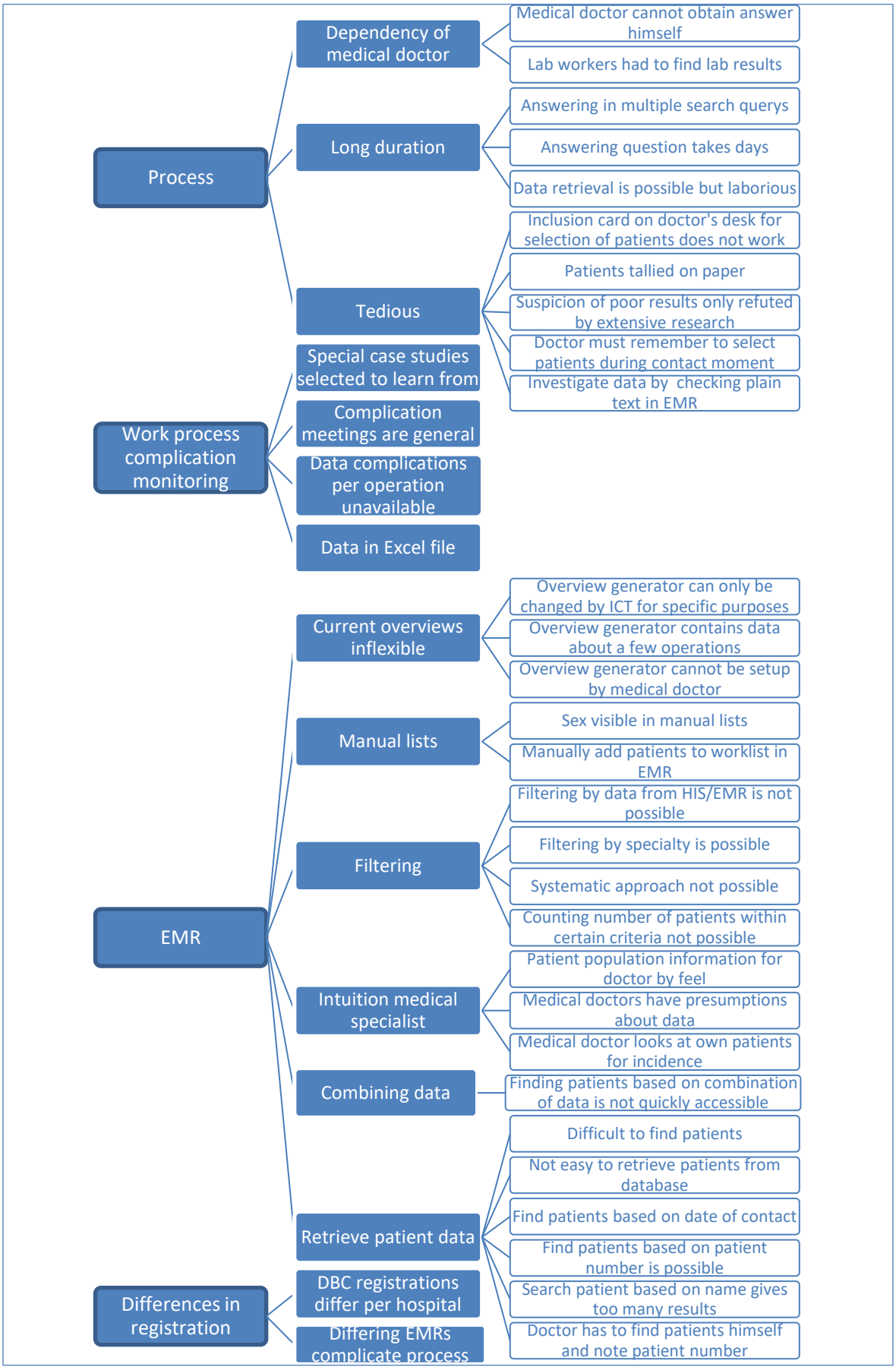
9. Do you have any questions or comments before we finish the interview?
10. Do you know other people who are interested in talking about this topic?

Thank you very much for your time and attention and for talking to me about this. You can always contact me via email if you have any further comments on this subject.

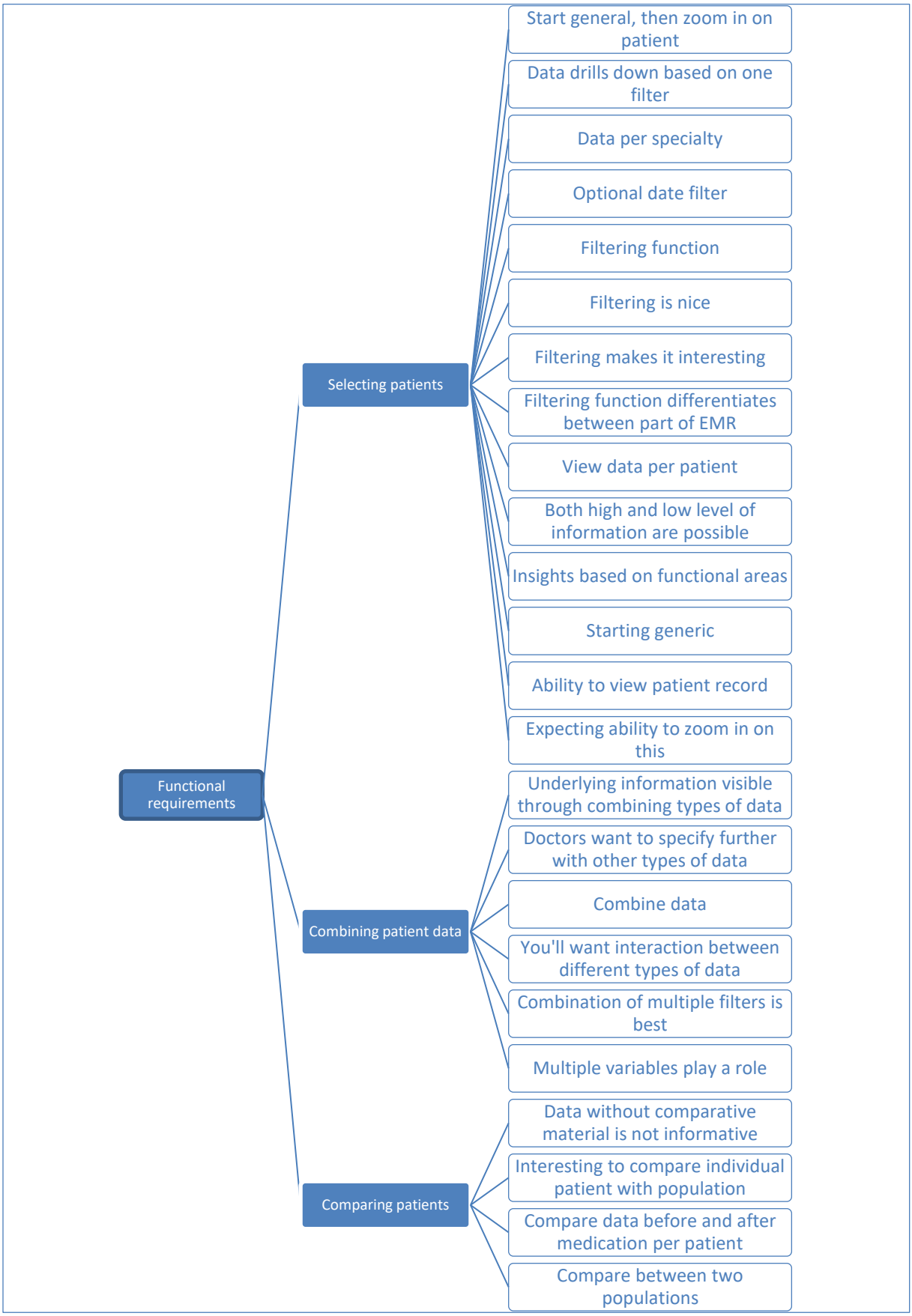
13.2 Appendix 2: Codes for the purpose of information requests about patient groups



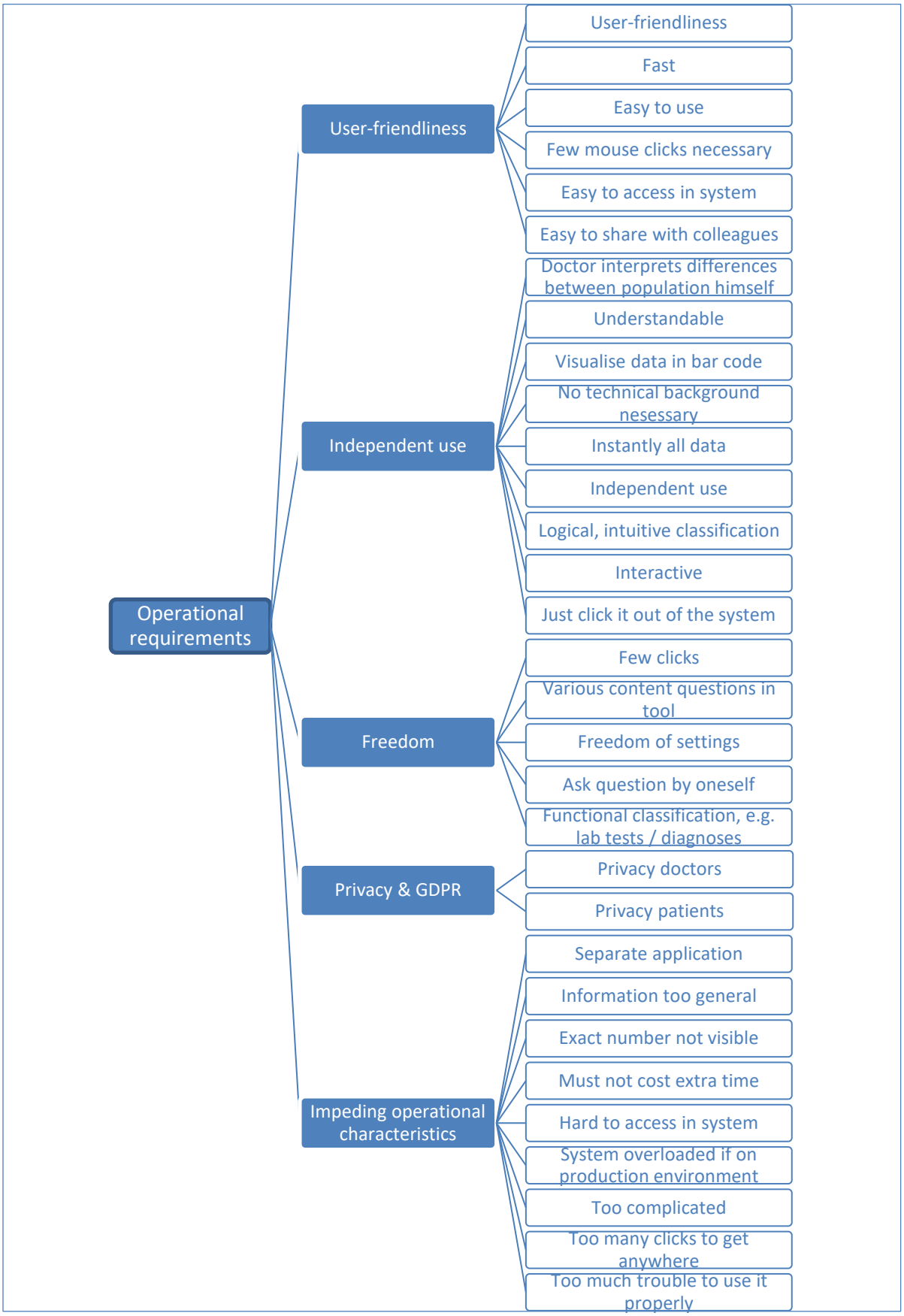
13.3 Appendix 3: Codes relating to the current method of answering



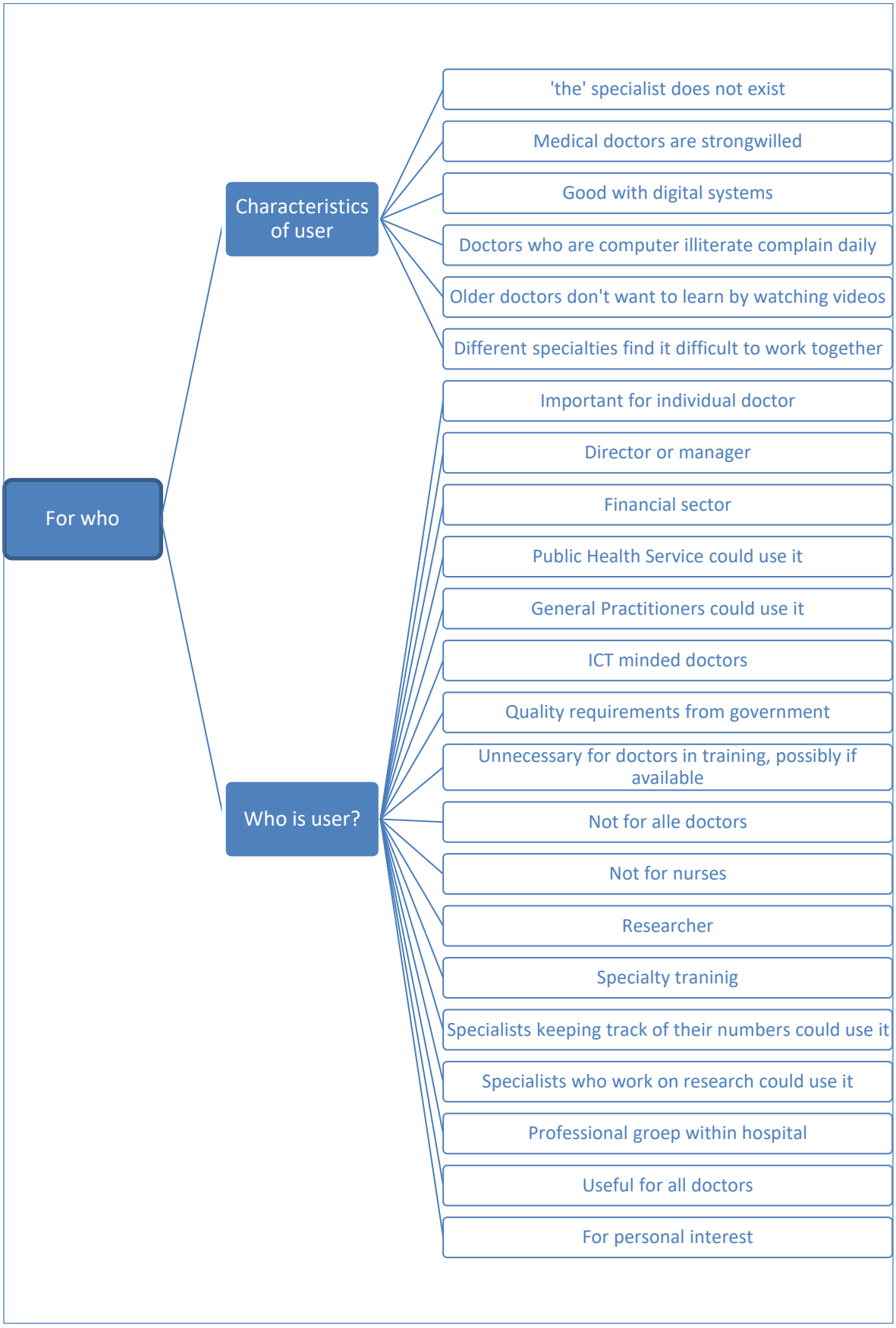
13.4 Appendix 4: Codes relating to desirable content characteristics of the tool



13.5 Appendix 5: Codes relating to operational characteristics of the tool



13.6 Appendix 6: Codes concerning user of information on patient groups



13.7 Appendix 7: Users' manual of inspirational dashboard (NL & EN)

Nederlands (origineel)

Pagina: Complicatievergelijking in populaties

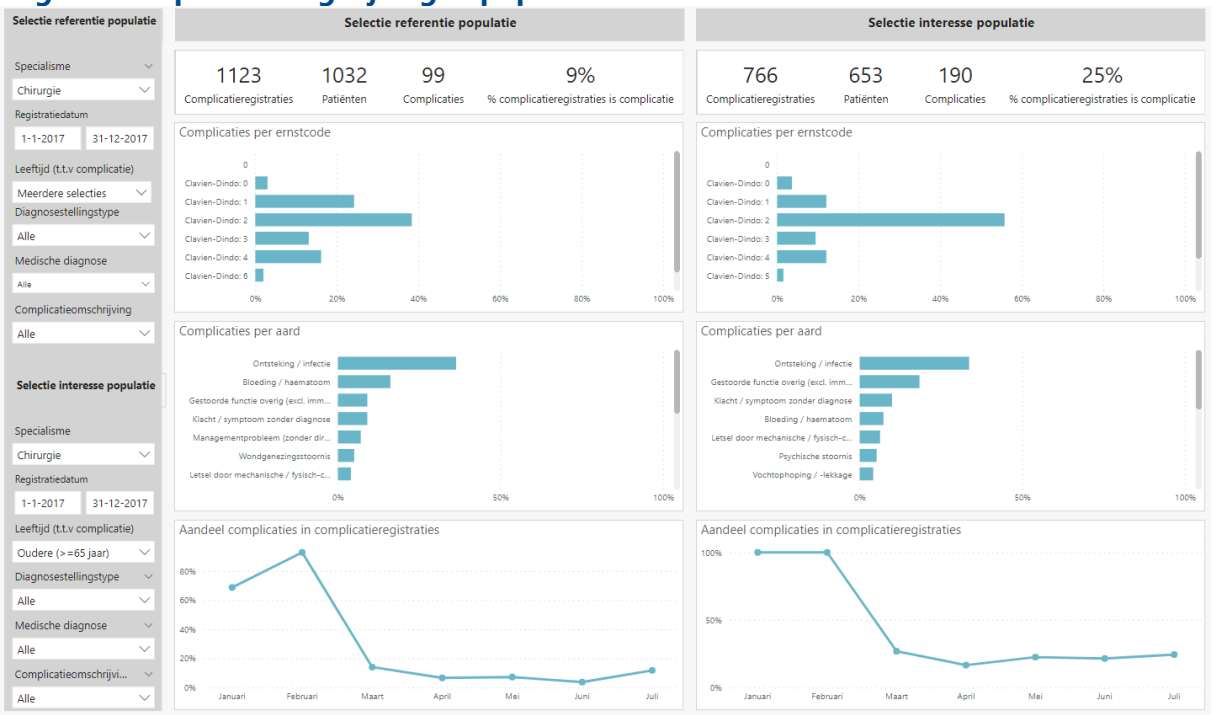


Figure A7 IM Medical dashboard: Complicatievergelijking in populaties. Dit is een fictief voorbeeld voor het registrerend specialisme 'Chirurgie', met registratiedatum in 2017. Complicaties worden vergeleken tussen patiënten onder de 65 jaar (linkerzijde) en boven de 65 jaar.

De pagina *Complicatievergelijking in populaties* biedt de mogelijkheid om twee patiëntpopulaties zelf in te stellen en complicaties tussen deze populaties te vergelijken. De pagina bevat twee panelen aan de linkerkant. De bovenste helft bevat filters waarmee een referentiepopulatie kan worden geselecteerd. De onderste helft bevat filters waarmee een interessepopulatie kan worden geselecteerd. De filters voor de referentiepopulatie en interessepopulatie zijn identiek en worden hieronder toegelicht.

Filters

- Registrerend specialisme: het registrerend specialisme van de complicatieregistratie.
- Registratiedatum: tussen welke datums de complicaties zijn geregistreerd.
- Leeftijd (t.t.v. complicatie): de leeftijd van de patiëntpopulatie ten tijde van de complicatieregistratie.
- Diagnosestellingstype: het type medische diagnose dat in het filter 'Medische diagnose' wordt geselecteerd.
- Medische diagnose: de medische diagnose.
- Complicatieomschrijving: de omschrijving van de complicatie.

De filters onder 'Selectie referentie populatie' hebben invloed op de visualisaties onder 'Selectie referentie populatie' en op elkaar. De filters onder 'Selectie interesse populatie' hebben invloed op de visualisaties onder 'Selectie interesse populatie' en op elkaar.

Visualisaties
De visualisaties aan de linker- en rechterzijde van het dashboard zijn identiek. Door de filters aan de linkerzijde in te stellen kan een vergelijking worden gemaakt tussen een referentiepopulatie en interessepopulatie.
De velden 'Complicatieregistraties', 'Patiënten' en 'Complicaties' tonen respectievelijk het aantal complicatieregistraties, het aantal unieke patiënten en het aantal complicaties dat voldoet aan de ingestelde filters. Het veld '% complicatieregistratie is complicatie' toont het aandeel complicatieregistraties waarbij een complicatie is geregistreerd (binnen de ingestelde filters): het aantal complicaties gedeeld door het aantal complicatieregistraties * 100%.
De visualisaties in staafgrafiekvorm geven de verdeling weer van het aantal complicaties, afhankelijk van de ernstcode en de complicatieaard. Dit aantal kan worden getoond per jaar, maand of dag. Alle staaf- en lijngrafieken bevatten muishints met gedetailleerde informatie.

English:
The Complication Comparison in Populations page allows you to set up two patient populations and compare complications between them. The page contains two panels on the left-hand side. The top half contains filters with which a reference population can be selected. The lower half contains filters with which a population of interest can be selected. The filters for the reference population and the population of interest are identical and are explained below.

Filters
- Registering specialism: the registering specialism of the complication registration
- Registration date: between which dates the complications were registered
- Age (at time of complication): the age of the patient population at the time of complication registration
- Diagnosis type: the type of medical diagnosis selected in the 'Medical diagnosis' filter
- Medical diagnosis: the medical diagnosis
- Complication description: the description of the complication

The filters under 'Reference population selection' affect the visualizations under 'Reference population selection' and each other. The filters under 'Population of interest selection' affect the visualizations under 'Population of interest selection' and each other.

Visualizations
The visualizations on the left and right side of the dashboard are identical. By setting the filters on the left-hand side a comparison can be made between a reference population and a population of interest.
The fields 'Complication registrations', 'Patients' and 'Complications' show respectively the number of complication registrations, the number of unique patients and the number of complications that comply with the set filters. The field "% complication registration is complication" shows the proportion of complication registrations in which a complication has been registered (within the set filters): the number of complications divided by the number of complication registrations * 100%.
The visualizations in bar graph form show the distribution of the number of complications, depending on the severity code and the complication type. This number can be shown per year, month, or day. All bar and line graphs contain mouse hints with detailed information.

13.8 Appendix 8: Background of feedback on prototype

Feedback is categorized by topic.
General:

- Fairly intuitive.
- Buttons with ‘previous’ and ‘next’ were used all the time.
- As the next step in development, you want to be able to show two things side by side, so that you can compare.
- Very often used: button to reset all filters. Is this also available in HiX? Or only in the PBI service?
- Often as a reference to see what you are looking at: checked with the number of patients, if you know it is 1.14M, then you know that there are no filters left on. Worked better than the table to check if you had any filters left on.
- It is not always clear what one is searching for. So then they search in the operations search bar for a diagnosis.
- Tip for accessibility of dashboards: better data visualisation, see video
- You want to be able to save a selection for later use.

Searches:

- Searches in 'medical diagnosis', and ‘operations’ take a long time before the results appear.
- Searches: It would be nice if this were a smart search function, so that if a doctor frequently searches for a synonym of a diagnosis, this would also be the result. And, for example, for an abbreviation. A kind of google-like search engine.
- Search window with suggestions when opened does not go away automatically, although this was sometimes expected.
- Not clear what the result is when multiple options are selected: AND, OR. So are patients shown who meet one of the criteria, or only patients who meet both criteria?
- In all search boxes: apply hierarchy. E.g. when searching for ‘partus’ (birth): that you see different types of partus and can choose from these.

Front page:

- Smoking behaviour not used. Is sometimes important but not always, so as optional setting is fine. Yes/no answer is not enough. It is often expressed in pack years. Because it matters a lot how much someone smoked and for how long.
- Gender useful as a setting.
- Add patient search by postal code, optional, not standard.
- For BMI: not the numbers, but categories, based on standards used in the Netherlands. And a button with 'adapt', so that the doctor can fill it in himself if necessary.
  Filtering did not work well. No patients remained after selecting 'male' and smoking 'yes'.
- Age:
  - Add that it is about the patient's current age, i.e. today's age.
  - In practice, as a doctor you don't go back 10 years in the files. And it does make a difference whether someone is 20 or 80, but whether someone is 63 or 65 does not make much difference.
  - Categories with age groups would be useful. This is often relevant.

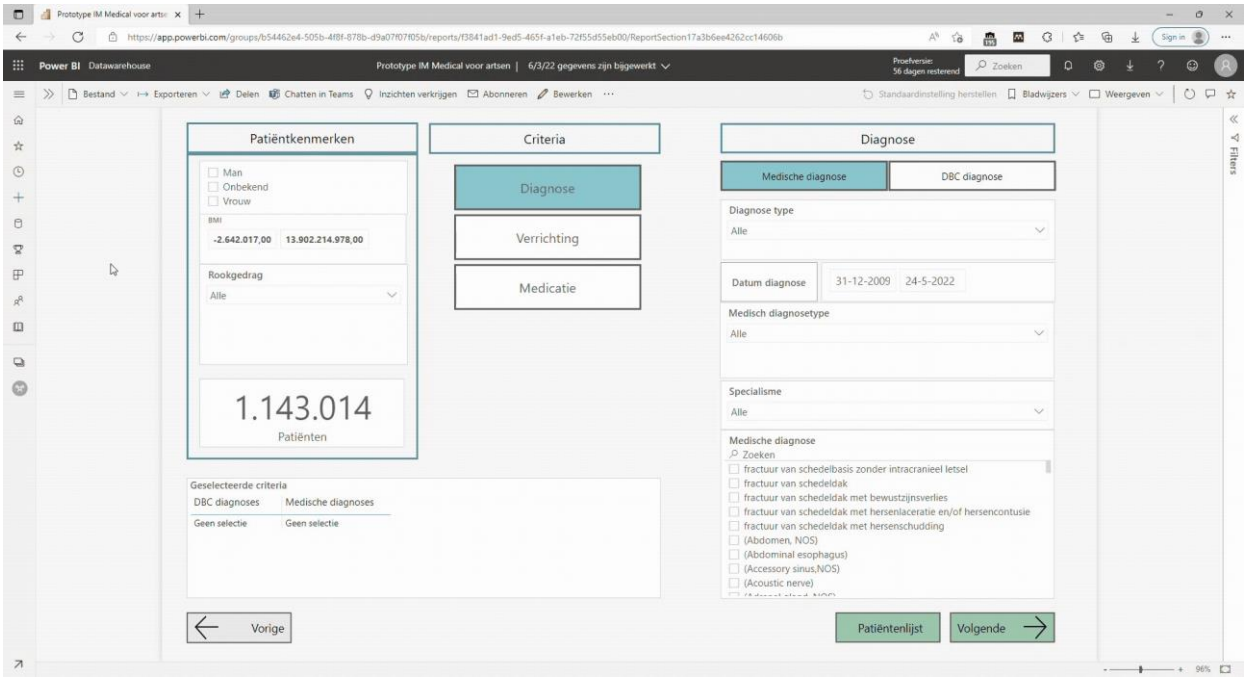
- Number of patients is good to know.

Criteria:

- Buttons with different sections (diagnosis, operation, and medication) are hardly ever used. Mainly 'previous' and 'next' buttons are used.

Diagnosis:
A doctor's thinking is always from diagnosis because that is the reason why someone is being treated. So diagnosis is the first step in thinking.

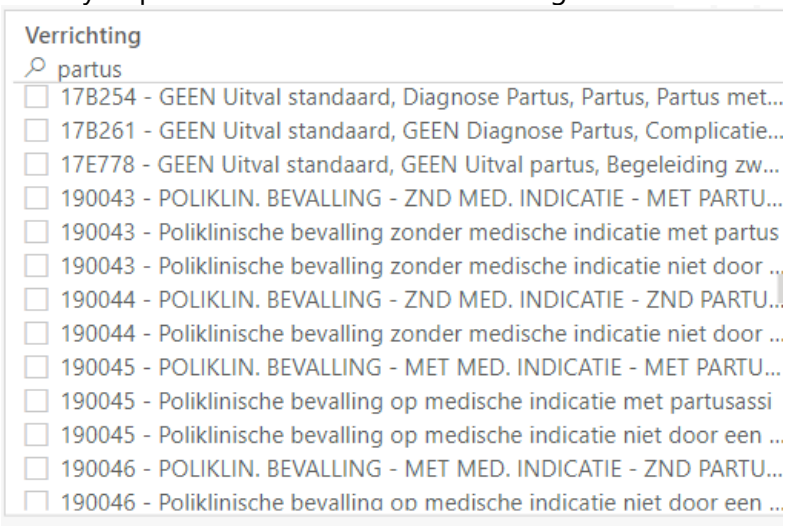
- DBC diagnosis: leave it in. Sometimes a doctor wants to see which DBCs are declared in his department, so it is useful information.
- Diagnosis type:
    - The “Diagnosethesaurus” is always used in Hix, so set that as the default. Don't give too many options because it gets confusing.
    - LBZ diagnoses: not known to doctor, so maybe not put in.
    - Is it possible to select both a certain history diagnosis and an 'active diagnosis'? So that you get as output patients who meet both conditions.
- Speciality of diagnosis: does not filter on 'medical diagnosis' now, but filters on number of patients. So not useful now. You want the specialty to filter on diagnoses.
- Medical diagnosis: the patients who are still in the filters do not filter the medical diagnosis now, as all diagnoses remain in the list even though there are no more patients with that diagnosis in the group. It would be nice if this could be filtered.
- Diagnosis type: if you select all 3 options, there are only 258,000 patients left instead of the 1.14M that are in the database.



- If a few transactions are selected, the number of patients is not correct on all pages.
- It would be nice to be able to search for patients who had a certain diagnosis as a history and who have another certain active diagnosis. So differentiate here in overview of selected criteria.

Operation:

- Care activities: is not used (anymore). At least not by doctors during the search.
- Many duplicate codes in the list. See image.



Medication

- It is recommended to enable seeing other medication use if certain medication is selected. Perhaps the dataset with the selected patients needs to be transferred to another PowerBI file to accomplish this.

Output:

- Clicking through to patient records is very useful and required.
- Number of patients: good that this is shown, useful information.
- Not always the same number of patients shown in 'number of patients' card
- Output: Last page is a table. Basically an overview of what you have selected. Is not really information. Expected that the start button on the top left would lead to the start of the insight.
- Comparison is what you want as an output, to set things against each other.
- Examples of good outputs: % of patients who have stayed in ICU/ length of admission/ saturation at entry/ complications/ what other medication is used.
- Number of digits: % of selected patients with admission yes/no + how long did admission last/ ICU admission/ how are lab values? Normal/high/low?

Other topics:

- Lab values:
    - It is possible to tick as a standard option whether you only want patients with a normal, too low, or too high value to have a lab test. Or that it can be set, e.g. everything between value 5 and 10.
    - Lab values: e.g. HB, categories can be made based on national standards, e.g. 'low', 'normal', 'high'.
    - Selection of a certain lab measurement: Different cut-off value in each healthcare institution because equipment can have different margins, so it is normally already partly interpreted by the lab.
- Complications:
    - Filter by which complication is possible

    - Filter by how serious the complication is.
- File:
    - Hierarchy: type of questionnaire --> questionnaire -> question -> score between x and y
    - Origin. E.g. Caucasian, but is this registered?
    - The questions that are interesting depend very much on the specialism.

It is preferred to select both a specific history diagnosis and an 'active diagnosis' at the same time, to select patients which are included in both criteria.