TOWARDS VALUE-BASED HEALTHCARE

A thesis on value-based IT architectures in the Dutch healthcare

TU Delft

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TOWARDS VALUE-BASED HEALTHCARE

RESEARCH TO THE DESIGN FOR AN IT ARCHITECTURE TO ENABLE VALUE-BASED HEALTHCARE IN THE DUTCH HEALTHCARE

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This research thesis has been written as partial fulfilment to obtain my Master degree in Management of Technology. This research shows the results of the barriers to value-based healthcare and proposes essential architectural components to overcome those barriers. This report can be used as an advisory document for healthcare managers and policymakers when introducing value-based healthcare practices in new and existing systems.

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EXECUTIVE SUMMARY

Background. The sustainability of the Dutch healthcare system is under severe pressure. The ever increasing expenditure influences the future affordability and quality of healthcare. Meanwhile changing demographics and increasing cases of multimorbidity places different demands on the healthcare industry. Whereas the demand for healthcare increases, there is a shortage of healthcare professionals. There is a high urgency to address these current challenges to be able to offer future generations access to affordable and high-quality healthcare.

Problem. The Dutch healthcare system is based on principles of regulated competition. Whereas competition in normal markets would indeed drive innovation and lead to higher quality and lower costs, competition in healthcare turns out to have opposite effects. Healthcare providers are rewarded for increasing volume, not for adding value. This leads to strategic behaviour of the provider to financially benefit. *Value-based healthcare (VBHC)* is one of the theories which argues that providers should be rewarded for the added value instead of the volume. While VBHC is getting widely adopted in the Netherlands, implementation faces some barriers. One of those barriers are the current healthcare information systems, which hamper outcome and costs measurement. Despite the importance of IT in VBHC, little research is conducted on the implementation. The need to understand the current barriers and how these could be redesigned resulted in the main question of this research: *"What are the essential components for an IT architecture to facilitate value-based healthcare in the Netherlands?"*

Research approach. The Information Systems (IS) research framework of Hevner, March, Park, and Ram (2004) was adopted. The framework consists of three elements: environment, knowledge base and IS research. For the first part, an *exploratory approach* was used to get an in-depth understanding of the scientific and environmental context of the problem. A *literature review* was conducted to analyse and synthesise the state-of-the-art literature on value in healthcare and IT architecture in healthcare. Subsequently, *semi-structured interviews* were carried out which validated the literature and brought insightful perspectives on the problem. These research activities answered the first two research questions. The results of the exploratory phase influenced the direction of the design efforts.

For the second part, *design activities* were conducted. Another round of *semi-structured interviews* was carried out to find the principles, requirements and components for the design. Subsequently, the components for VBHC were identified using a *layered approach*. The components were validated using descriptive evaluation methods and an expert panel.

Analysis. In the literature review, it was found that interoperability is an essential prerequisite for VBHC. A lack of interoperability impedes outcome and costs measurement which is essential to determine value. The environmental analysis found several deficiencies in the as-is architecture for VBHC which entail *a lack of patient-centredness*, *inaccessible or unavailable data*, and *complex to extract and integrate data*. However, purely focusing on the technical aspects would not lead to a successful transition as it depends on the way actors interact with it. Analysis of the semi-structured interviews revealed that *trust and collaboration* are essential to unlock the potential of VBHC. However, in the current situation, there is a low level of trust between stakeholders, thus hampering a transition. It was found that trust is often related to transparency and can be managed. Increasing transparency in the architecture would allow for (i) continuous quality improvements, (ii) improved decision-making, (iii) positive financial stimulus and (iv) patient empowerment.

Design. The architecture aims to facilitate VBHC through integrating components that reduce or eliminate the IT barriers and increase transparency. Taking these goal into account, principles and requirements were derived from both literature and semi-structured interviews. The components that are needed to facilitate a transition towards VBHC were in turn based on these principles and requirements. For each architectural layer components were determined.

The overall design developed uses three types of environment. The first one is the Healthcare Information System (HIS) where the end-users are the clinicians, the second is the Personal Healthcare Environment (PHE) that is used by patients and the third one is the Quality Registration System, available to all stakeholders. Outcome indicators follow from the measurement and evaluations in the care process. On a patient level, this can be analysed by both the physician and the patient. For learning and improvement purposes, the outcome indicators are aggregated, pseudonymised and extracted by the Quality Registration System. Here, data of multiple healthcare providers are processed and provides stakeholders with the opportunity to assess the quality of care.

Evaluation. The components were evaluated by compliance to the objectives, principles and requirements. The most essential components to realise the principles are: the PHE, the HIS, Quality Registry system, Clinical building blocks (Zibs), terminology standards, a data integration centre, logging and monitoring services, measurements and evaluations, auditing IT and care processes and an intermediary that stimulates improvement and collaboration is suggested.

The expert panel reached a consensus that transparency in healthcare would contribute to solving several problems, but it will not solve the core problems that lie within the healthcare structure. Furthermore, full transparency does not facilitate trust but instead has adverse effects.

Future research. This research has contributed to the first steps of value-based IT architecture in healthcare. There are several areas recommended for future research. First, the components should be evaluated with a broader expert panel to increase the validity. Second, the PHE is an essential component, but still in its infancy. It is recommended to further evaluate the utility for VBHC. Third, blockchain technology might enhance the design due to its inherent characteristics that offer transparency. Fourth, further research on the privacy-utility trade-off in the context of VBHC is recommended. Finally, interoperable systems rely on a shared and uniform language. It is recommended to research which standards have the highest potential to facilitate the architecture components.

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ACRONYMS

ADM	Architecture Development Method
BgZ	Basisgegevensset Zorg
DPA	Dutch Data Protection Authority
DIZRA	Duurzaam Informatiestelsel in de Zorg Referentie Architectuur
DTC	Diagnosis Treatment Combination
API	Application Programming Interface
EA	Enterprise Architecture
EBM	Evidence Based Medicine
EHR	Electronic Healthcare Record
ETL	Extract, Transform, Load
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GP	General Practitioner
HIS	Healthcare Information System
ICHOM	International Consortium for Health Outcomes Measurement
IOM	Institute of Medicine
IPU	Integrated Practice Unit
IT	Information Technology
LSP	Landelijk Schakelpunt
LOINC	Logical Observation, Identifiers, Names and Codes
NGI	Next Generation Infrastructure
NORA	Nederlandse Overheid Referentie Architectuur
NZa	Nederlandse Zorgautoriteit
PCC	Patient Centred Care
PHE	Personal Healthcare Environment
PREM	Patient-reported experience measures
PROM	Patient-reported outcome measures
SNOMED-CT	Systematized Nomenclature of Medicine - Clinical Terms
TOGAF	The Open Group Architecture Framework
VBHC	Value-Based Healthcare
Zib	Zorginformatie bouwstenen
ZiNL	Zorginstituut Nederland
ZIRA	Ziekenhuis Referentie Architectuur

1 INTRODUCTION

The Netherlands has one of the best healthcare systems in Europe (Björnberg and Phang, 2018, p. 26). However, being ranked amongst the best comes at a price as the Netherlands is one of the top spenders (Bakx, O'Donnell, & van Doorslaer, 2016). In 2019, expenditure on care amounted to over 100 billion euros, which is an increase of more than 5% compared to 2018 (Statics Netherlands (CBS), 2020a). A recent study estimated that the sustainability balance is -1.6% of Gross Domestic Product (GDP), and indicates that the total expenditure of the government will increase faster than the income (Adema & Van Tilburg, 2019). This results in a deficit and leads to a situation where future generations cannot benefit from the same governmental services as current generations.

1.1 SUSTAINABILITY OF DUTCH HEALTHCARE SYSTEM

The aim of the Dutch healthcare system is to provide high-quality care that is affordable and accessible to every citizen. Fundamentally, the system relies on solidarity as every citizen financially contributes to the care of others (Kooijman, Brabers, & de Jong, 2018). A well-functioning healthcare system makes an indispensable contribution to a vital labour market, economy and society (SER, 2020). Although the Dutch healthcare system is ranked among the best, the sustainability of the system is under pressure (Adema & Van Tilburg, 2019; SER, 2020). According to a study of the SER (2020), there are three dimensions that affect the sustainability of healthcare: the labour market, financial resources, and public support.

1.1.1 Scarcity on the labour market

The Netherlands is an ageing society and almost 20% of the Dutch population are over-65s (Statics Netherlands (CBS), 2020b). The senior citizens consume significantly more care than the young population (RIVM, 2018). Furthermore, the life expectancy of Dutch citizens increases gradually (Statics Netherlands (CBS), 2020c), which means that the elderly consume more care for a longer period of time. The increasing demand for care requires in turn more human resources. However, due to scarcity on the labour market, healthcare providers are having difficulties recruiting new professionals (Wolters, Sanne, 2020). The Ministry of Public Health Welfare and Sport (2018b) estimates that there will be a shortage of 80,000 healthcare professionals in 2022. Although the effects of the COVID-19 pandemic are not yet entirely clear, it is expected that more clinicians are needed to restart regular healthcare services (SER, 2020).

One of the consequences of a shortage in human resources is a higher administrative burden per person (SER, 2020). A recent survey among 3.500 dutch healthcare professionals found that 80% of the respondents experienced 'regularly' to 'very often' an administrative burden (VvAA, 2020). Respondents indicated that healthcare insurance companies, legislation and IT systems are the main cause of the administrative burden. According to the respondents, the highest potential for improvements are within those areas (VvAA, 2020).

1.1.2 Increasing healthcare expenditure

Rising expenditure is a common challenge in healthcare across many countries (Stepovic, 2019). According to a sustainability study of Adema and Van Tilburg (2019), the annual increase in healthcare expenditure stems from changing demographics, wage developments and socio-cultural developments. The ageing society places a different demand on the healthcare system in the future. Besides the fact that a growing senior population places a different demand on the healthcare system, age also correlates with the height of the expenses. Whereas a 70-year-old spends €6000 per year on healthcare on average, an 80-year-old spends €13,000 and a 99-year-old spends €50,000 (SER, 2020). At the same time, the population growth is levelling off and the number of employed citizens - who partly generate the governments' income by taxes - decreases proportionally (Adema & Van Tilburg, 2019). Therefore, changing demographics affect the expenditure on healthcare and threatens sustainability in the long term.

The second factor affecting healthcare expenditure are developments in wage and prosperity. Some literature suggests that healthcare is a luxury good on economic level (Goodman, 2017; SER, 2020), which would mean that a 1% increase in GDP results in a more than a 1% increase in healthcare expenditure. The Netherlands Bureau for Economic Policy Analysis (CPB) agrees that the 'raw expenditure elasticity' lies between 1.4 and 1.7. However, when the expenditure on technology and insurance are taken into account, the income elasticity is reduced to 0.6 (Mot, Stuut, Westra, & Aalbers, 2016). This indicates that a 1% increase in GDP results in an increase in healthcare expenditure of 0.6%. Ultimately, healthcare consumption demand increases when the GDP increases.

The third factor which affects healthcare expenditure is due to socio-cultural developments. These developments include higher quality standards and investments in innovative technologies (Adema & Van Tilburg, 2019). For example, the recently implemented General Data Protection Regulation (GDPR) demand protection of personal data, and, therefore, healthcare providers need to adapt their processes to comply with the GDPR which is costly in terms of time and money (Przyrowski, 2018). On the other hand, there are investments in technologies and research which increase the expenditure strongly. In comparison to the other two factors, technological developments have a bigger share in the rising healthcare expenditure. According to SER (2020), technological developments account for 46% of the healthcare expenditure growth.

1.1.3 Public Support

To organise healthcare in the long term, public support is essential. As mentioned previously, solidarity is the foundation of the Dutch healthcare system. Kooijman et al. (2018) defines solidarity as *"the willingness of others to pay for care treatments in the basic package that one does not use (yet)"*. The healthcare premium for the basic insurance package contributes to the payment of healthcare for both ourselves as for others.

Although the solidarity, in general, is quite high throughout the years (Kooijman et al., 2018), it also comes under pressure if healthcare expenditure continues to rise. The chairman of health insurer CZ expresses his concerns in an interview (Mandemaker, 2019): *"If the premium for the basic insurance package becomes so expensive that individuals cannot, or will not, equally contribute anymore, then the core of the Dutch healthcare system is inevitably in danger."*

1.2 STRUCTURE OF DUTCH HEALTHCARE SYSTEM

The previous section expressed the urgency of the problem. That is, the healthcare system cannot be organised in the long term. The Dutch government has taken several measures throughout the years to increase the quality and reduce the costs of healthcare (Kroneman et al., 2016).

One of the most important developments was the Healthcare Insurance Act in 2006, which introduced a new healthcare structure (Kroneman et al., 2016). This structure is based on the so-called principle of 'regulated competition', where the government determines which care is included in the basic health insurance package and private insurance companies determine additional packages (Ministry of Public Health & Sport, 2016). The insurance companies selectively contract healthcare providers and agree on prices and quality for healthcare services. Dutch residents have the freedom to choose one of the insurance companies. In that way, healthcare providers, and in turn the insurers, gain a competitive advantage when providing high-quality care for lower prices. Eventually, competition and market forces stimulate innovation, increase the quality of care, and reduce the overall expenditure.

Whereas competition in normal markets would indeed drive innovation and lead to higher quality and lower costs, competition in healthcare turns out to have opposite effects (Porter & Teisberg, 2006). Hospitals and medical specialists are profit-oriented companies and deliver services according to a case-based funding scheme. This funding scheme in the Netherlands is also known as the Diagnosis Treatment Combination (DTC)[1], where reimbursement per case is fixed (Hassaart, 2011). The DTC includes all activities and services of the entire care process at one provider, starting with the first consultation of the medical specialist and ending with the completion of the treatment (Hassaart, 2011).

The market forces indeed resulted in lower prices, but not in lower costs since healthcare providers compensate by a higher volume of patients (Kroneman et al., 2016). Sometimes the most lucrative treatment is provided, regardless if this is necessary for the envisioned outcomes (BDO, 2018). This phenomenon is also known as *upcoding* (Hassaart, 2011). In addition, healthcare providers have low bargaining power and are dependent on the insurance companies and their agreement terms (e.g. price, volume, quality) (van Manen, Meurs, & van Twist, 2020). This results in low-profit margins (BDO, 2018), and only reinforces the incentive for strategic behaviour to financially benefit. Besides increasing volume or upcoding, there exists a risk that providers are *cream skimming* for profitable patients or *quality skimping* in which care services are denied or delayed to save costs (Hassaart, 2011).

1.3 PROBLEM STATEMENT

The sustainability of the Dutch healthcare system is under pressure. One of the underlying dimensions discussed in Section 1.1is the increasing expenditure, which poses pressure on the affordability of healthcare and has far-reaching consequences. The regulated market competition and DTC reimbursements only exacerbate the situation. As long as healthcare providers are required to act strategically to have a positive business case, volume and costs will continue to rise.

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[1] In Dutch known as: Diagnose Behandeling Combinaties (DBC's)

1.3.1 Transition Towards Value-Based Healthcare

Porter and Teisberg (2006) argue that the competition itself is not the problem, but the nature of the competition is. In the current healthcare system, providers are focused on increasing revenue and decreasing costs. Therefore, providers are rewarded for increasing volume, but not necessarily for increasing value. This may result in misalignment with patients' interests, as they seek the best healthcare. In other words, patients desire a maximum outcome of value. Porter and Teisberg (2006) introduced a strategic framework called *VBHC* to restructure the healthcare system from volume-based competition towards value-based competition.

According to Porter and Teisberg (2006) achieving the maximum value for patients must become the overarching goal of healthcare delivery, where value can be defined as "*the outcomes achieved per dollar spent*". In the VBHC model, the individual patient has a central position and the outcomes achieved should matter to the patient. Value focuses on the outcomes achieved instead of volume of delivered care services (Porter, 2010b). Porter and Teisberg (2006) argue that competition based on value will lead to improved outcomes for patients and will have beneficial side effect of reduced costs.

VBHC is seen as one of the candidate frameworks to improve the Dutch healthcare system and contribute as a solution to the sustainability challenges as indicated in Section 1.1 (Seoane et al., 2020). In the Netherlands, VBHC is getting widely adopted and healthcare providers are enthusiastically carrying out projects to implement VBHC (Mjåset, Nagra, & Feeley, 2020). Although the government, healthcare providers and insurance companies recognise the benefits of outcome-based care (Ministry of Public Health Welfare and Sport, 2018a; Skipr, 2016), the healthcare structure is not ready yet.

1.3.2 Knowledge gap

Porter and Lee (2013) provided a strategic framework to move towards a high-value healthcare delivery system: (1) Organise into Integrated Practice Unit (IPU), (2) Measure costs and outcomes, (3) Move to bundled payments, (4) Integrate care delivery systems, (5) Expand geographic reach and (6) Build an enabling Information Technology (IT) platform [2]. The first five steps should be supported by an IT platform. Feeley, Landman, and Porter (2020) discusses the evolution of healthcare IT systems and explains the importance of IT in the transition towards VBHC. For example, IT must facilitate access to medical data for both patients and physicians, and support outcome and cost measurement across multiple providers.

While VBHC is getting widely adopted across the Dutch healthcare providers, insurance companies and the government, the implementation faces some barriers. One of the most important steps of the strategic framework is a supporting IT system (Alnofeye, Hasan, & Abstract, 2019; Feeley et al., 2020; Mjåset et al., 2020). If the IT infrastructure is not organised in the right way, limited benefits from the other steps can be gained (Porter & Lee, 2013). In fact, current IT systems are considered to be a major barrier to achieving VBHC (Feeley et al., 2020). The fragmented IT landscape impedes interoperability (Vreugdenhil, Ranke, De Man, Haan, & Kool, 2019), which is a prerequisite for the outcome and cost measurement. While the introduction of the Electronic Healthcare Record (EHR) helped to digitise the medical records, they are

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[2] A description of the strategic framework and steps can be found in Appendix C: Implementation of VBHC.

not designed to manage medical data across multiple institutions. Therefore, patients leave data scattered across various organisations (R. Janssen, Stam, Visser, de Vries, & Wijnker, 2017). Consequently, patients lose access to records easily, while healthcare providers face the challenge of continuously updating medical data.

Despite the importance of IT in VBHC, little research is conducted on the implementation (Alnofeye et al., 2019). Many studies have conducted research on VBHC or similar holistic frameworks, but no integrated value-based IT architectures have been found yet. Then the question arises, *what components of the IT architecture do hamper the transition towards value-based healthcare? and, maybe even more important, how could those barriers be reduced or eliminated?* In addition, the scientific literature is mostly focused on the U.S., which may not hold for the Dutch healthcare system. Consequently, there is a need to understand the current barriers of the IT architecture and how components could be redesigned to unlock the full potential of VBHC in the Netherlands.

1.4 RESEARCH OBJECTIVES & QUESTIONS

From the problem statement, it can be concluded that there is a knowledge gap in the literature for an IT architecture that enables VBHC. The objective of this thesis is: *"To identify and design the essential components for a value-enabling IT architecture for the Dutch healthcare system."*

The research objective will be achieved using exploratory research methods to gain an in-depth understanding of the problem and design research methods to create an IT architecture. The research will provide recommendations for policymakers and healthcare managers on how business processes, information flows and technology could be aligned in order to enable a transition to VBHC. The results and recommendation may create a starting point for an interoperable IT landscape that supports future research and implementation of value-based healthcare. Following the research objective, the main question for this research is:

"What are the essential components for an IT architecture to facilitate value-based healthcare in the Netherlands?"

The research question is artifact-related and focuses on a *design product* rather than a design process (Thuan, Drechsler, & Antunes, 2019). To conduct the research in a systematic way, there are four subquestions defined:

1. *What is the state-of-the-art literature of IT architecture in the context of healthcare, and VBHC?*
   This subquestion provides insight into the components of IT architectures, specifically for the healthcare domain. The objective is to collect and analyse the literature for theories, frameworks, methods and related works. In addition, the concept of value-based healthcare will be further explored.

2. *How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?*
   In order to answer this question, the current situation will be described and analysed. An in-depth understanding of the environment (e.g. people, organisation

and technology) will be developed and the business needs will be made explicit. This will allow the researcher to pinpoint the deficiencies in the baseline architecture.

3. *What components could be incorporated in the IT architecture to facilitate a transition towards VBHC?*
   The barriers for VBHC identified from the research activities to answer subquestion 2 will be the focus of further research. This subquestion aims to find out what components, that put together the artifact (Thuan et al., 2019), could facilitate VBHC.

4. *What components are essential to facilitate VBHC?*
   The aim of the final subquestion is to assess the appropriateness of the proposed components and evaluate to what extent these match with the business needs and VBHC prerequisites. Although essential components for VBHC should be essential, they should also be feasible to realise in the short or long term.

An overview of the research questions, methods and deliverables can be found in Appendix A.

1.5 RELEVANCE OF RESEARCH

The relevance to investigate this topic is divided into academic and managerial relevance:
Academic Relevance. Although much research is conducted on VBHC and other emerging healthcare delivery models, little research is done on the implementation of IT. In addition, Mjåset et al. (2020) argue that information technologies provide more opportunities to stakeholders than a couple of years ago. The existing knowledge on IT architectures and VBHC is scattered and not integrated yet, and, therefore, the research is relevant to investigate further from an *academic perspective* (Sekeran & Bougie, 2016).

Managerial Relevance. On the other hand, the research is also relevant from a *managerial perspective* since the knowledge can be applied to improve the status quo (Sekeran & Bougie, 2016). The results and recommendations will help policymakers and healthcare managers to gain an understanding of the IT landscape and how it could be designed to enable VBHC. *PwC Netherlands* can use the knowledge and outcomes to advise their clients in the healthcare industry or other similar contexts. This contributes to the mission of PwC to "build trust in society and solve important problems".

1.6 SCOPE OF RESEARCH

This thesis will focus on the elements of an IT architecture in the context of the Dutch healthcare, in light of the transition towards a value-based healthcare system. Since VBHC is rotated around achieving value for the patient, they are the ultimate point of focus. In addition, clinicians that provide healthcare services are end-users of the information systems that capture outcomes and value. Besides the clinicians, insurance companies play an important role in the transition because a true value-based healthcare system requires a financial incentive to move away from volume-based healthcare. The scope of the research is focused on a solution that adds value for patients, providers and insurers.

The Dutch healthcare system is highly complex and consists of many actors and organisations. Due to time constraints, this research will be limited to the curative care that falls under the Healthcare Insurance Act (Zvw). All Dutch citizens are obligated to be insured for curative healthcare under the Act (Kroneman et al., 2016). Long-term care (e.g. home nursing, patients that need 24 hours supervision) is organised differently in terms of finance and actors and will be outside the scope of this thesis.

1.7 RESEARCH DESIGN

In order to achieve the research objective, a systematic methodology is required. The aim of the research is not only to identify components but also to apply them to Dutch healthcare for the purpose of VBHC. Therefore, an in-depth understanding of the environment is essential. In the Information Systems research framework of Hevner et al. (2004) both the design science paradigm and behavioural paradigm are coming together. This framework will be used to understand, execute, and evaluate this research.

Whereas the design science paradigm is focused on creating and evaluating IT artefacts, the behavioural science paradigm tries to understand and explain real-world phenomena (Hevner et al., 2004). The framework consists of three components: environment, knowledge base and design science research. Hevner (2007) establishes a connection between these elements using cycles. The *Relevance Cycle* analyses the environment and extracts a real-world problem, which can be formulated as the 'business needs'. The *Rigor Cycle* ensures that 'applicable knowledge' such as theories, methodologies and frameworks, are drawn from the knowledge base. The business needs and applicable knowledge together from the input for the *Design Cycle*, in which the artefact is built and evaluated. After an iterative design process, the output will be fed back into the Relevance and Rigor Cycle.

1.7.1 Exploratory Research

To capture the business needs and applicable knowledge, exploratory research methods will be used. An exploratory approach is useful to get an understanding and explore the nature of the problem in-depth (Johannesson & Perjons, 2014). Qualitative research methods will be used to explore the problem and scientific knowledge. A *literature review* will start the Rigor Cycle and analyse methods, theories and related work. This research activity will answer subquestion 1. Next, the Relevance cycle is triggered by conducting the *preliminary interviews*. Analysing the environment and IT architecture allows the researcher to explicate the business needs and pinpoint the deficiencies in the IT architecture. This answers subquestion 2.

As a result of the literature review and interviews with experts, new insights and perspectives on the problem are gained. It is worth noticing that the answers to subquestion 1 and subquestion 2 determine the direction of the research. Subsequently, the *in-depth semi-structured interviews* will be carried out to capture the requirements, principles, and best practices to develop the target architecture.

1.7.2 Design Science Research

Identifying essential components of the IT architecture is the heart of the research design. The business needs together with the applicable knowledge, will be the input for the Design Cycle. An IT architecture will be visualised. The components required to facilitate VBHC will be designed per layer and will be the answer to subquestion 3.

The evaluation of the components determines to what extent the design offers an appropriate solution to the identified problem. The selection of evaluation methods must be matched appropriately with the designed artefact and the selected evaluation metrics (Hevner et al., 2004). A qualitative evaluation method is used in the form of an *expert panel*. Experts with various backgrounds will evaluate the components necessary for VBHC on its importance and feasibility. By answering subquestion 4, it can be decided whether to iterate back to the development stage. Eventually, the results are fed back into the Relevance and Rigor Cycle.

1.8 THESIS LAYOUT

This Chapter provided an introduction to the problem area and the objectives of this research. Chapter 2 will provide a literature review on value in healthcare and IT architectures in healthcare. Subsequently, Chapter 3 provides the research methodology and discusses methods for data collection, analysis and designing the components for the IT architecture. Next, Chapter 4 analyses the current situation based on literature. Chapter 5 will analyse the semi-structured interviews. In Chapter 6 the architecture components will be developed and presented. Subsequently, In Chapter 7 the components are evaluated to determine the importance. Chapter 8 addresses the limitations of this research and discusses the scientific and managerial contributions. Finally, Chapter 9 provides the conclusions, opportunities for future research, and link to Management of Technology. The bibliography and appendices will complement this thesis.

2 LITERATURE REVIEW & BACKGROUND

A literature review is essential to analyse the existing scientific knowledge and to identify potential knowledge gaps. The aim of this literature review is to analyse and synthesise the state-of-the-art literature on IT architectures for value-based healthcare. First, the key definitions and theories about value in healthcare will provide a background. Second, implementation and the role of IT will be discussed. Third, a review of the state-of-the-art literature on IT architectures in healthcare will be conducted. By acquiring, analysing and synthesising relevant scientific literature, a knowledge gap may be unravelled which will be the starting point of this thesis.

2.1 BACKGROUND: VALUE IN HEALTHCARE

The aim of this research is to identify and design components for a value-enabling for the Dutch healthcare system. This section reports fundamental background information for the reader to understand the concept of value and VBHC. A detailed description of value theories and frameworks is provided in Appendix B.

One of the first models that incorporated 'value' from a patient perspective was *Evidence Based Medicine (EBM)*. EBM combines scientific evidence and clinical judgement to improve clinical decision-making (Guyatt et al., 1992). Although EBM involved the patient's values (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996), the provided care was not individualised but established on population-based evidence. This may not represent every patient, which called for a shift towards patient-centredness (Marzorati & Pravettoni, 2017).

Patient Centred Care (PCC) goes beyond clinical decision making and includes the patient as a decision-maker in the care process, also known as shared decision-making (Barry & Edgman-Levitan, 2012). Throughout the years, shared decision making got increasingly important (Maassen, Schrevel, Dedding, Broerse, & Regeer, 2017). The Institute of Medicine (IOM) includes PCC as one of six domains of quality in healthcare and defines it as *"care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions"*.

Although researchers agree on the fact that patient-centredness is an important dimension of value in care (Berwick, Nolan, & Whittington, 2008; Gray & Jani, 2016; Porter, 2010b; Sackett et al., 1996), consensus on a definition is still not reached yet (Marzorati & Pravettoni, 2017). Many stakeholders define value from an economic perspective as the '*clinical benefit per money spent*'. However, from the patient's point of view, the term value is much broader (Institute of Medicine (IOM), 2010). For care to add value it must both treat the medical condition and satisfy the patient's needs. The achieved health status is not limited to the disease but involves also the quality of life (QoL) (Marzorati & Pravettoni, 2017).

2.1.1 Healthcare systems Based on Value

Later, more holistic frameworks were suggested to simultaneously increase quality in care and deal with the sustainability challenges of healthcare (Seoane et al., 2020). Interestingly, all these theories reason from a value perspective. Value-based healthcare

(VBHC), Triple Aim and Triple Value are three frameworks that discuss reorganisation of healthcare systems. Appendix B elaborates on these three frameworks.

The scope of this study is the Dutch healthcare system. In the Netherlands, several providers and insurance companies have already engaged in some elements of VBHC (Mjåset et al., 2020) and therefore, it is assumed that this model is most influential and accepted in the Dutch healthcare system. Moreover, a governmental programme called 'Outcome-based Healthcare 2018 - 2022' refers to elements of the VBHC framework. For that reason, this research will mainly focus on the implementation of the VBHC framework.

2.1.2 Value-based Healthcare

In 2006, Porter and Teisberg published their work '*Redefining Health care*' and introduced the concept of value-based competition. As explained in Section 1.3, Porter and Teisberg (2006) argue that competition itself is not the problem, but the nature of competition is. They argue that the problems the healthcare sector is facing stem from the zero-sum competition, which can be defined as "*A competition in which one participant wins totally and another loses without gaining any objectives*" (Oxford Reference, 2006). In a positive-sum competition, on the other hand, providers would be financially stimulated to deliver high-quality care in more efficient ways, which is, in turn, beneficial for patients and payers.

Porter and Teisberg (2007) determine three guiding principles that lead to a value-based healthcare system: (1) The goal is value for patients, (2) Organise medical practices around medical conditions and care cycles, and (3) Outcomes and costs must be measured across the care cycle. Porter and Teisberg (2006) defines value as *"healthcare outcomes achieved per dollar spent"*. By "health outcomes", the authors mean the health outcomes achieved which matters to the patient. Outcomes are considered beyond the disease and incorporate also the process of recovery and the sustainability of the outcomes (Porter, 2010b). By "costs" is meant the total costs to achieve the health outcomes (Porter, 2010b).

A limitation of VBHC is that the definition is considered to be too narrow (European Commission, 2019). The narrowly defined concept of value reduces the holistic concept to a cost-efficiency question (Seoane et al., 2020). Therefore, this study will follow European Commission (2019) and define VBHC as *"comprehensive concept built on four value-pillars: appropriate care to achieve patients' personal goals (personal value), achievement of best possible outcomes with available resources (technical value), equitable resource distribution across all patient groups (allocative value) and contribution of healthcare to social participation and connectedness (societal value)."*

2.2 IMPLEMENTATION OF VALUE-BASED HEALTH CARE

As described in the previous section, VBHC is one of the most used frameworks in the Netherlands. Porter and Lee (2013) provided six independent strategic steps to move towards a high-value healthcare delivery system, see Figure 2.1. Appendix C.1 provides a theoretical background on the implementation of VBHC and the status in the Netherlands. This section provides a brief overview of the implementation framework and discusses the role of IT in more depth.

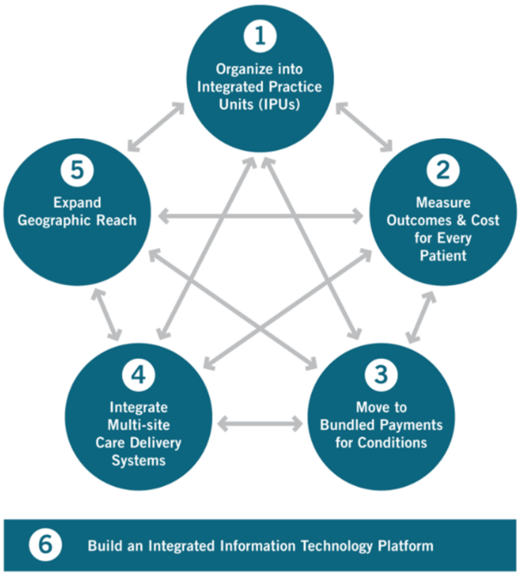

Figure 2.1: The strategic agenda to enable VBHC. Adopted from Porter and Lee (2013).

1. Organize into IPU

Healthcare delivery should be organised around the patient to coordinate the care process. An Integrated Practice Unit IPU is a multidisciplinary team that delivers specialist care, organised around the medical condition (Porter & Lee, 2013).

2. Measure costs and outcomes for every patient

According to Porter and Lee (2013) rigorous measurement of both outcomes and costs is necessary to improve and excel. At the core of VBHC are the outcomes that matter to the patient, which are divided into the following dimensions: (i) health status achieved, (ii) nature of cycle and recovery, and (iii) sustainability of health. These three dimensions are very broad and should be specified to condition-specific measurements. The International Consortium for Health Outcomes Measurement (ICHOM) provides standardised outcomes sets for specific health conditions and play an important role in the adoption outcome measurement (European Commission, 2019; Mjåset et al., 2020).

On the other hand, the costs to achieve that outcome must be measured across the full cycle of care (Porter & Lee, 2013). The cost includes all of the human resources, supplies, and support services that are involved to achieve the outcomes. If care processes for each medical condition are standardised, providers can use time-driven activity-based costing (TDABC) to assign costs accurately (Kaplan & Porter, 2011).

3. Move to bundled payments for care cycles

Porter and Lee (2013) describe that bundled payment - a payment tied to the overall care for a specific medical condition provided by an IPU - would match VBHC best. This type of payment motivates IPUs to improve efficiency and outcomes and rewards them for excellent value achievements.

4. Integrate care delivery systems

The organisation of healthcare delivery should be matched to providers and their expertise. Overall the IPU should coordinate all the healthcare activities. To organise delivery systems carefully, organisations must define the scope of services, concentrate volume in fewer locations, choose the right location for each service and integrate the care across locations (Porter & Lee, 2013).

5: Expand Geographic Reach

Porter and Lee (2013) propose to create centres of high expertise to take care of complex medical conditions. The expertise centres are located strategically and collaborate with smaller centres located regionally.

6: Build an Enabling Information Technology Platform

The aforementioned 5 strategic steps towards a high-value healthcare delivery system should be supported by an IT platform (Porter & Lee, 2013). If the IT infrastructure that is not organised in the right way, limited benefits from the previous steps can be gained. Feeley et al. (2020) discusses the evolution of healthcare IT systems and explains that medical data is siloed which hampers outcome and cost measurement. For a healthcare IT system to enable value it must:

- Be patient-centred
- Use common data definitions
- Encompass different data types
- Be accessible to all parties involved
- Include specified medical condition templates
- Be easy to extract information

2.2.1 IT & Value Based Healthcare

Alnofeye et al. (2019) researched the utilisation of IT in VBHC and found that there are positive impacts in multiple perspectives of VBHC such as improved healthcare outcomes, positive experience of the patients, increased efficiency of the current health systems, and potential influence on patient safety. To stress the importance of IT, Alnofeye et al. (2019) argue that it is the heart of VBHC's strategic framework.

Feeley et al. (2020) researched the implementation of IT for value-enabling IT platforms. A value-enabling IT platform should include condition-based templates and multi-disciplinary teams must be able to view medical data and outcomes. Outcome measurement is one of the core abilities of an IT platform. Feeley et al. (2020) emphasizes the importance of outcomes at patient level and on an aggregated level. For patients and physicians, outcomes are important to make informed decisions about the treatments. On an aggregated level outcomes are important to be able to compare results with other providers. In addition, outcomes are fundamental to value-based reimbursement models. In fact, current IT systems are considered to be a major barrier for achieving VBHC (Feeley et al., 2020).

Also, Seoane et al. (2020) recognises the importance of outcome measurement and argues that implementation of value frameworks can only be achieved by the availability of accurate and valid information. Therefore, if IT is not organised in the right way, limited benefits from the other steps can be achieved (Porter & Lee, 2013). Currently, the EHRs are the heart of medical information within healthcare institutions. While the introduction of the EHR helped to digitise the medical records, they are not designed to manage medical data across multiple institutions (Feeley et al., 2020). As a result, patients leave data scattered across various organisations and lose easily access of their data (R. Janssen et al., 2017). Meanwhile, healthcare providers face the challenge to continuously updating medical data and face an administrative burden. Therefore, IT systems are considered to be a major barrier for achieving VBHC (Feeley et al., 2020).

The fragmented IT landscape impedes interoperability between providers (Vreugdenhil et al., 2019), and, therefore, hampers outcome and cost measurement across the care cycle. Interoperability can be defined as "*the extent to which different IT systems and software applications to communicate and exchange data with each other*" (Gordon & Catalini, 2018). A lack of interoperability results in more administrative efforts, duplicated medical interventions and influences the quality of clinical care due to the accessibility of the medical history (Gordon & Catalini, 2018; The Open Group, 2016). Although most Dutch healthcare providers nowadays offer their patients access to their EHR by the means of an institution-based patient portal, providers can still not observe relevant medical history nor analyse outcomes (Vreugdenhil et al., 2019).

Similar to Alnofeye et al. (2019) and Feeley et al. (2020), Mjåset et al. (2020) emphasizes the importance of IT systems and recommends to focus on creating an integrated IT system across multiple providers that cover the full cycle of care. Many Dutch healthcare providers and insurance companies have embraced the concept of VBHC and seek how to improve interoperability and data exchange between organisations (Mjåset et al., 2020). The next section will explore literature for IT and VBHC in more depth.

2.3 LITERATURE REVIEW: IT ARCHITECTURES IN HEALTHCARE

In the previous sections, the definition of VBHC and the strategic agenda to implement VBHC were presented. As highlighted in Section 2.2.1, IT is an important element of VBHC. Therefore, this section will search, analyse and synthesise the literature on IT architectures in the context of (value-based) healthcare.

2.3.1 Search strategy and process

The electronic database *Scopus* was used to search relevant literature on VBHC and IT architectures. Unfortunately, no literature was found using the combination of 'value-based healthcare' and 'IT architecture'. The previous section pointed out that *interoperability* and *data exchange* were hampered due to the fragmented and siloed IT landscape. An initial search was carried out using the following keywords: ((″IT architecture″) OR (″information system architecture″) OR (″enterprise architecture framework″) AND (″data exchange″ OR ″interoperability″) AND (″healthcare″ OR ″medical″)). Only 34 articles were found, which seemed limited considering inclusion and exclusion criteria have not been applied yet.

A second search was conducted without ′data exchange′ and ′interoperability′ to broaden the scope. The following keywords were used to search the literature: *(“IT architecture″) OR (“information system architecture″) OR (“enterprise architecture framework″) AND (“healthcare″ OR “medical″)*. The search provided 191 articles. In addition, some articles were found based on suggestions of PwC experts or from backwards referencing.

Literature types that were included are peer-reviewed articles, grey literature (e.g. reports, non-academic research) and book chapters. The language should be preferably English, however, if the content is highly relevant, then Dutch literature will also be included. Literature is considered to be relevant if it discusses: IT architecture frameworks, design principles and requirements for healthcare information systems, data or information exchange or interoperability. Another important criterion was the publication year. Much research on this topic is originated from the United States. In 2014, 59% of the U.S. hospitals had a basic EHR and very few were able to provide patient online access and share EHR summaries with other providers (Adler-Milstein et al., 2014). Considering the importance of EHR for this research, literature from 2015 and later are included.

Once the search was completed, the papers were selected based on the inclusion and exclusion criteria. The selection process involved four stages. First, the papers were screened on the language and year. 137 articles were excluded. Second, the title and keywords were screened, 27 articles were excluded. However, not all titles and keywords gave a clear understanding of what the author tried to communicate. Therefore, in doubt, an article could be included in the next stage. Third, the abstract, introduction and conclusion were scanned. In some cases, it was found that some keywords such as ′healthcare′ were only mentioned in the abstract, but did not further discuss this topic. The fourth and final stage included screening the full text. From the literature search, 9 articles were included. Additionally, 6 papers from backwards referencing and suggested papers were added, 15 articles were included for the synthesis.

2.3.2 Enterprise Architecture

Zachman (1987) was one of the first that addressed the need for systematic frameworks to design information systems. The paper explained the principles of information systems architecture by analogy using the context of construction. Zachman reasons that the same object can be described differently for different purposes or from different viewpoints. The framework for information systems architecture proposed by Zachman classifies objects into different perspectives and different dimensions. The rows define stakeholders' views and the columns define the abstraction level.

The framework is theoretical and does not provide guidance on the implementation. In addition, the are no relationships between the elements which makes it hard to establish a full overview. Finally, some argue that the analogy with construction is incorrect and that the framework does not rely on any empirical evidence (Gaver, 2010).

After the introduction of information systems architecture, broader and more holistic perspectives on organisational planning began to rise and the term Enterprise Architecture (EA) emerged (Gaver, 2010). In contrast to Zachman, Ross (2003) argues that EA is not only about a detailed design of the firm's processes, data and applications, but rather a tool to align business strategy and IT capabilities. Ross (2003) defines an IT architecture as *"the organizing logic for applications, data and infrastructure technologies, as captured in a set of policies and technical choices, intended to enable the firm's business strategy"*.

Ross (2003) researched competency in IT architectures, which is the ability of an organisation to align their business strategy and IT capabilities. Here, the IT capabilities are the objective of the architecture and specify the behaviour of the architecture. In the case of healthcare, an IT capability could for example include the ability to access the medical data of an individual patient. According to Ross (2003) the logical steps for developing an EA are (i) define the strategic objective, (ii) define key IT capabilities for enabling those objectives, and (iii) define policies and technical choices to enable the required IT capabilities.

Whereas Ross (2003) views EA as an instrument to align business strategy and IT capabilities, M. Janssen (2009) sees EA as the overview of an enterprise as a whole at the current and possible future states. M. Janssen (2009) distinguishes an architecture in descriptive and prescriptive, where the first is an abstraction of the existing infrastructure and the latter is the desired architecture. EA can be used as guidance for design efforts to move from the descriptive state to a prescriptive state. Then, design projects can realise the prescriptive architecture into the Next Generation Infrastructure (NGI).

A commonality in the definitions of EA is that it aims to address architectural elements and the relationships between them at an abstract level (M. Janssen, 2009). Therefore, M. Janssen (2009) follows Janssen and Verbraeck (2005) and defines EA as *"The coordination of subsystems at various levels of abstractions for the purpose of developing the NGI"*. Often a layered approach is used to deal with complexity and to describe heterogeneous subsystems and the relationships between them. M. Janssen (2009) provides an architecture meta-framework that captures the subsystems and dependencies among them in five architectural layers: business, business processes, information, application and technology.

A well-known framework for EA is The Open Group Architecture Framework (TOGAF). The framework provides a structured approach to develop, implement and govern an EA. The Open Group (2018) embraces the definition of an architecture as defined by IEEE: *"The fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution"*. The term "Enterprise" can refer to both a single organisation or an extended enterprise in which partners, suppliers, and customers are included. EA can be used to design the enterprise as a whole or to design specific areas of interest (The Open Group, 2018).

Similar to Janssen's meta-framework, it uses a layered approach to deal with complexity by describing the elements and subsystem at different abstraction levels. The Open Group (2018) uses the following architecture layers:

- Business architecture includes the business strategy, governance, organisation and key business processes.
- Data architecture describes the structure of storage, maintenance and management of data artefacts. This includes logical and physical data models.
- Applications architecture describes the applications that deploy application services in order to serve the business processes and realise business goals.
- Technical architecture includes the software, hardware and infrastructure that are required to deploy the business, data and application services.

2.3.3 Enterprise Architecture in Healthcare

Da Luz Júnior, Silva, Albuquerque, Medeiros, and Lira (2020) conducted a systematic literature review to capture the state-of-the-art literature on EA in healthcare systems. The authors analysed and synthesized 46 studies. It was found that EA positively impacts healthcare systems in, for example, describing and categorising the architecture and business process, organisational structure and data to facilitate information acquiring. EA was, not surprisingly, applied mostly in the context of hospitals. The application of EA in healthcare faced several barriers including: (i) Complexity of health environments; (ii) Obtaining and integrating data of various kinds; (iii) Different stakeholder interests and communication problems; and (iv) No clear definition of the business objectives, goals, processes.

It was found that TOGAF was the most applied framework and Archimate the most used tool for the development of the architecture (Da Luz Júnior et al., 2020). Moreover, TOGAF is not only the most common framework but according to a study of Haghighathoseini, Bobarshad, Saghafi, Rezaei, and Bagherzadeh (2018) also the most appropriate framework to apply in hospitals.

In the Netherlands, there are several institutions that develop and maintain reference architectures. Three applicable reference architectures for this study are presented in Table 2.1. The Dutch Government's reference architecture, Nederlandse Overheid Referentie Architectuur (NORA), is a high-level reference architecture for public information systems in the Netherlands. NORA's objective is to ensure collaboration and seamless information exchange across different public contexts. NORA formulated 10 basic principles and 44 derivative principles for developing information systems in the public domain (NORA, 2019).

The so-called ‘daughters’ of NORA represent domain-specific architectures. *Ziekenhuis Referentie Architectuur (ZIRA)* is a daughter architecture that is concerned with architectures for hospitals. Other domain-specific architecture in healthcare focus on public health (PURA) or long-term health (LIDA). Another daughter is the *AORTA architecture* and describes the national infrastructure for information exchange in Dutch healthcare. Information exchange is established using standardised messaging over the AORTA network with a central intermediary (LSP).

Table 2.1: Reference architectures for the Dutch healthcare

Architecture type	**Name**	**Description**
Foundation architecture	NORA	Reference architecture for governmental information systems in the Netherlands.
Domain specific Architecture	ZIRA	The ZIRA is a reference architecture that is based on a collection of models for structuring and sharing information in Dutch hospitals. ZIRA is based on the layered framework of Nictiz.
Organisation specific architecture	AORTA	Dutch national infrastructure for the exchange of data between healthcare providers. The infrastructure specifications include a description of technical, organisational as well as implementation aspects.

2.3.4 Design Principles and Requirements

The design efforts of an EA can be guided by design principles and requirements. Although there is no uniform definition of a principle (Bharosa & Janssen, 2015), most articles describe principles as ‘general rules’ or ‘guidelines’ (M. Janssen, 2009; The Open Group, 2018). Bharosa and Janssen (2015) discuss the importance of design principles and follows the definition: *“normative, reusable and directive guidelines, formulated towards taking action by the information system architects”*. A principle-based design is especially useful in socio-technical contexts where it is hard to formulate problems in an explicit way (Bharosa & Janssen, 2015).

The Open Group (2018) explains that principles must reflect the business objectives and key architecture drivers. Components of well-defined architectural principles are: (i) name, (ii) statement, (iii) rationale and (iv) implications. For each architecture layer, architectural principles can be defined and positioned (M. Janssen, 2009). However, too many principles should be avoided as it may reduce the flexibility of the design efforts.

Bharosa and Janssen (2015) argue that principles are not intended as rules or blueprints that have to be strictly followed. Instead, principles should provide guidance towards solutions. Requirements, on the contrary, state what the architecture should or must adhere to. Requirements are often derived from individual stakeholder needs and preferences, and, therefore, could contradict with other requirements (Bharosa & Janssen, 2015). According to M. Janssen (2009) should contain trade-offs. For instance, a trade-off in the healthcare context could be the preference for a high level of privacy over traceability.

Ilin, Levina, Lepekhin, and Kalyazina (2019) studies the business requirements of an IT architecture in healthcare. In light of the digital transformation, identifying the business requirements correctly are key to a successful implementation of IT projects. In addition, unlike other authors, Ilin et al. (2019) recognise the transition towards a value-based and personalised healthcare system. Ilin et al. (2019) uses EA because it harmonises business and IT. Ilin et al. (2019) reviewed the goals of VBHC and identified the following business requirements for healthcare organisations:

- Health and Patient Support Information: Information must be organised around medical conditions, provide insight on providers and treatment methods, and supports the patient in choosing a provider. Further, information provision and interaction with the patient should be established through the full cycle of care.
- Restructuring of Relations with Medical Service Providers: Information exchange must be established for the purpose of adding value to the provided care. Healthcare professionals must be stimulated to add value to innovation.
- Redefining Contracts, Transactions, Billing, and Pricing: Contracts between providers and insurers must be established for multiple years. Further, administration and transactions should be simplified and standardised or eliminated.
- Patient Medical Records: Services to aggregate, update and verify medical records.

In another study, Ilin, Lepekhin, Ershova, and Borremans (2020) provided principles focused on the application and technology layer which can guide the development of an IT architecture. This article takes again the digitisation and the transition to VBHC and PCC into account. The following principles are suggested:

- Rely on reference architectures: building an EA is a difficult task and one should consult reference architecture developed by specialists.
- Both internal and external equipment must be integrated: medical equipment within the hospitals, but also wearable devices should be integrated into the IT architecture. A higher volume of data is collected which enables higher personalised treatment and contributes to patient-centredness.
- Maximise system integration: systems should be connected and integrated to allow efficient information exchange. That facilitates business processes to deliver patient-centred care without additional administration.
- Data should be secured to the maximum level: roles should be declared and customised, the system should be able to isolate from the 'outside' world without interrupting the interaction with other systems used in the landscape.

Ilin et al. (2020) suggest integrating the principles into the IT architecture and propose to systematically design the architecture using the Architecture Development Method (ADM) of TOGAF. The business requirements and principles seem to be derived from Porter and Lee (2013). For instance, 'health and patient support information' suggest that information should be adding value for the patient's care process and could be linked to Porter's first IT criteria *'be patient-centred'*. Although all the principles are explained logically and connections to VBHC can be made, there is no scientific evidence that these support these principles. This makes it rather difficult to determine the validity of the principles.

2.3.5 Interoperability and integration

The Open Group argued in a white paper that patient-centred and value-based healthcare depends on interoperability (The Open Group, 2016). Interoperability enables actors to be provided with a flow of information within and across healthcare systems. The underlying IT infrastructure allows data exchange across Healthcare Information System (HIS), and is a prerequisite for VBHC as outcome measurement highly depends on the availability of clinical data.

Peng et al. (2019) researched the literature on heterogeneous health data integration as well as the methods of utilizing the integrated health data. Healthcare data integration is defined as *"data from heterogeneous or distributed sources processed by a certain approach to act as they come from one source in a seamless way"*. Figure 2.2 shows different data sources on the left side, for example, an EHR and wearables, data integration, and, on the right side, the utilisation of integrated data for different purposes.

There are several purposes for which data integration is necessary. For example, general health information management, chronic disease management and health/lifestyle management (Peng et al., 2019). Also for the purpose of VBHC, data integration is needed to be able to monitor the health status of the patient. Moreover, integrated data could be utilised by multiple actors, such as patients themselves, referrers, or for clinical research.

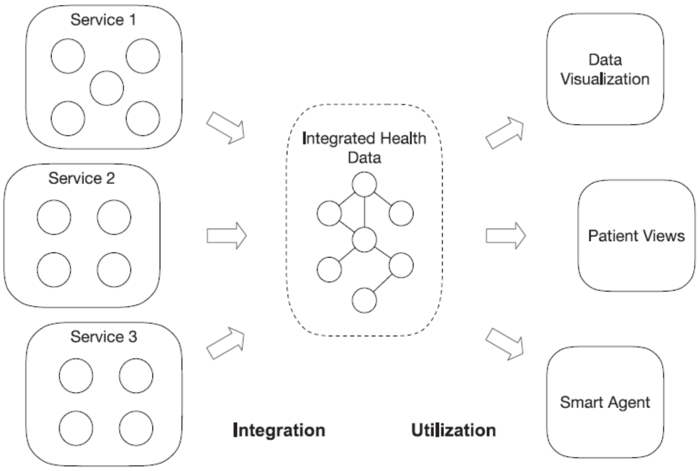

Figure 2.2: Schematic overview of data integration and utilisation. Adopted from Peng et al. (2019).

A prerequisite for integration is *interoperability*. Peng et al. (2019) categorises interoperability in three different types: *Foundational interoperability*, which is the technical ability to exchange data, *Structural interoperability*, which allows for data exchange in specific formats to interpret the syntax of the data, and *Semantic interoperability* which allows for data exchange, meaningful interpretation and usage.

Peng et al. (2019) classify three health data integration approaches: (i) APIs with manual alignment, (ii) Semantic Web (iii) Platforms, and five utilisation approaches: (i) Database, (ii) API, (iii) Semantic Web, (iv) Application platform and (v) Composition.

The literature review concluded that there are two main challenges for health data integration. First, one is to call various services for aggregating data. A suitable approach mentioned is the *Web API*, because it is platform-independent. However, using Web

APIs to call various services might be much effort and time-consuming. Therefore, a combination with Semantic Web Technologies Semantic Web Services may increase efficiency. Second, the way to integrate the aggregated data in an effective way is a challenge. Peng et al. (2019) mentions standardisation or Semantic Web technologies as possible solutions to alleviate the problem. However, these solutions have some limitations as the first is costly and probably will not match the specific wishes and needs, while the latter may bring only more complexity and inefficiency. The paper concludes that there is a trade-off between flexibility, efficiency, interoperability and standardisation. The combination of *Web service technologies* and *Semantic Web technologies* has the potential to balance these trade-offs best.

Garai, Pentek, Adamko, and Nemeth (2017) demonstrate a prototype for clinical research using smart-device body sensors. An interoperability scheme was used to connect HIS, telemedicine and e-health devices. The authors propose a hybrid cloud-based Open Telemedicine Interoperability Hub (OTI-Hub) to interconnect these. The receiver module uses *Web APIs* to obtain the data, and subsequently, the transformation module transforms this data into an *HL7* format. Then, the most important module, the integration module, offers a data exchange future to export data from telemedicine to external systems by using *REST API* endpoints. Garai et al. (2017) tested the OTI-hub prototype using data from spirometry and cardio sensory and imported, interpreted and presented it successfully into the HIS. To conclude that interoperability between HIS, e-health devices and telemedicine is possible. However, this research only investigated one-way from e-health devices and telemedicine into HIS.

The prototype uses a hybrid cloud approach, where patient's medical data is stored privately and the public cloud deals with processing the transaction capacity. Although a hybrid solution enables such a solution to keep medical records private and assures scalability, the engineering faces quite a challenge as many elements need to be synchronised (Garai et al., 2017).

Almodovar (2015) researched the data accessibility of information systems architecture in healthcare organisations. An information system is defined as a collection of data, processes, people, and information technology that interact to acquire, process, store, and transmit an output (data or information) to achieve organisational goals (Almodovar, 2015). Typically, for HIS, there is a distinction between administrative systems and clinical systems. A healthcare record should at least be able to: collect information, outcome management, medidcation management, decision support, communication services, administrative services, patient support and population health management (Almodovar, 2015).

Almodovar (2015) describes three different information system structures: multiple non-integrated applications, enterprise-wide integrated system and a hybrid approach. Whereas the non-integrated system is flexible and can be customised, the enterprise-wide system is more standardised. Regarding data management, a non-integrated approach has the disadvantages of data in multiple places and needs to be integrated with interfaces (using web-based applications). The enterprise-wide system uses a common database and is easier to access across different departments.

2.3.6 Related Architectural Designs in Healthcare

In Germany, a research consortium called Smart Medical Information Technology for Healthcare (SMITH) researches Data Integration Centers for healthcare. Winter et al. (2018) provided insight into the architectural design components of these centres. The design is based on the Reference Model for an Open Archival Information System (OAIS). SMITH aims to build a medical network in which HIS and data integration centres of participating hospitals are connected. The tasks of the data integration centres are to ingest data and nourish data. The (unstructured) data is ingested from the local EHR and then stored into the local Health Data Storage of the integration centre. Then data nourishing adds value to the ingested data. For data sharing, widely adopted communication (IHE profiles, HL7 CDA, HL7 FHIR) and terminology standards (SNOMED-CT, LOINC) are used to achieve semantic interoperability.

Osei-Tutu and Song (2020) propose an enterprise architecture that supports Healthcare Information Exchange (HIE) migration to the cloud for the facilitation of timely health data sharing. In HIE, there are external healthcare entities (e.g. other HIEs, research institutions) and healthcare providers. Both users can update and request medical data. The components of a HIE include: (i) an interface, (ii) patient indexing (i.e. mapping data), (iii) notification services, (iv) a portal and (v) analytics (i.e. transforming data into information). Cloud services are leveraged by using patient and provider databases as a web storage service. After fully functioning databases, the clinical data repository and cloud computing capabilities are migrated. After cloud migration, Osei-Tutu and Song (2020) argues that a cloud-based clinical data repository allows for real-time notifications and analytics.

2.4 SUMMARY BACKGROUND AND LITERATURE REVIEW

In this chapter, the background of value-based healthcare (VBHC), the relationship to IT and IT architectures in healthcare were discussed. Conducting a systematic literature review answered subquestion 1: *"What is the state-of-the-art literature of IT architecture in the context of healthcare, and VBHC?"*. This section provides a summary.

While VBHC is getting widely adopted across the Dutch healthcare providers, insurance companies and the government, the implementation faces some barriers (Mjåset et al., 2020). One of the most important steps of the strategic framework of Porter and Lee (2013) is a supporting IT system. The fragmented IT landscape impedes interoperability between providers, insurers and patients, which is a prerequisite for outcome and costs measurement. Moreover, a lack of interoperability causes administration overhead duplicated medical interventions and reduces the quality of clinical care (Gordon & Catalini, 2018; The Open Group, 2016).

Enterprise Architecture (EA) is an instrument to align business strategy and IT capabilities (Ross, 2003). In EA, the business goals are achieved by organisational policies and business processes that are served by applications and technology infrastructures. An EA can be seen as an overview of the enterprise at various abstraction levels at the current and desired future state (M. Janssen, 2009). EA provides opportunity to deal with complexity and is a suitable approach to use in healthcare (Haghighathoseini et al., 2018).

Despite the importance of the IT element in VBHC, little research is conducted on the implementation (Alnofeye et al., 2019). In addition, research queries to *IT architecture* and *value-based healthcare* provided little articles, emphasizing the gap in the literature. Porter and Lee (2013) provided six basic criteria for IT systems to be value-enabling. Ilin et al. (2019) provided business requirements and Ilin et al. (2020) principles for IT architectures to support PCC and VBHC. The requirements and principles are however quite general. Although the reasoning seems sound, evidence for the requirements and principles lacks which makes it rather difficult to determine the validity.

Although little research was found for the specific purpose of VBHC, much research could be found on data exchange, data integration and interoperability in healthcare, which complies with some of the basic criteria of Porter and Lee (2013). The Open Group (2016) argues that the outcome measurement highly depends on the availability of clinical data and interoperability a prerequisite is for VBHC. Peng et al. (2019) research the literature on heterogeneous health data integration and methods to use integrated data. For seamless integration of health data, a certain level of interoperability must be established. According to Peng et al. (2019), there are trade-off when choosing ways to integrate health data. The combination of Web service technologies and Semantic Web technologies has the potential to balance these trade-offs most optimal.

There is a noticeable gap in the state-of-the-art literature about how IT should be designed for the purpose of value-based healthcare. From the literature it can be concluded that interoperability between information systems is one of the barriers for value-based healthcare. However, there are no specific architectural designs on value-based healthcare or its components. There is a need to identify what the components are for an enabling value-based IT architecture. This would contribute to unlock the potential of VBHC in the Netherlands.

3 METHODOLOGY

This chapter presents the methodology to answer the research questions. First, a short recap of the research design, as presented in Chapter 1, is provided. Subsequently, the methodology for both the exploratory research and design research is described. Finally, the research methods for data collection are presented.

3.1 FRAMEWORK FOR RESEARCH DESIGN

In Chapter 1 the research design of this study was briefly introduced. This study applies a Design Science Research (DSR) method which is focused on the design product. A risk of DSR is to prioritize building and evaluating the IT artifact, while, on the other hand, behavioural science may focus too much on the context and fails to identify the technological elements. A combination of both paradigms is fundamental when creating an IT artifact. To mitigate the risk, the conceptual framework of Hevner et al. (2004) is adopted. Figure 3.1 illustrates the framework.

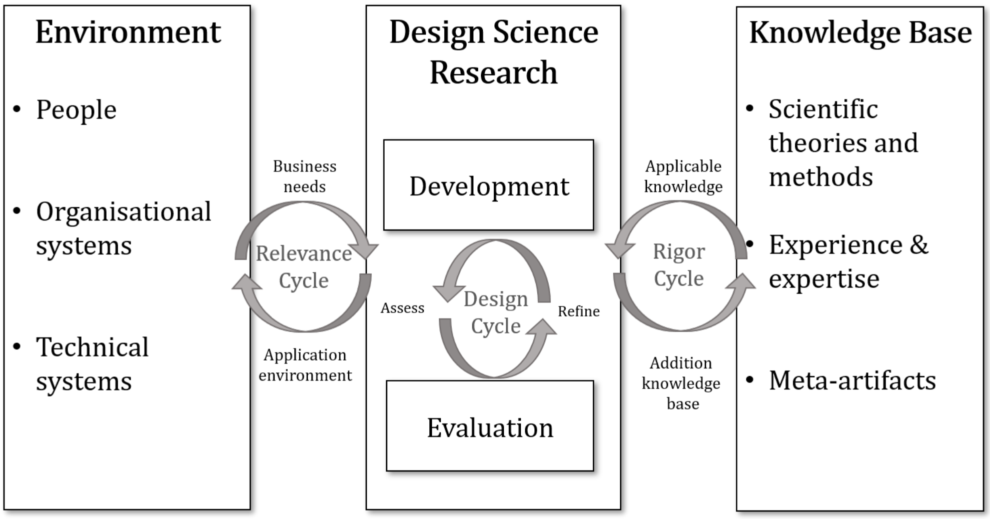

Figure 3.1: Framework for Design Science Research. Adopted from Hevner et al. (2004).

The relevance in the artifact is established by the contextual environment, which includes people, organisational systems and technical systems. Rigour in the artifact stems from the knowledge base of scientific theories, methods, expertise and meta-artifacts. The business needs and applicable knowledge both serve as input for the design science activities. At the core of the framework, there is the development of the artifact and the evaluation. The design activities iterate between development and evaluation. Finally, the artifact is applied to the environment and the knowledge is added to the knowledge base.

3.2 RESEARCH METHODOLOGY

The literature review provided some useful insights into the state-of-the-art literature on IT architecture and VBHC. The scientific theories, methods and meta-artifacts are used as input to start the Rigor cycle as shown in Figure 3.1. To fill the identified knowledge gap, this study aims *"to identify and design the essential components for a value-enabling IT architecture for the Dutch healthcare system"*. The literature review positioned the research and is the starting point for this research.

3.2.1 Exploratory Research

According to Hevner (2007) proper design science research often starts by identifying problems and opportunities in the actual environment. An exploratory research approach answer subquestion 2: *How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?*. The environment consists of people, organisational systems and technical systems (Hevner et al., 2004). A thorough understanding of the current situation identifies problems that are currently faced in the transition towards VBHC. The following steps are carried out to explore the problem.

First, the people and organisational system are described. A stakeholder analysis will be conducted to determine stakeholders' interests and power in the VBHC transition. Second, the as-is situation of the technical systems will be described. This can be used to analyse the weaknesses and opportunities (M. Janssen, 2009). For the technical systems, the *Layer Framework* of Nictiz will be adopted to describe the current situation. The layers are organised as follows:

1. Organisation
2. Care processes
3. Information
4. Application
5. IT-infrastructure

A gap analysis will be executed to pinpoint the deficiencies in the as-is situation. Finally, preliminary interviews will be conducted. Although some barriers can be identified from the environmental analysis, an in-depth understanding can be derived from the perceptions of healthcare experts. These perceptions are essential for successful design efforts as they determine the criteria for an appropriate design. The interviews will be analysed using ATLAS.ti. In Section 3.3 the research methods and analysis are discussed in more detail.

3.2.2 Design Science Research

The results of the exploratory research will be the starting point for the design activities. A second round of interviews will be conducted to obtain requirements and design principles to create a design space for the components. Subsequently, the identified gaps are aimed to be fulfilled by the design research activities. Like the as-is architecture, a *layered approach* will be used to guide the design and identify what components should be incorporated to facilitate VBHC. The steps for the design activities are inspired by ADM of The Open Group (2018) and described shortly below.

Architecture Vision

The architecture vision describes the capabilities, goals, and strategic objectives of the target architecture. Normally, an EA will be developed for a specific enterprise. However, since this is not the case for this study, the architecture vision will focus on the generic capabilities, goals and objectives for a value-based architecture. The stakeholders, requirements and principles derived from interviews and analysis are described.

Organisation

The highest level of the layered model is the organisational policy layer. Here the business strategy, governance, and organisation are outlined. Since the architecture is generic, the elements will be described at a general level. Components are proposed to fulfil the gaps to enable a transition to VBHC.

Processes

Business processes can be divided into management processes, operational processes and supporting processes (M. Janssen, 2009). The key business process in healthcare organisations is the care process. Components will focus on improvements in the processes, for example, efficiency or time, or lacking elements for VBHC.

Information

The information architecture describes the data artefacts which are involved in the application architecture. By selecting viewpoints from the different stakeholders involved, it should be understood how data is created, maintained, transformed and reused in other applications.

Application

The application architecture describes the information assets that store, process, reuse, and distribute information within and across the enterprise to fulfil the end-users needs (M. Janssen, 2009). The application architecture identifies the dependencies of the end-users to the applications.

IT-infrastructure

The IT infrastructure is the underlying layer of the architecture. It describes the structure and interaction of technology services and components to support the information systems layer and care processes to achieve the organisational goals. For this study, this layer will look at the opportunity of integrating emerging technologies.

3.3 RESEARCH METHODS

This research is exploratory in nature and therefore uses qualitative research methods to answer the research questions. Research methods that will be used are: literature review, semi-structured interviews and an expert panel for validation of the artifact.

3.3.1 Literature review

A critical literature review is essential to conduct to become an expert on the topic (Sekeran & Bougie, 2016). Reviewing the literature involves selecting, analysing and synthesising relevant literature to identify relevant theories, methods, meta-artifacts and related work. Literature can be selected from books, academic journals, reports, theses, conference proceedings or newspapers (Sekeran & Bougie, 2016). The literature review has been presented in Chapter 2 and provided the research with (i) state-of-the-art literature on IT architecture in healthcare and (ii) an overview of VBHC.

3.3.2 Semi-structured interviews

A structured interview is a qualitative research method to collect data from an expert using a predetermined list of questions. For this study, interviews will be conducted in a semi-structured way, which allows the researcher to guide the interview in certain directions, but leaves room for other perspectives, ideas and topics (Sekeran & Bougie, 2016). The interviews will be divided into two phases and have different objectives. The objectives and eligible participants are presented in Table 3.1.

Table 3.1: Overview of semi-structured interviews, objectives and participants

Interview	Objective	Eligible participants
Preliminary interviews	General interview to understand the situation, identify the problems and solutions	Clinicians and health managers, experts in VBHC, consultants in healthcare, IT specialists in healthcare
In-depth interviews	Capture principles, requirements and components for value-based healthcare IT architecture	Experts in VBHC and implementation, and/or IT in healthcare.

Preliminary interviews

The preliminary interviews will be broad interviews and have two objectives: (i) to gather in-depth information about the current situation and problems, and (ii) to explore the business needs for a possible solution. In Appendix E, the interview protocol can be found.

In-depth interviews

The goal of the interview is to derive practical experience and best practices. The components that were found to be hampering the transition to VBHC in the exploratory research phase will be used as a focal point for the in-depth interviews. Requirements and design principles will be captured for the design activities. In Appendix F, the interview protocol can be found.

Data Analysis

Rigour in the design is often assessed by adherence to appropriate data collection and analysis techniques (Hevner et al., 2004). The interviews will be recorded with the consent of the interviewee. The interviews are transcribed manually in a light edited form, also referred to as ‘intelligent transcriptions’. In the transcriptions, meaningless expressions such as ‘uh’, or ‘hmm’, pauses and repetitions will be omitted. For the interviews, intelligent transcriptions are suitable because the meaning of what was said is more important than the exact wording or non-verbal expressions. The transcriptions are included in a separate appendix and can be provided upon request.

Data analysis is the process of reducing the amount of collected data to allow for interpretation. Coding is an analytic process in which labels are attached to data which organises the amount of data into categories (Corbin & Strauss, 1990). Data analysis will be carried out with the computer-assisted qualitative data analysis software ATLAS.ti. First, all transcriptions are uploaded to ATLAS.ti and each of them is read through again. Interesting segments of data are marked with the quotation tool. Each quotation will be renamed or given a comment so that later the data can be retrieved and reviewed easily. Second, the quotations are openly coded. Open coding often generates many codes. Therefore, third, the number of codes will be reduced by merging codes and creating overarching categories. Fourth, the network tool will be used to establish connections between the categories. This offers new insights and relationships among the codes and categories, resulting in another round of merging codes. Finally, there will remain several core categories.

3.3.3 Expert Panel

Evaluation is an essential step in design science research. The selection of evaluation methods must be matched appropriately with the designed artifact and the selected evaluation metrics (Hevner et al., 2004). For the evaluation of the components, *descriptive evaluation methods* will be used because other forms of evaluation are not feasible because the components are not simulated or applied in the environment.

An expert panel is a composed group of people specifically that have expertise and opinions about a topic (Sekeran & Bougie, 2016). The group will be composed of people preferably from the semi-structured interviews to evaluate the architecture. The experts who are eligible are (i) experts in VBHC and/or healthcare management, (ii) experts in IT systems and data exchange (preferably in healthcare) and (iii) experts in designing EAs. The expert panel session aims to obtain experts' thoughts, opinions and feedback on the presented components. To elicit these aspects, the researcher will act as a moderator and steers the discussions with questions.

Procedure

The session follows a scripted procedure. A detailed overview of the procedure, including topics discussed and time, is presented in Appendix G. The expert session is organised as follows. First, the researcher introduces the topic, the problems found in the literature and the semi-structured interviews. The architecture vision is explained and to confirm whether the experts understand the objectives of the model, the experts are invited to start the discussion on the suitability of the proposed solution. Second, the components will be presented and the researcher asks the experts for their general thoughts and opinions on the architecture. Hereafter, every layer of the architecture will be discussed in more detail. Finally, the session is wrapped up and the researcher asks if the experts have any additional questions or feedback regarding the architecture or the research.

4 ANALYSIS: ENVIRONMENT

This chapter provides an analysis of the current situation. The environment provides relevant information about the current situation and consists of people, organisational systems and technical systems (Hevner et al., 2004). First, the organisation of the Dutch healthcare system is described. Second, the people are described and analysed using stakeholder analysis. Third, the technical systems are described according to the Layered Framework of Nictiz. Finally, a gap analysis is conducted to identify which components of the as-is architecture hamper VBHC.

4.1 ORGANISATIONAL SYSTEMS

The Dutch healthcare landscape can be described as a complex system wherein many actors are involved. In 2006, the healthcare structure was reformed and the term *regulated competition* was introduced. Kroneman et al. (2016) categorises the healthcare system in three markets as illustrated in Figure 4.1.

- **The healthcare purchasing market.** In this market, health insurers purchase healthcare services from healthcare providers. Contract negotiations include agreement on price, volume and quality of care. Healthcare insurers selectively contract providers based on their services, costs and quality.
- **The health insurance market**. Insurance companies are obligated to offer the basic insurance package as composed by the government. In addition, insurers can offer additional packages, for instance, a dentist package. Dutch citizens can choose an insurance company and insurance plan which they feel fits their needs best. It is worth noticing that insurance companies cannot reject anyone for the basic insurance package and they are not allowed to adjust premiums based on health status or risk.
- **The healthcare provision market**. The provision market offers patients the opportunity to consume care services by a provider of choice. Every Dutch citizen is listed at a practice of a General Practitioner (GP). The GP acts as a gatekeeper and refers patients with specific conditions to a medical specialist.

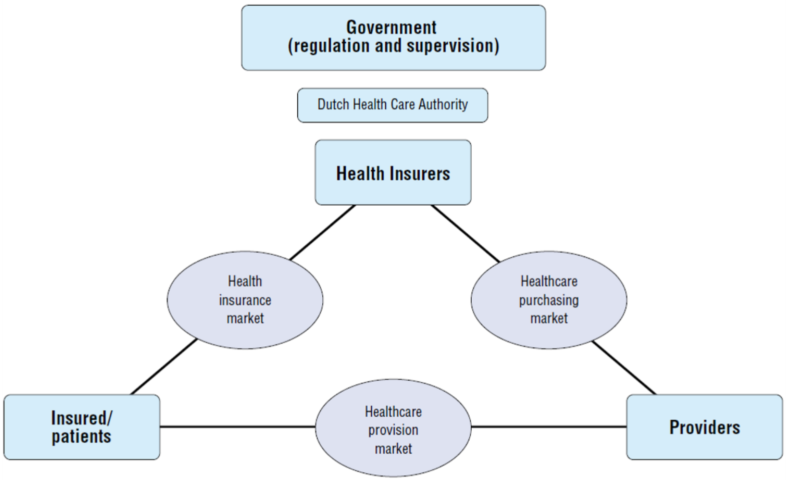

Figure 4.1: Actors and markets in the Dutch healthcare system for curative care. Adopted from Kroneman et al. (2016).

Freedom of choice is essential for regulated competition to work properly. Being insured is obligated, but the type of insurance plan and the insurance company is free to choose for the patient. Moreover, the patient is free to visit any healthcare provider they want. Patients should be able to critically assess insurers and providers based on information about quality, costs and availability. In reality, only a little information on quality is available. Kroneman et al. (2016) argues that there is a lack of reliable quality indicators that are available to citizens.

4.2 PEOPLE

The *People* in the environment are described using stakeholder analysis. A stakeholder analysis is indispensable when researching a problem in a multi-actor environment because it allows finding ideas feasible and worth implementing (Bryson, 2004). As mentioned in the Chapter 1, this research is limited to curative care. Hence, only stakeholders involved in the curative care will be taken into account for the environmental analysis. This section will discuss the stakeholders, their role, interest in VBHC and the power to initiate change. A comprehensive overview of all stakeholders can be found in Appendix D.

A power-interest grid is a well-adopted approach to identify stakeholders, their interest in the problem and the power they can exercise. The stakeholders can be divided into four categories: *players* having high interest and power, *context setters* having little or no interest but high power, *subjects* having a high interest but little power and, finally, the *crowd* having both little interest and little power (Bryson, 2004). Figure 4.2 presents the power-interest grid for the case of VBHC implementation.

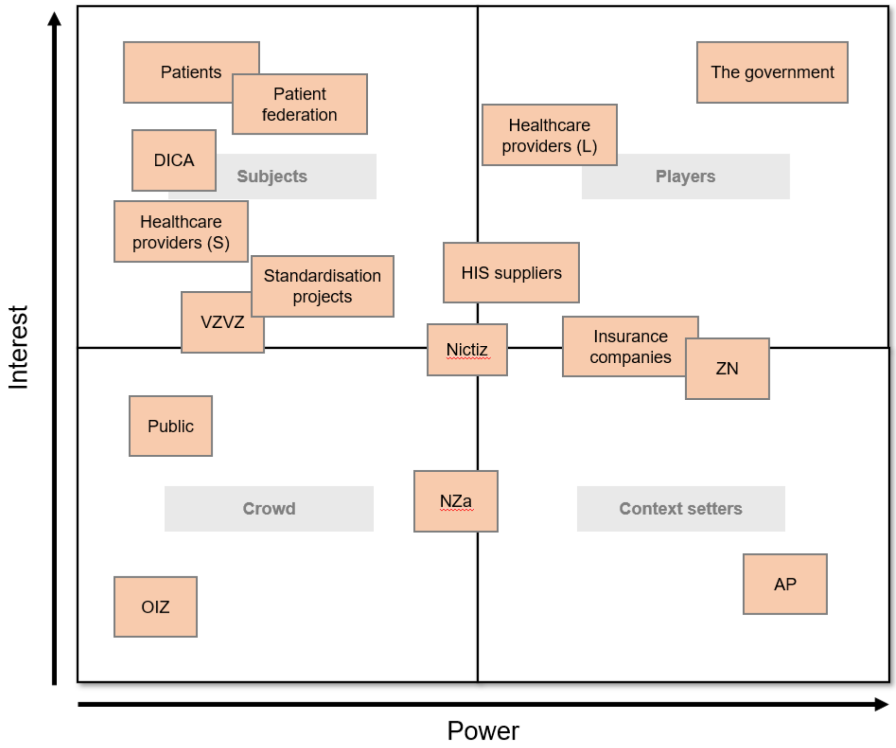

Figure 4.2: Power-interest grid for transition to VBHC

Players

The government, large healthcare providers (e.g. academic hospitals), insurance companies and HIS suppliers are stakeholders that all have medium to high interest and power. The *Government* is an important player because it has the authority to develop policies and enact them. Since the healthcare structure was reformed and regulated competition was introduced in 2006, the role of the government has changed and now regulates and supervises the market. The ambition of the government is to provide high-quality care that is affordable and accessible to every citizen (Ministry of Public Health & Sport, 2016). The government has a high interest in VBHC and launched a governmental programme in 2018 (Ministry of Public Health Welfare and Sport, 2018a).

The *health insurers* are responsible for purchasing and remunerating all curative health services covered by basic health insurance (Kroneman et al., 2016). The core responsibility of an insurer is to purchase care services with a proper balance between quality and price. Whether reimbursement models are based on value or volume, their main interest is to have *low costs*. Controlling costs based on volume is far easier then on outcomes as metrics are straightforward and unambiguous. Nevertheless, some insurers such as Menzis, Zilveren Kruis and VGZ are experimenting with value-based reimbursement models (Mjåset et al., 2020). Insurers and overarching interests groups like Zorgverzekeraars Nederland (ZN) do have an essential role in a transition to VBHC as positive financial incentives are required to move away from the volume-based services. It is likely that not all insurers are willing to adopt VBHC and innovative financial schemes because it is uncertain if the benefits will outweigh the investments. Therefore, ZN has a capricious attitude towards VBHC and even can enact blocking power to prevent such a transition.

Technology and information systems are indispensable in healthcare. *HIS suppliers* provide the information systems that clinicians interact with on a daily basis. A transition to VBHC is dependent on the implementation of value-enabling functionalities such as easy to extract information and encompass various data types (Porter & Lee, 2013). Therefore, HIS suppliers have medium to high power. In addition, they have medium to high interest in a transition to VBHC because if they are able to introduce a value-enabling IT system early, they can reap the benefits of being the first mover.

Most *healthcare providers* are interested in providing patient and value centred care. While both providers aim for high-quality care, there is also an interest in a positive business case. In a regulated market, healthcare organisations are profit-oriented after all. It should be recognised that there is a discrepancy between larger and smaller organisations. Often smaller institutions do not have the resources to facilitate research or invest in innovations. A transition towards value-based healthcare is therefore not likely to be initiated by smaller providers, but rather in a collaborative network. If a transition towards VBHC is not rewarding in terms of money or time providers are expected to lose interest. Finally, it is worth mentioning that for some healthcare providers it might be beneficial not to move to a performance-based funding scheme because they do not have outstanding outcomes. Without any enforcement, such parties are not likely to engage in a transition to VBHC simply because of loss of revenue.

Subjects

For *patients* and *patient federations*, there is a high interest in personal, value-based healthcare. Ultimately, their objective is high-quality care to achieve their envisioned healthcare status. Patients want to be more in control of their own patient journey and be involved in the decision-making. However, their power to make decisions is considered to be limited. The government acts on behalf of the public and realises these wishes and needs in a governmental programme 'shared decision-making' (Ministry of Public Health Welfare and Sport, 2015).

Other stakeholders that are involved with *standardisation projects* or facilitating data exchange (VZVZ) do not have a direct interest in VBHC, but rather improving information exchange and enable outcome measurement. These stakeholders are considered to have limited power to initiate change to move to VBHC.

Crowd

The Dutch citizens, the general *public*, is an important stakeholder as decisions in the healthcare system affect all. For instance, rising premiums for basic insurance due to rising expenditure. Similar to patients, individual citizens have low power. It is assumed that the public has less interest in VBHC if there is no demand for care.

Context setters

Context setters have little to no interest in a transition to VBHC, but have the authority to withheld decisions and policymaking. All stakeholders categorised in this quadrant are public bodies delegated by the government. One of the authorities is the *Nederlandse Zorgautoriteit (NZa)* which has a crucial role to supervise and regulate the healthcare markets. The NZa has significant power because they can impose obligations to the providers and insurers or adopt regulations. Other stakeholders that supervise compliance with law and regulation are the Data Protection Authority (Dutch Data Protection Authority (DPA)), *Health Care Inspectorate (Inspectie Gezondheidszorg, IGZ)* and *the National Healthcare Institute (ZiNL)*. These stakeholders do not necessarily have a positive or negative interest in VBHC, however, as mentioned previously, it is much easier to supervise and enact on unambiguous metrics such as volume.

Conclusion Stakeholder Analysis

From the stakeholder analysis, it can be concluded that VBHC needs support from the government, (large) healthcare providers, insurance companies and overarching interest groups and HIS suppliers are required. HIS suppliers have to facilitate the clinicians with supporting IT systems. Although patients and patient interest groups may have little power and resources, they should be consulted to successfully implement VBHC. Although many stakeholders have a positive attitude towards VBHC, some organisations (i.e. providers and insurers) will lose revenue with an outcome-based funding scheme. If the rewarding do not outweigh the costs, such parties would not participate or even block a transition.

The government has an important role as a policymaker VBHC but also as a facilitator. From the government's side, there is a positive attitude towards VBHC and has the power to realise a transition by imposing laws and regulations upon market players. Furthermore, the government can stimulate stakeholders with a negative attitude towards VBHC with, for example, subsidies.

4.3 TECHNICAL SYSTEMS

In order to define which components of the currently hamper VBHC, a generic architecture of the current situation will be described and analysed. The reference architecture from the Dutch society of hospitals hereafter called the ZIRA (in Dutch: Ziekenhuis Referentie Architectuur) is the architecture reference framework for Dutch hospitals and is based on the 5 layer model of Nictiz. These layers are: Organisational policy, Care process, Information, Application and IT-infrastructures. The layered model is depicted in Figure 4.3. First, each layer will be described. Second, a gap analysis will be performed to pinpoint the deficiencies in the current architecture.

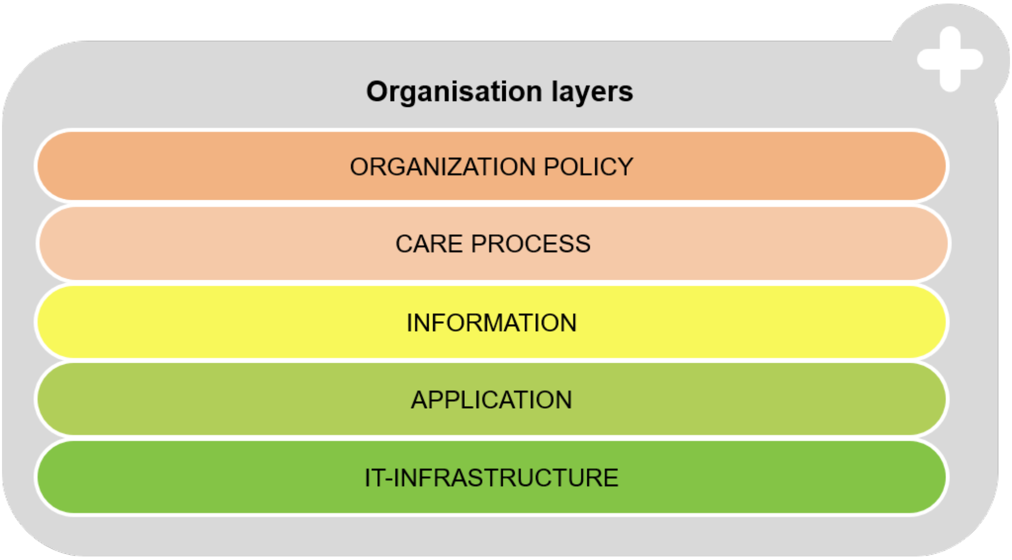

Figure 4.3: Layered model of Nictiz. Adopted from Meijboom and Klein Wolterink (2020)

4.3.1 Organisation policy

The organisation level is the highest level in the layered model of Nictiz and relates, together with the care processes, to the business architecture. The relationship between the actors and elements are presented in Figure 4.4.

Business objectives

The objective of healthcare organisations is to provide high-quality care services in an efficient and convenient way. ZIRA developed five basic architectural principles and are inspired by the principles of other reference architectures such as Duurzaam Informatiestelsel in de Zorg Referentie Architectuur (DIZRA) and NORA. The basic principles are:

1. Patient's value comes first
2. Hospitals collaborate closely together
3. Clear and one-time data recording
4. Information provision is flexible, safe and sustainable
5. Quality can be derived from the care process

Actors

The following actors considered are for the architecture: patients, providers, insurers, quality registration and the government. For simplicity, other actors will be outside the scope of the analysis. A description of the roles and responsibilities can be found in section 4.2.

Business services

This study limits the business services to curative care services. Services include physician and nursing care, surgery, medications and therapies.

4.3.2 Care processes

A key business process in healthcare is the curative care process. The process is triggered to start when someone is in need of healthcare services. For simplicity, curative care is divided into four subprocesses:

- Intake & Diagnosis: The letter of referral will be analysed and an intake appointment with a specialist will be scheduled to diagnose the patient. The physician will collect relevant medical information about history and complaints in the consultation. The physician will analyse the information and provides the patient with a diagnosis.
- Treatment plan: The physician will analyse the medical record and diagnosis and proposes a treatment plan to the patient. In light of law and regulations (i.e. Wgbo), the physician must inform the patient about the interventions and possible risks. The patient has to give the physician permission to start the treatment. This is also known as *informed consent*.
- Treatment: Clinicians provide care services to the patient. For instance, an operation, therapy or medical treatment. Dependent on how the process is designed, the progress will be evaluated one or multiple times.
- Evaluation & Referral: The treatment process is ended. The physician will evaluate the health status achieved and outcomes. The physician can refer the patient to another healthcare professional (e.g. different specialisation or providers)

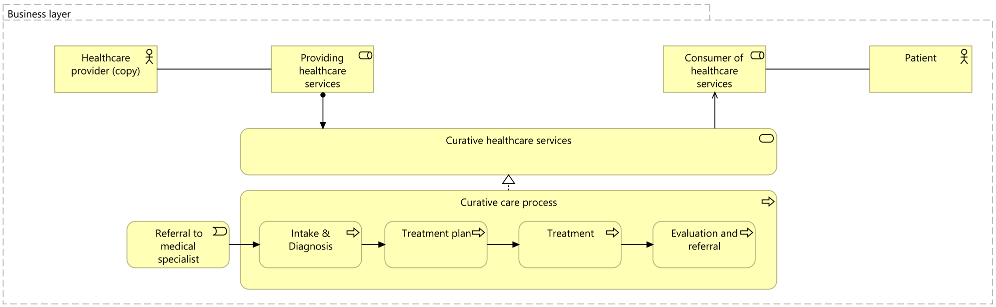

Figure 4.4: Business architecture of the as-is situation

4.3.3 Information

The information architecture describes the information elements that a healthcare provider must record to provide curative care services. This includes information for healthcare professionals, patients and third parties. Clinical observations, diagnosis, treatment plans are examples of information that is captured and recorded in the EHR.

Information models and sets

Information standards opt to use generic components as much as possible in order to create a standardised language. Standards ensure that information throughout the care process can be reused for different purposes, such as quality registration or patient-related research (Nictiz, 2020a). In the Netherlands, Nictiz is developing these generic components called *healthcare information building blocks (Zorginformatie bouwstenen (Zib)s)*. Internationally, these can also be referred to as Health and Care Information Models (HCIM), or Clinical Building blocks (CBB's), but for the scope of this study, the term Zib is followed. A Zib is an information model that describes clinical concepts by predefined data elements. The content, structure and relationships are agreed upon.

An example is the Zib 'Tobacco use'. The information model of tobacco use is presented in Figure 4.5. For instance: *a patient smokes daily [TobaccoUseStatus] 5 [Amount] cigars [TypeOfTobaccoUsed] since the age of 20 [StartDate]. The patient tries to quit smoking with a stop-smoking programme [Comment].* If the root concept is transferred to another information system, application logic should be able to map the Zibs to their own data model so that meaningful interpretation can be realised.

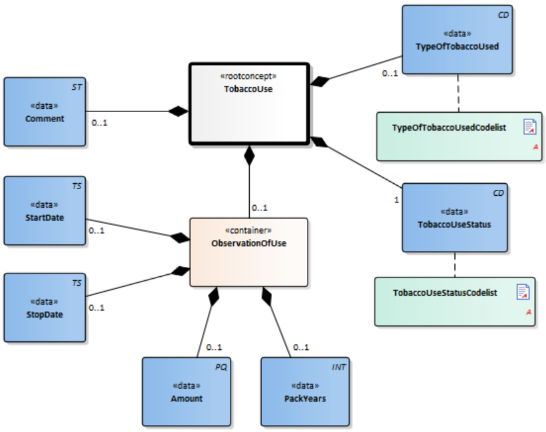

Figure 4.5: Healthcare information model of tobacco use. Adopted from Nictiz (2020a).

A special dataset is the Common Clinical Dataset (Hereafter Basisgegevensset Zorg (BgZ)). The BgZ is a patient summary of the most relevant (clinical) information. The BgZ is defined as: *"a minimal healthcare dataset that is always appropriate for caregivers in order to provide continuity of care for a patient"* (Nictiz, 2020b). For example, contact persons, allergies, problems and diagnosis, or medication. The elements are derived from and based on the International Patient Summary as adopted within the European Union.

Another essential data set are the outcome indicators of ICHOM. ICHOM determines outcome indicators per disease and describes how these should be measured and reported. To date, they have defined 24 outcome sets. Van Duivendijk and Hutink (2018) analysed the usability of the ICHOM data sets in the Dutch healthcare setting. The research concluded that 56% of the analysed items are suitable for mapping to Zibs. Moreover, the study shows that the ICHOM sets of different disorders are not mutually consistent and did not use international terminology standards. Although there is some criticism, Zorginstituut Nederland (ZiNL) decided to use the ICHOM sets as a guideline for defining the outcome sets in the Netherlands (van de Poel, 2018). By following the international sets and adapt these for the Dutch context, ZiNL aims to accelerate the development of outcome sets and achieve their objectives of the governmental programme 'outcome-based healthcare 2018-2022' (Ministry of Public Health Welfare and Sport, 2018a).

Terminology standards

To assure that information is recorded in the same way agreements and standards are essential. Terminology standards are widely used to determine the meaning of the elements in healthcare. Systematized Nomenclature of Medicine - Clinical Terms (SNOMED-CT) and Logical Observation, Identifiers, Names and Codes (LOINC) are commonly used reference terminology systems.

The SNOMED-CT is an international medical terminology system that offers a wide range of (medical) terms, synonyms and their meaning in a structured hierarchic way (SNOMED-CT, 2015). LOINC is a code system focused on laboratory contexts and aims to standardize concepts of laboratory applications, laboratory results and clinical concepts. Both are terminology systems but have different purposes and structures. While SNOMED-CT is appropriate to record clinical findings and procedures, LOINC is more suitable for recording laboratory determinations. Since 2013, the code systems are harmonised so that users can enjoy the benefits of both systems (Hielkema-Raadsveld, 2016).

4.3.4 Application

The application architecture describes the information assets that store, process, reuse, and distribute information within and across the enterprise to fulfil the end-users needs (M. Janssen, 2009). In the ZIRA meta-model, only the *application functions* are presented in different categories (i.e. Management, Care, Research, Education, Support, Generic IT functions). However, there are no application processes or components described nor the relationships within and across the architecture layers. This subsection will discuss the components of the application architecture that is presented in Figure 4.7.

Health information systems

The Healthcare Information System (HIS) can be categorised into two separate systems (Salleh, 2021): the Managerial Information Systems and Patient Care Systems. Figure 4.6 presents the HIS and how it serves the clinical information services. The first category system entails the usage of the HIS for managers to run the hospital as a business entity. Often referred to as Enterprise Resource Planning (ERP) systems. This study focuses on clinical information and outcome information to determine the value for the patient. Therefore, ERP applications are outside the scope. The second category refers to systems that directly facilitate the care process and can be subdivided into the following systems:

- **Patient Management System.** This system is involved with administrative functionalities and provide the following services: patient registration (e.g. admission, discharge), resource management (e.g. appointments) and financial services (e.g. billing).
- **Clinical Information System.** This system directly facilitates the primary care process with health data management and monitoring services. Data management that clinical information systems should support include collection, storage, extraction, transmission, presentation and analysis. The EHR is part of the Clinical Information System.

- **Clinical Support Systems.** The system supports the care process with optional services such as laboratory, blood banking, radiology, pharmacy, etc. The services of the Clinical Support System are connected to the Clinical Information System.

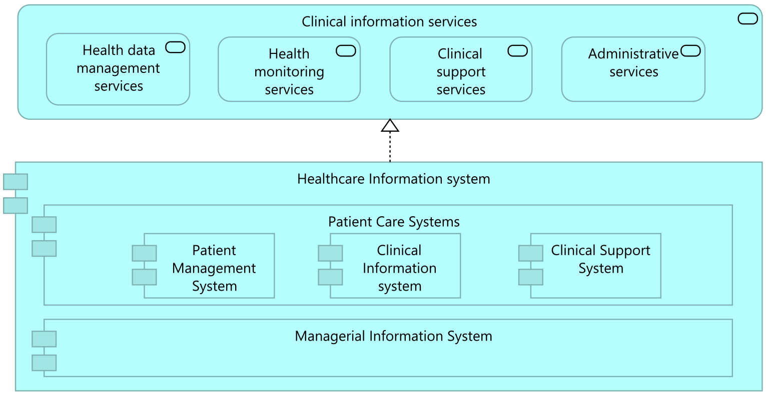

Figure 4.6: Visualisation of Healthcare Information System (HIS) and application services.

The HIS is connected to a user interface so that clinicians can interact with the applications. A *patient portal* is connected to the HIS, which via an interface, provides patients with access to their own patient portal. In these patient portals, patients can view their appointments, medical records, download their patient summary (BgZ) and fill out questionnaires.

An upcoming trend is the *Personal Healthcare Environment (PHE)*. A PHE provides the patient access to all their (medical) information stored at different HIS. The data is collected directly from the HIS and transferred to the PHE. For the HIS to be connected to the network, they have to be certified with the Medmij-label (Nictiz, 2020b). The information systems of IT suppliers are audited and tested thoroughly. Only certified suppliers of HISs and PHEs can participate in the network. Therefore, Medmij guarantees a secure digital exchange of personal health data.

Standards for information exchange

During the care process, information about the patient can be collected internal or external. Internal data collection includes for instance examination, questionnaires and monitoring. External data collection refers to (clinical) information that is obtained from external sources, for example, the letter of referral. On the other hand, the clinicians must be able to send information to other professionals in the care cycle. For example, an intermediate report or a letter of discharge.

Information exchange is crucial for VBHC as it facilitates collaboration between healthcare providers (Porter & Lee, 2013). There are many different ways to transfer information in which the 'old-fashioned way' of hard-copy medical records and hand-written referral letters are no special cases. Despite this, digital information exchange is increasingly adopted. There exists a wide range of standards to exchange health information. The most adopted standards are (Nictiz, 2020b):

- **HL7 CDA**: This standard can display and exchange a patient file in one structured document. CDA (Clinical Document Architecture) is part of the HL7 version 3, which was developed for data exchange across HIS. The CDA document contains textual information (for human reader) and structured information (for software applications). The disadvantages of CDA are that there is no transport mechanism and processing the document can take much time due to large patient files (Mulders, 2020).

- **HL7 FHIR**: FHIR is a recently developed standard by HL7 and is based on a widely used internet standard Application Programming Interface (API). The focus of FHIR API is to support the workflow of a process where data is exchanged. The core of FHIR is formed by reusable building blocks, the FHIR resources. Different from CDA, the FHIR specifies an exchange mechanism based on REST. While APIs are widely known and can be applied to healthcare using only the internet as an infrastructure, a disadvantage is that healthcare providers that register the data must have implemented the FHIR API (Mulders, 2020).

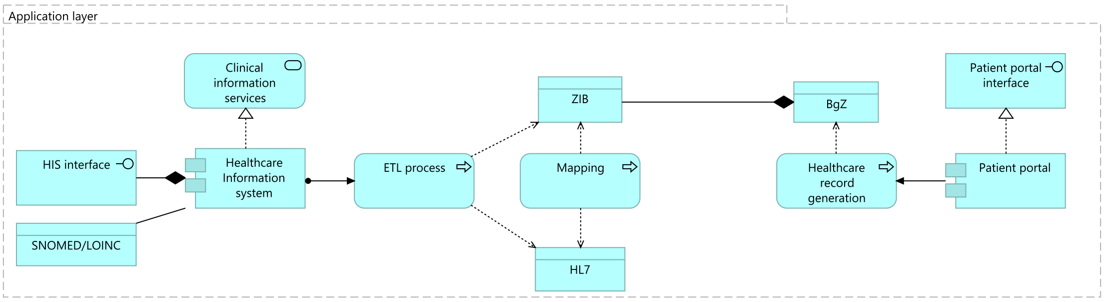

Figure 4.7: Application architecture of the as-is situation

4.3.5 IT-infrastructure

This layer relates to the technical processes, services and infrastructure in which the information systems are located. These include for example data storage and servers, soft- and hardware, and networks.

Processes and services

For this study, the technological services are limited to data management services and data exchange services. A query process answers a query request of the application by searching the database and obtain the results of the query. The data management service is connected to the Extract, Transform, Load (ETL) process in the application layer. Data is extracted from the clinical repository then transformed to a data structure, for example to Zibs, HL7 FHIR resources or HL7 CDA, and loaded into an exchangeable message. The data exchange services are connected to the data exchange process in which data is sent and received. HL7 standardised messages are sent over the networks.

Data storage

For a long time, the standard was to store patient's data on servers at the HIS suppliers location. Controlling the data in-house has advantages for the supplier as the data is verifiable and they are independent. In recent years, an upcoming trend is to outsource data storage to cloud service providers. Reasons to move to the cloud is to achieve a higher level of security with state-of-the-art encryption techniques and higher availability, because data is backed up (ICTrecht, 2019).

In 2019, cloud services got the attention of Dutch newspapers as they found that tech giant Google hosts hundreds of thousands of medical records of Dutch citizens. MDRM processes medical data of hospitals for the quality registrations of DICA. MDRM moved to the cloud, which is in compliance with the European GDPR. Google cannot see nor analyse the data. However, according to critics there exists a high risk for the privacy of patients (Klaassen & Bremmer, 2019).

4.3.6 Network infrastructures

In order to exchange data, a transport mechanism is required. There are a few wide adopted standards (Registratie aan de bron, 2017)

- **Landelijk Schakelpunt (LSP)**: AORTA is the national infrastructure, originally developed by the government (Registratie aan de bron, 2017). The LSP is central in the infrastructure and most healthcare providers (i.e. GPs, pharmacy, primary and speciality care) are connected to the network. A healthcare provider can request medical information at the LSP. If a provider requests information (pull), he/she has to authenticate himself with a UZI certificate. LSP check if the provider is authorised, and if so, the query process will be performed in other databases. LSP is provided with the information from the data sources and answers the query. It is worth noticing that LSP only acts as an intermediary and does not store any data.

  The LSP has recently fulfilled all the requirements in the MedMij certification process and the name has changed from LSP to LSP+. The available information will be shared in the form of bundles of FHIR resources, using Zibs as much as possible.

- **XDS-IHE infrastructure**: An infrastructure that is often developed for regional usage is XDS. These regions are called 'affinity domains'. XDS is a profile of IHE in which multiple users set up an infrastructure. The location of data in the HIS of different providers is stored at a so-called Document Registry. If a provider requests information, the Document Registry checks which documents are available and the provider can select the documents and access them.

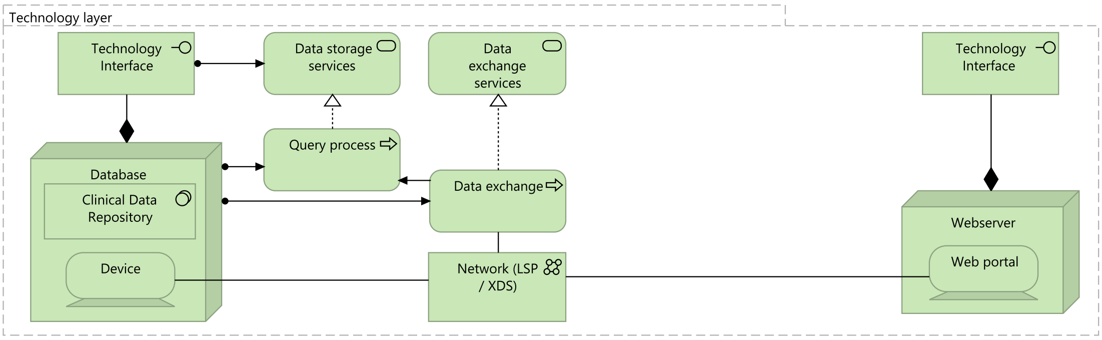

Figure 4.8: Technology architecture of the as-is situation

4.3.7 Gap Analysis

A gap analysis is a method to assess the differences in the current *as-is situation* and the desired *to-be situation*. Based on the identified gaps, specific actions can be carried out. For the gap analysis, the criteria of a value-enabling IT platform of Porter and Lee (2013) will be used as a basis (see also Section 2.2). Table 4.1 provides a simplistic overview of the criteria and if they are included in the current situation.

Table 4.1: Gap Analysis

Criteria	Included?
1. Be patient-centred	No
2. Use common data definitions	Yes
3. Encompass different data types	Yes
4. Be accessible to all parties involved	No
5. Include specified medical condition templates	Yes
6. Be easy to extract information	No

IT systems should follow the patient in the full cycle of care instead of the other way around. Currently, the healthcare landscape is highly fragmented and medical data is spread across various systems. Although PHEs are promising, all IT suppliers should comply with the agreement set of Medmij to get access to the network. To conclude, at this moment, systems are not patient-centred yet.

Terminology standards such as SNOMED-CT and LOINC are widely adopted within the Netherlands but also internationally. Standardisation in terminology is key to create semantic interoperability. Further, IT systems encompass different data types such as notes, images and lab results. However, transferring these different data types is still complex as the Zibs do not cover everything and are also not meant to.

Porter and Lee (2013) stated that information systems should be accessible to all parties involved, which includes the care team and patients. While there are many developments in data and information sharing, there is still much room for improvement. For example, with IHE-XDS, parties can have a look at documents that are stored in other HIS. However, a prerequisite is to be connected to the regional IHE-XDS network. Information sharing across different regions is therefore still complex.

Often, the care process is tailored to specific medical conditions. This makes it easier for clinicians to provide care in a standardised procedure. Also, clinical information systems are customised to the wishes and needs of the clinicians. While customised processes and systems provide patient-centred care, it hampers to create uniformity that is needed for outcome measurement.

For the last criteria "easy to extract information" is suggested to use the term "easy to extract and integrate". While intermediaries such as LSP and IHE-XDS provide opportunities to capture (parts of) the medical record, not all data is Zib compliant. Moreover, research on the usability of the ICHOM outcome sets concluded that a large part of the outcomes is not compatible with the Zibs. While some developments are ongoing, such as the recently launched HL7 FHIR standard, semantic interoperability is still in its infancy.

4.4 SUMMARY ENVIRONMENTAL ANALYSIS

This chapter conducted the environmental analysis for a transition to VBHC. The environment is divided into three categories: organisational systems, people and technical systems (Hevner et al., 2004).

Organisational systems. The healthcare reform of 2006 introduced regulated competition with a purchasing market, insurance market and provision market. Market forces lead to innovation, costs reduction and. An essential element is freedom of choice for citizens. They are able to choose insurance plans and care provision that matches their needs best. Citizens should be able to critically assess insurers and providers based on information about quality, costs and availability. In reality, however, there is little information available that impedes individuals in making informed decisions (Kroneman et al., 2016).

People. The stakeholder analysis concluded that the government, insurance companies and overarching interests groups, larger healthcare providers and HIS suppliers are important stakeholders to take into account for the transition towards VBHC because they have relatively high interest and power. Other stakeholders such as patients, smaller healthcare providers and research institutions have high interest but less power to initiate changes. The government should consult patients wishes and needs and in their interest as they have the responsibility to provide affordable, accessible and high-quality care. They have an essential role in stimulating stakeholders with an indifferent or negative attitude towards VBHC. An overview of the stakeholders, their role, interest and power can be found in Appendix D.

Technical systems. The as-is situation of the technical systems was analysed. Using the criteria of Porter and Lee (2013), several gaps were identified. First, information systems are not patient-centred because patients leave their data scattered across multiple institutions. The introduction of the Personal Healthcare Environment (PHE) is promising as it allows patients to access and manage their medical data from one place. Second, it can be concluded that information is not accessible to all parties. IT-infrastructures are often organised regionally and connections have to be established. Third, it is complex to integrate data from multiple sources because of the lack of standardisation. This hampers the reusability of data and possibilities to measure outcomes across the care cycle.

The desk research activities partly answered subquestion 2: *"How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?"*. To verify findings from the literature and scrutinize the problems in more depth, semi-structured interviews are conducted. The findings are discussed in the next chapter: *Analysis: interviews with experts*.

5 ANALYSIS: INTERVIEWS WITH EXPERTS

This chapter provides the findings of the preliminary and in-depth interviews. First, the problems identified in the literature are verified in the preliminary interviews. The analysis of the preliminary interviews show that trust is an essential element for VBHC. The concept of trust is further explored. Finally, the in-depth interviews aimed to find out how and which IT architecture components can increase the level of trust in the healthcare system.

5.1 PRELIMINARY INTERVIEW

The preliminary interviews were held to explore the current situation further and to identify problems and solutions. In total, 7 interviews were conducted in this phase. Table 5.1 presents the participants, the organisation they represent and their expertise. The interview protocol is shown in Appendix E.

Table 5.1: Overview participants preliminary interviews

ID	Organisation	Expertise
1.1	Pharmaceutical company	Value-based healthcare
1.2	Healthcare provider	Healthcare management
1.3	PwC Advisory	Advisory of clients in healthcare
1.4	PwC Advisory	Advisory of clients in healthcare
1.5	PwC Assurance	IT audit healthcare insurance companies
1.6	IT provider healthcare	IT solutions for healthcare
1.7	IT provider healthcare	IT solutions for healthcare

The interviews were recorded, transcribed and analysed. The software ATLAS.ti was used for data analysis. The methodology for data analysis can be found in Chapter 3: *Methodology*. The data analysis resulted in 7 overarching code groups: (i) Challenges, (ii) Finance, (iii) Barriers for VBHC and (iv) Enablers for VBHC, (v) Implementation, (vi) Concerns and (vii) Requirements. The underlying codes are interrelated within and across the groups.

The relationships on an aggregated level can be found in Figure 5.1. Although many issues are rooted within the IT area, technology does not operate in an isolated environment and thus other barriers and enablers can influence the implementation of VBHC. Financial factors are associated with barriers and enablers for VBHC. In turn, the implementation of VBHC and financial incentives affect the current challenges healthcare is facing. The category 'requirements' is used in section 5.3. It is worth noticing that some interviewees expressed their concerns about the transition towards VBHC. This category is outside the scope for this chapter, but will be further discussed in Chapter 8.

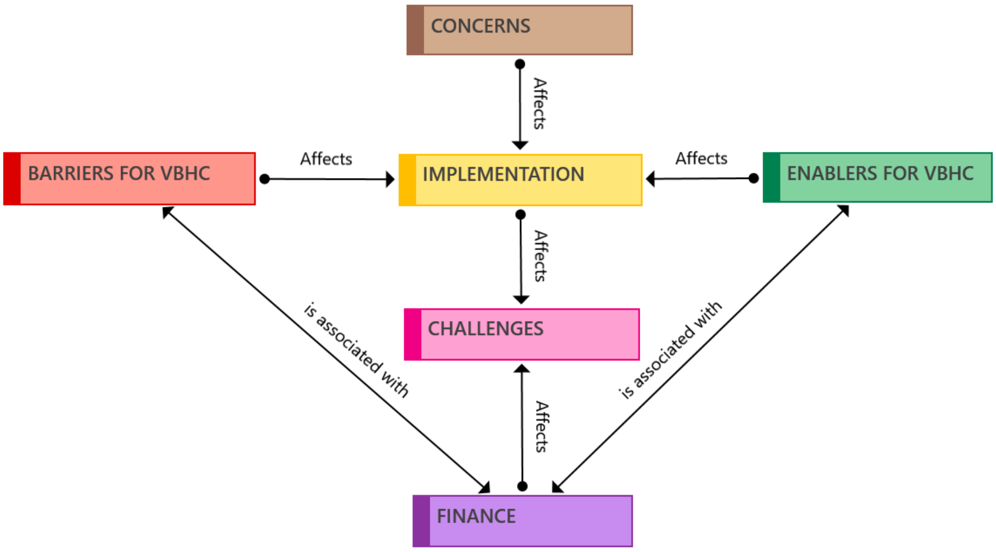

Figure 5.1: Overview network of overarching code groups of preliminary interviews

5.1.1 Challenges

The interviewees were asked what are the challenges Dutch healthcare is facing? Interviewees that were closely related to the care processes recognised challenges on a more organisational level such as having a *positive business case*, *dealing with the COVID-19 pandemic*, *work pressure* and *administrative burden*. In addition, one of the interviewees mentioned that *laws and regulation*s can change quite fast. The interviewees from consultancy provided answers from a higher level and mentioned *sustainability of healthcare*, *shortage in the labour market*, *rising need for care* and *complexity of care*. In addition, one of the consultants mentioned that *loneliness* could be a problem in the near future because it leads to a higher demand for healthcare and reinforces the aforementioned challenges. The interviewees with a background in IT mentioned challenges more related to information and communication such as *administrative burden* and *availability of information*. The relationship between these challenges is shown in Figure 5.2.

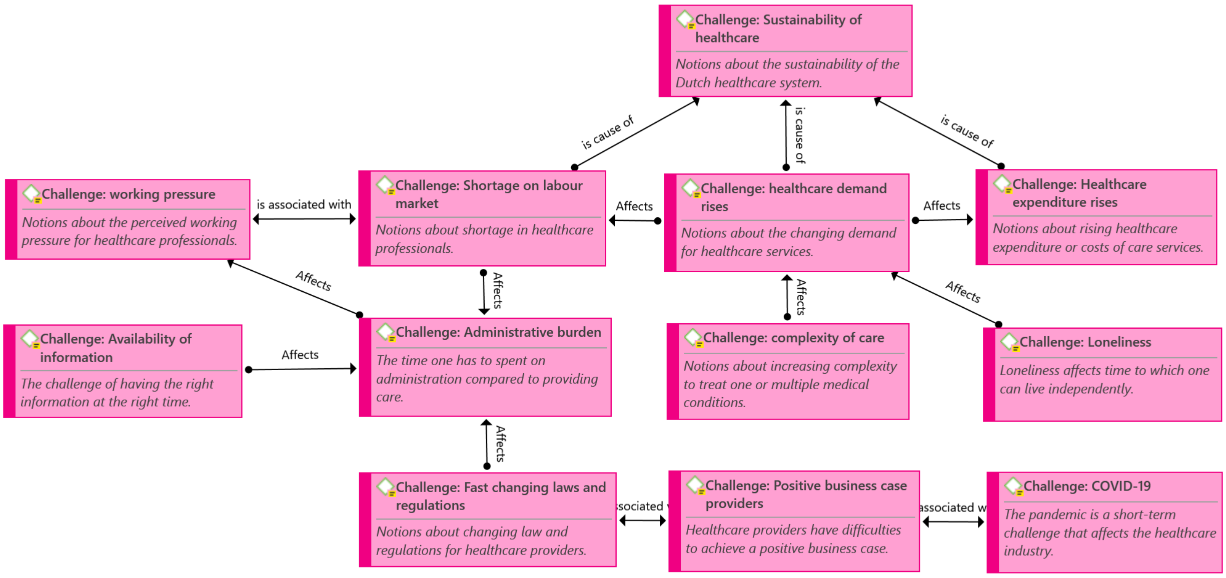

Figure 5.2: Overview challenges in healthcare industry

5.1.2 Finance

Financial related factors were mentioned by all interviewees. The *legitimacy of the claim* entails quotations about the reimbursements and claim processes. It was found that there are many administrative efforts to 'prove' care was provided justly. For contracts, there was much mentioned about the *terms and conditions*. According to several interviewees, quality is a secondary condition currently. Interviewee 1.1 explains: *"The insurance companies steer always from the financial incentives because that is easy to have a grip on. [...] an example, if a patient has a complication after surgery, insurers could say 'we do not pay for possible complications, only for the surgery itself', so you better not have any complications. Cost control is much easier to handle as an instrument"*. Additionally, contracts based on quality are *complex to execute due to the lack of outcome indicators*. Interviewee 1.2 explains that even if the quality was a primary term, there would be mistrust in the outcomes. Concluding that value-based contracts are currently unable to realise due to the lack of good quality indicators and procedures the measure those.

The *perverse financial stimulus* refers to the tendency of providers to act strategically to earn more revenues. Healthcare providers have relatively low bargaining power in the contracting process as interviewee 1.2 explains *"I would be in no position to negotiate. Just assume that whenever a big insurer offers a contract, in 95% of the cases, I would sign directly."* The low bargaining power results in relatively low-profit margins for healthcare providers, which in turn leads to upcoding, cream-skimming or quality skimping and have an effect on the challenges. In sum, financial factors have influenced the transition to VBHC providers and insurers should come to agreements about outcome indicators and how these should be measured.

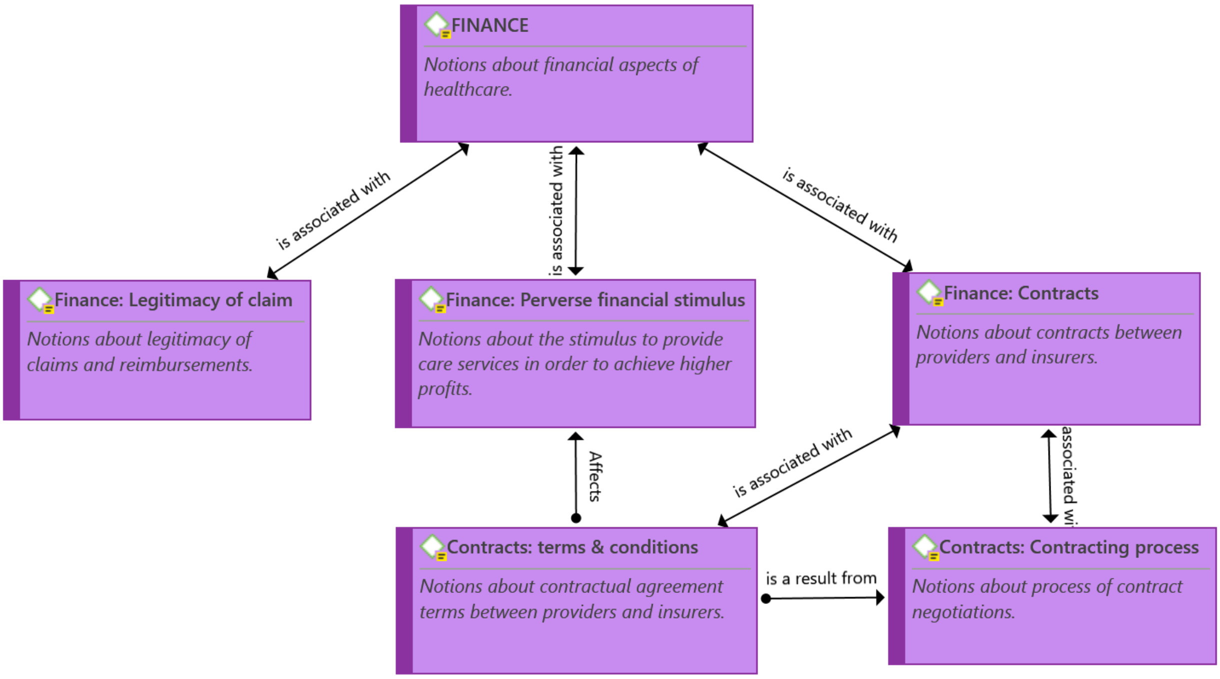

Figure 5.3: Overview financial factors for VBHC

5.1.3 Barriers

During the interview barriers to VBHC were explicitly or implicitly mentioned by the interviewees. The barriers are divided into multiple subcategories: Organisational & Policy, Relationship, IT, and Implementation.

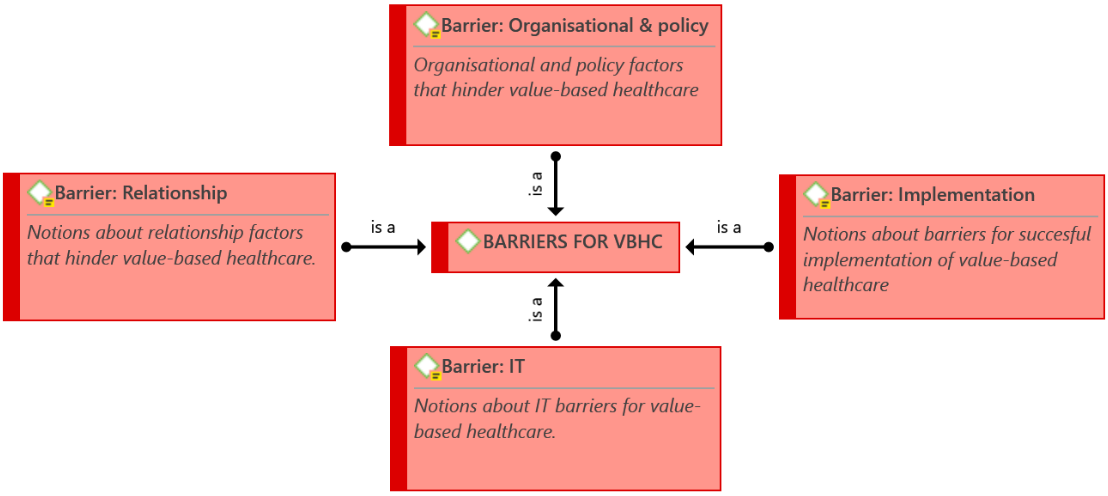

Figure 5.4: Overview of barriers for VBHC

Organisational and policy barriers

Barriers in the organisational context lie mainly in the *definition of value* and *how to measure and report* that. Additionally, some physicians have to register more than others because of the role they have in the chain (e.g. GP). Considering the current administrative burden, it is likely that more administration only has negative effects.

On a national level, it is mentioned that the healthcare industry is highly *fragmented*. The introduced market competition can hinder collaboration which is essential to implement VBHC. In addition, *law & regulations*, such as the GDPR, did not make collaboration and exchanging data easier.

Relationship barriers

Due to the reform of healthcare, actors have certain roles to fulfil. It became clear that the insurers and providers have *conflicting interests*. Moreover, the relationship is characterised by much regulation and control. Interviewee 1.2 emphasises that the *deeply rooted mistrust* is driven by revenue and costs. For VBHC, there needs to be a certain level of trust to collaborate. Interviewee 1.4 explains that there is a *lack of transparency* and, for VBHC, insurers need to gain more insight in processes and outcomes to be able to steer on quality instead of costs.

Interviewee 1.2 thinks it is frustrating that the insurers do not have the medical expertise, but often *interfere* with how healthcare should be provided. From the provider side, insurers are perceived as solely cost-driven parties. According to the consultancy interviewees, that clinicians feel like they cannot provide the best care and think that the revenues go to the top management instead of patient care. The *perceived image* affects the level of trust between providers and insurers. However, as mentioned, the providers have *low bargaining power* and so they have, more or less, to deal with the imposed regulation of the insurers.

IT barriers

In line with the results of the literature review, it was found that *data is not accessible* which is associated with the *lack of interoperability*. There is a *lack of uniformity of language* and therefore *data is not reusable*. It was found that there are many ongoing initiatives to standardise data and information models. Nevertheless, when there are too many 'standards', there is no standard at all.

In turn, a lack of interoperability requires clinicians to *manually enter* data which influences the administrative burden and is prone to human errors that affect the *data quality*. Moreover, if there is a possibility to receive medical data digitally, physicians may not have the complete information and the accuracy and completeness of the data may be questionable. Finally, it was mentioned that the current HIS have much focus on the financial features, such as the claim process. In combination with the ambiguous definition of value and no uniformity in outcome indicators, it is *difficult to administer 'value'* in the systems.

Implementation

One of the major implementation barriers mentioned is the *acceptance of technology*. Interviewee 1.4 explains that *"One can use IT and technology, but human contact is irreplaceable"*. Interviewee 1.3 agrees and mentions that clinicians have an intrinsic motivation to care in which they believe should be delivered by people. Another barrier is that the providers have *little resources* in terms of money and time to innovate and lead to a transition to VBHC.

5.1.4 Enablers

Similar to barriers, the enablers for VBHC are divided into several subcategories: Financial, Relationship, IT, and Implementation enablers.

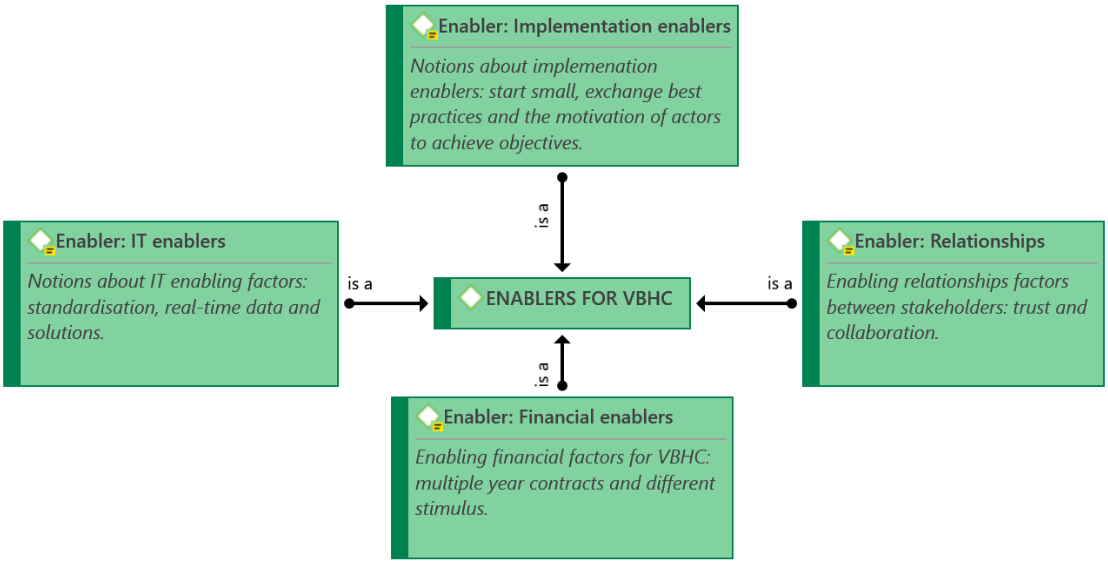

Figure 5.5: Overview of enabling factors for VBHC

Relationship enablers

Interviewees mentioned that *trust between actors* is essential for successful implementation. Trust is an intangible but highly important factor in relationships and allows for collaboration between actors. One of the interviewees mentioned the example of

Santeon, a group of hospitals that pioneers in VBHC: *"They also do a benchmark with the hospitals to analyse the outcomes and, in that way, challenge each other [. . .] The analysis will look at what you do differently and sometimes they work together to see how colleagues do it to learn and improve. There exists a mutual trust and they also have much more coordination"*. In order to exchange data on outcomes, trust needs to be established among the providers and activities have to be coordinated.

Financial enablers

The interviewees that were related to healthcare from an organisational point of view mentioned that there are few resources to innovate in terms of time and money. *Multiple years contract* would offer providers more certainty and allows them to start long-term innovation projects. In addition, interviewees mentioned that a *different financial stimulus* would contribute to motivating providers to achieve certain outcomes instead of a DTC code. The overarching goal then would be creating value for patients.

IT enablers

One of the most important enablers related to IT is *standardisation*. Many actors are working on standardisation which results in, again, heterogeneity in solutions and fragmentation of care delivery. Interviewee 1.6 explains that standardisation should be coordinated by one party: *"I think that the way in which we get the information standardized so that data exchange is scalable and readily available, that there should be one organization that takes the lead. An organization that simply says: we have three options A, B, C. We choose to do A, for this and this reason. Done."* When standardisation is achieved, major steps forward can be taken in semantic interoperability and outcome measurement.

Further, interviewees mentioned that *reliable and real-time data* would enable actors to assess their performance and make decisions accordingly. For VBHC this is important as patients' treatment can be evaluated regularly and, if necessary, the original plan can be adjusted to achieve the envisioned outcomes.

Specific IT-solutions mentioned were data exchange networks solutions such as *XDS* and *Medmij*. Consultancy interviewees mentioned the use of *wrappers and APIs* to connect legacy systems with, for example, a platform. Indeed, *one single platform* where all different stakeholders can come together was also opted as a solution to overcome fragmentation. *Benchmarking providers* came up several times which could provide the necessary insight into outcomes on an aggregated level and learn from others. An innovative solution for clinical research mentioned was the use of a *Personal Health Train*. This innovation allows clinical researchers to use data from multiple sources but instead of the data travelling to one processing point, the 'train' comes by the data sources to extract the data. Further, *automating processes* where possible is necessary to reduce the manual interaction and lowers the administrative burden.

Implementation enablers

For successful implementation, several enablers were mentioned by the interviewees. First of all, it is important to *start small* and gradually scale up. Second, *communication and clear objectives* are necessary to gain support from the stakeholders. For example, explaining the benefits of reporting certain data types. This also related to the *intrinsic motivation of clinicians* to achieve the best possible care for their patients. Together, these can determine the success of implementation.

Another, more abstract implementation enabler is a *changing mindset* of stakeholders. Interviewee 1.1 suggests that one has to think in health instead of sickness, which refers to the core concepts of VBHC. Furthermore, actors have to be less stubborn and realise that collaboration will create the power to impact healthcare.

5.1.5 Implementation

The category implementation refers to the question *"how?"* rather than the barriers or enablers previously discussed. From the stakeholder analysis, it was found that the government plays an important role as they have a high interest in healthcare improvement and the power to do that. Interviewees agreed on the fact that the *government should have a facilitating role* and *market players should be the drivers*. Interviewee 1.3 mentions that: *"the government should reduce or eliminate barriers if there would be any"*. However, according to interviewee 1.6, there should be a right balance between market forces and guidance of public bodies, because market forces lead to innovation. Finally, *one party must take the lead* to streamline the variety of initiatives and coordinate implementation.

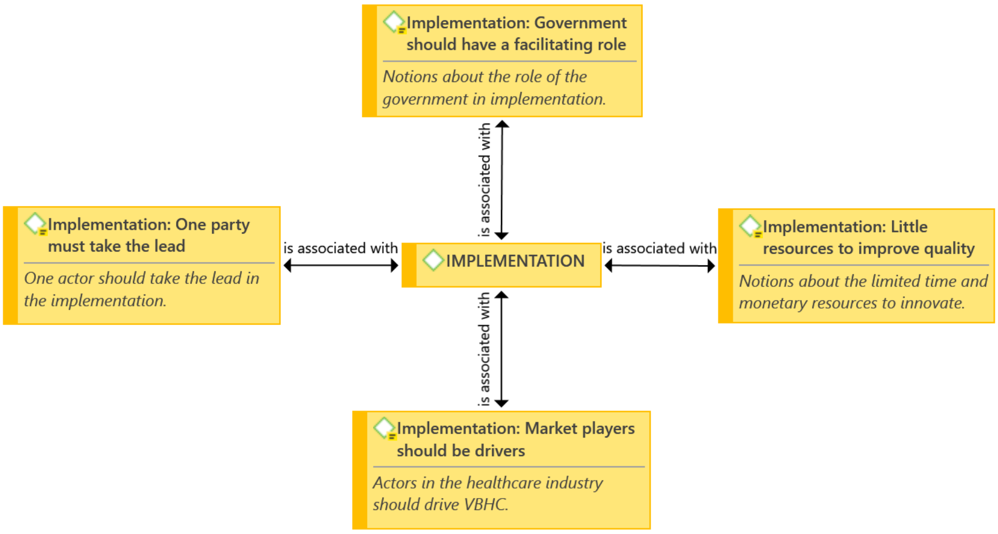

Figure 5.6: Overview of implementation factors for VBHC

5.1.6 Conclusion Preliminary Interviews

There is a design flaw in the current healthcare system that leads to misalignment of interest and trust issues between stakeholders. Whereas providers are looking for a positive business case, insurers control the legitimacy of the provided care strictly. Including outcome indicators in contracts is not a silver bullet to fix the underlying trust issues between insurers and providers. In fact, ill-defined outcome indicators and no uniformity of measurement procedures would only lead to more administrative efforts and there still would be mistrust, but then based on the achieved outcomes.

According to the interviewees, VBHC requires collaboration and trust between the actors. When there is no trust, actors will continue to have a suspicious attitude and the need for control. Even if there were IT capabilities to measure outcomes and IT systems would be interoperable, it would not solve the root causes of the problems. Therefore, the problem is scoped down to these trusts issues. The following section will further explore the concept of trust.

5.2 EXPLORING THE CONCEPT OF TRUST

In the preliminary interviews, several interviewees emphasized the importance of trust between actors and stakeholders for VBHC. Indeed, theorists have seen trust as an intangible asset that is required for collaboration in and between organisations (Lopez-Fresno, Savolainen, & Miranda, 2018). A much-cited article by Mayer, Davis, and Schoorman (1995) studies trust and defines it as *"willingness to be vulnerable to another party"*. While there are many different definitions of trust, it often involved terms as 'vulnerability', 'confidence', 'positive expectations' and 'perception' (Rousseau, Sitkin, Burt, & Camerer, 1998). Based on literature and empirical evidence, Rousseau et al. (1998) proposed the definition: *"Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another"*, which is followed in this study.

5.2.1 The Relationship Between Trust, Trustworthiness and Transparency

The level of trust depends on the extent to which the trustee is perceived as *trustworthy* (Mayer et al., 1995). In Mayer's trust theory, the perceived trustworthiness is influenced by the following characteristics of the trustee:

- **Benevolence.** The perceived willingness of an organisation to do well aside from an egocentric profit motive.
- **Integrity.** The extent to which an organisation follows rules and principles that are acceptable perceived from another organisations' perspective.
- **Ability.** All the skills, competencies, and characteristics that enable an organisation to execute influence within a task- and situation specific nature.

Trustworthiness perceptions are key in building and maintaining trust in relationships. Schnackenberg and Tomlinson (2016) studied the concept of transparency and argue that it is an antecedent of trustworthiness. Transparency shapes the perceptions to what extent the trustee is benevolent, integer and competent. Schnackenberg and Tomlinson (2016) determines four characteristics of transparency. First, transparency is about *information*. Secondly, this information is *intentionally shared* by one party to another. Third, the interpretation of the information depends on the *perception* of the receiver (i.e. the trustor). Fourth, and finally, transparency is related to the *perceived quality of the information*. Consequently, Schnackenberg and Tomlinson (2016) define transparency as *'the perceived quality of intentionally shared information from a sender'*.

In the article, Schnackenberg and Tomlinson (2016) draw upon the trust theory of Mayer et al. (1995) and argue that the expectations of the trustee's intentions can be shaped by the quality of shared information (i.e. transparency). The authors propose a conceptual model, as presented in Figure 5.7, to show the relationship between trust, trustworthiness and transparency. Transparency is divided into three factors:

- **Disclosure.** This is the extent to which relevant information is shared open and timely by another party. Besides transferring information it must be documented and communicated appropriately.
- **Clarity.** Information must be clear, comprehensible, understandable and coherent in order to analyse and interpret it.
- **Accuracy.** The extent to which the trustor perceives the information as correct and reliable. Accurate information is associated with truthfulness and honesty.

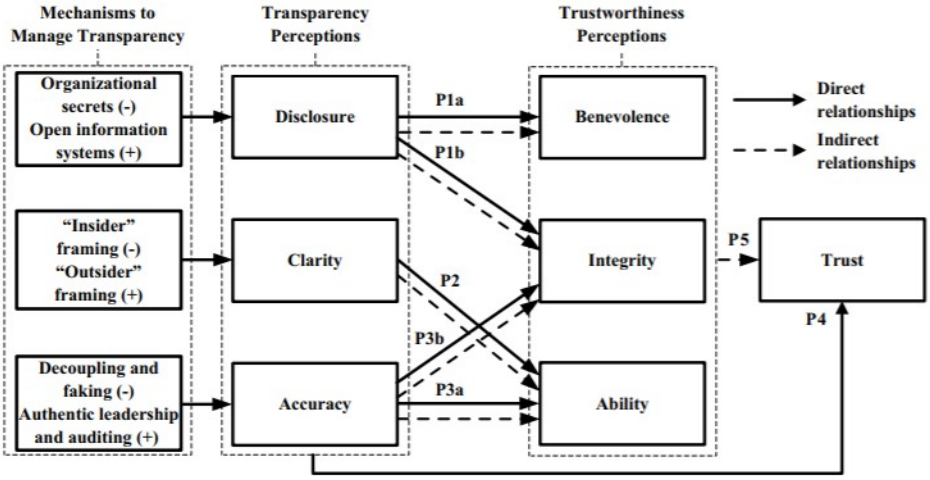

Figure 5.7: Conceptual model of the relationship between trust, trustworthiness and transparency. Adopted from Schnackenberg and Tomlinson (2016).

5.2.2 Managing Transparency

Relational trust is derived from repeated interactions over time between trustor and trustee (Rousseau et al., 1998). Building trust requires frequent communication and information sharing (Lopez-Fresno et al., 2018). Increasing the disclosure, clarity and accuracy of the information positively influences the trustor's perception of the information quality (Schnackenberg & Tomlinson, 2016). In turn, this will enhance the perceived trustworthiness of an organisation and influences the level of trust positively (Mayer et al., 1995).

Organisations are able to control the perceived trustworthiness to some extent by shaping expectations using mechanisms that influence disclosure, clarity and accuracy. Schnackenberg and Tomlinson (2016) proposes some examples for managing these elements. For example, disclosure can be managed by using open information system, clarity by the way information is framed and presented, and accuracy by performing internal and external audits.

5.2.3 Transparency for VBHC

Since transparency can be managed and indirectly influences the level of trust, it is interesting to determine how this can be realised in Dutch healthcare for the purpose of VBHC. Increasing transparency in the IT architecture would have the following benefits:

- **Continuous quality improvement.** Providers gain more insight into their own business and additionally provides the opportunity to learn from each other and share best practices.
- **Improved decision-making.** Policymakers and managers are able to act upon data instead of making false assumptions.
- **Positive financial stimulus.** Insurers can benchmark providers and reward them on quality.
- **Patient empowerment.** Patients are able to see which provider or treatment fits their needs best and can make informed decisions.

The in-depth interviews are used to find out what components can be integrated into the IT architecture to manage transparency in healthcare.

5.3 IN-DEPTH INTERVIEWS

In the previous section, the model of Schnackenberg and Tomlinson (2016) was explained. The disclosure, clarity and accuracy of the information can be closely managed within an organisation itself in order to strategically shape the expectations of the trustor and consequently influence the level of trust. The in-depth interviews are used to find out what components are missing to manage transparency in the IT architecture. Hence, this could lead to trust-building in the relationship between stakeholders.

The interview protocol was based on the conceptual model of Schnackenberg and Tomlinson (2016) and the three factors (i.e. disclosure, clarity and accuracy) were central to the interviews. The interview protocol is included in Appendix F. In total, 4 interviews were conducted with persons having various expertise. Table 5.2 presents the participants, the organisation they represent and their expertise.

Table 5.2: Overview participants in-depth interviews

ID	Organisation	Expertise
2.1	Healthcare provider (pioneer in VBHC)	VBHC and IT
2.2	Healthcare insurer (pioneer in value-based reimbursements)	VBHC and payments
2.3	IT supplier	Data-driven healthcare
2.4	Academic hospital	VBHC implementation

Similar to the preliminary interviews, the in-depth interviews were recorded, transcribed and analysed. The software ATLAS.ti was used for data analysis. The methodology for data analysis can be found in Chapter 3: *Methodology*. The data analysis resulted in 5 overarching code groups: (i) Transparency & VBHC, (ii) Transparency risks, (iii) Principles, (iv) Requirements[1], (v) Architectural components. The underlying codes are interrelated within and across the groups. The relationships on an aggregated level can be found in Figure 5.8.

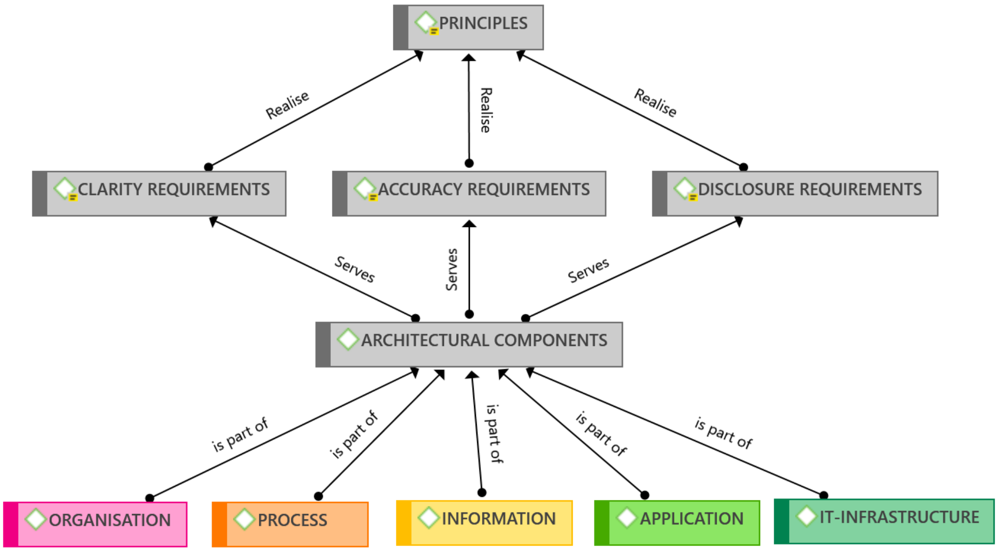

Figure 5.8: Overview of overarching code groups and relationships

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[1] Codes regarding requirements are merged with the requirements found in the preliminary interviews.

5.3.1 Trust, trustworthiness and transparency for VBHC

First, the findings from the environmental analysis and the concept of trust were explained. To verify whether increasing transparency in the IT architecture would be a solution, it was validated throughout the interview. The interviewees were asked questions such as: *"What would be the effect of transparency on the relationship between stakeholders?"*. All interviewees acknowledge the trust issues between stakeholders and, interestingly, they all confirm that transparency is a part of the solution in the long term.

Fundamental for VBHC are outcome measurements. The information derived from these measurements shape the healthcare journey for individual patients shows where healthcare should be improved and enable insurers to pay for performance. According to interviewee 2.1, trusting the information systems and the underlying processes is key to trust data. Communicating how underlying IT processes are organised and gaining experiences with the systems enhance the perceptions. Nevertheless, interviewee 2.4 emphasizes that negative experiences with information systems can destroy the established trust right away.

Advantages of transparency recognised by the interviewees were that it may lead to data-driven healthcare where stakeholders are enabled to reason on data. Reasoning from the same data results in a mutual understanding of definitions. Interviewee 2.2 expects that, in line with the theory, transparency will influence the perceived ability of the providers and, in turn, insurers will trust more and more on these outcomes. A side effect is that providers feel an extra responsibility to do well (i.e. benevolence) and less law and regulation are necessary. Interviewees agree with the theory that the way how information is framed (i.e. clarity) affects the perceived trustworthiness.

Nevertheless, there are some risks to transparency. A major concern is that being transparent about health outcomes will have *negative consequences for providers*. For example, insurers use this information not to reward, but to impose penalties on providers. Consequently, *data could be contrived for egocentric motives* such as company image or profits to avoid those penalties. Moreover, there are *privacy risks* involved because if there is a possibility to trace data back to the patient. In practice, transparency could lead to *more questions from patients* and an *excessive need to double-check data* which is time-consuming.

All things considered, a solution that increases transparency has a huge potential. It creates the opportunity to compare outcomes and improve healthcare. As noted, this is not without risk. Trust can only be established when the intentional vulnerability is not exploited (Rousseau et al., 1998). An essential prerequisite for sharing data and outcome information is that there should be no punishing strategies attached to 'negative' results and the privacy of individuals (i.e. patients, clinicians) should be respected.

5.3.2 Principles

In the interviews, it was found that some topics and quotations kept reoccurring. If these quotations had a normative, directive character, they were labelled as principles. Principles can be used for the design. Figure 5.9 shows the principles derived from both interviews.

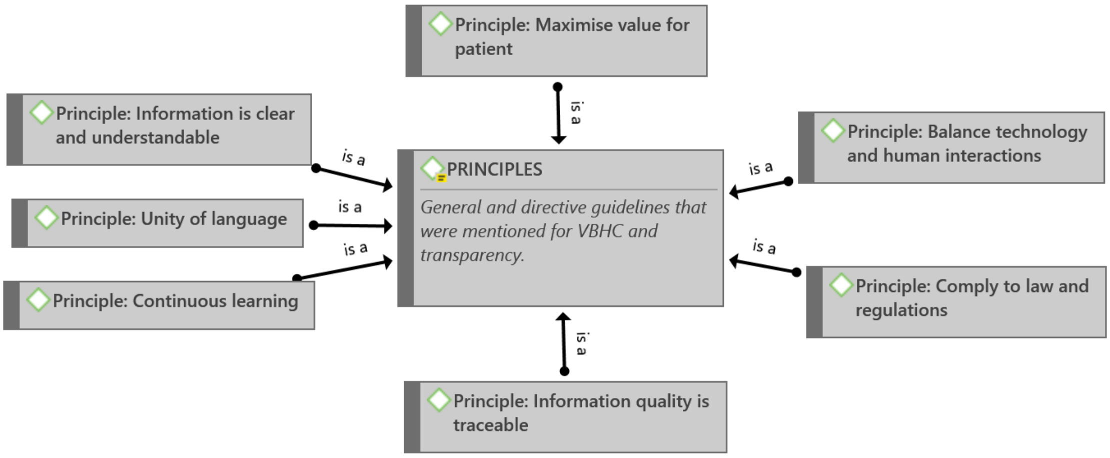

Figure 5.9: Overview of principles mentioned in the in-depth interviews

By far the most mentioned principle is to *maximise value for patients*. This is the ultimate objective of VBHC and should be taken into account in the design. Another principle often mentioned is *continuous learning*, which refers to the fact that VBHC aims to improve healthcare by learning from data and each other. In order to do that the quality of information should be able to assess, leading to the principle *information quality is traceable*. The principle *unity of language* stimulates the ability to exchange data and interpret syntax and meaning. Associated with interpretation is the principle that *information is clear and understandable*, referring to the presentation of information. While technology is an inevitable element in VBHC, a human touch is indispensable. Therefore, there should be a balance between technology and human interactions. Finally, an obvious, yet important principle is to *comply with law and regulations*.

5.3.3 Requirements

Quotations that were implying IT *should, must or could* have a characteristic or the ability to do something were labelled as requirements. The requirements are the means to realise the objective of the architecture (The Open Group, 2018). The requirements are categorised into the dimensions of transparency: disclosure, clarity and accuracy.

Disclosure

Requirements for disclosure involve the availability and accessibility to relevant information. In line with one of the criteria of Porter and Lee (2013), *all actors must have access to relevant data*. This is a very broad requirement and should be specified more in terms of access management. Another essential requirement for VBHC is the *ability to exchange data* and data should be available for *analysis on patient-level* and *on an aggregated level*. These requirements facilitate the principles ‘continuous learning’ and ‘maximising value for patients’.

In all circumstances, *patients should be in control of their own patient journey*. That means that patients should have all relevant information available to make informed decisions about received care. Furthermore, patients should be informed when their data is consulted by others. This establishes patient empowerment.

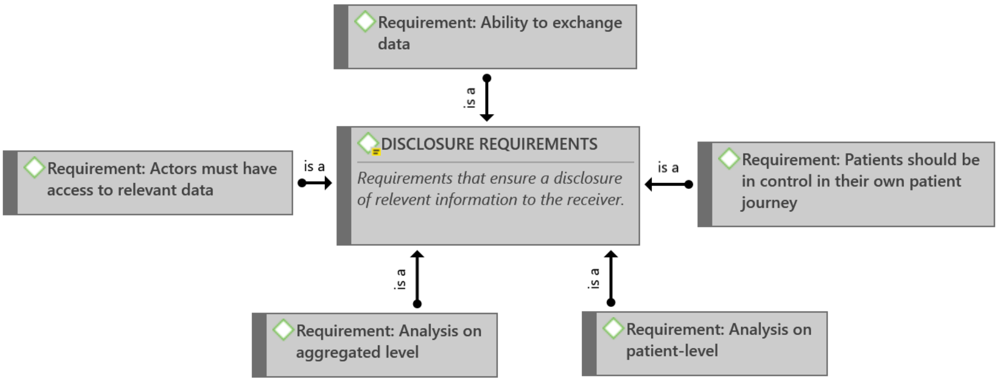

Figure 5.10: Overview of requirements for disclosing relevant information

Clarity

Requirements that are categorised under clarity involve notions about the communication and presentation of information. At a higher level, it was mentioned that before implementing something the *objectives and plan should be communicated* clearly. According to interviewee 2.4, successful implementation can only be achieved by frequently informing stakeholders. Associated with that requirement is determining *roles and responsibilities*. At an operational level, the *presentation of information should be tailored to the audience*. For example, a patient requires a different vocabulary or visuals to understand information than a physician. Information can be presented in an easy way to the patient, there should, however, always be a *possibility to get information explained by a professional*. Finally, it is important that the *effectiveness of communication is evaluated* for the purpose of further improvements.

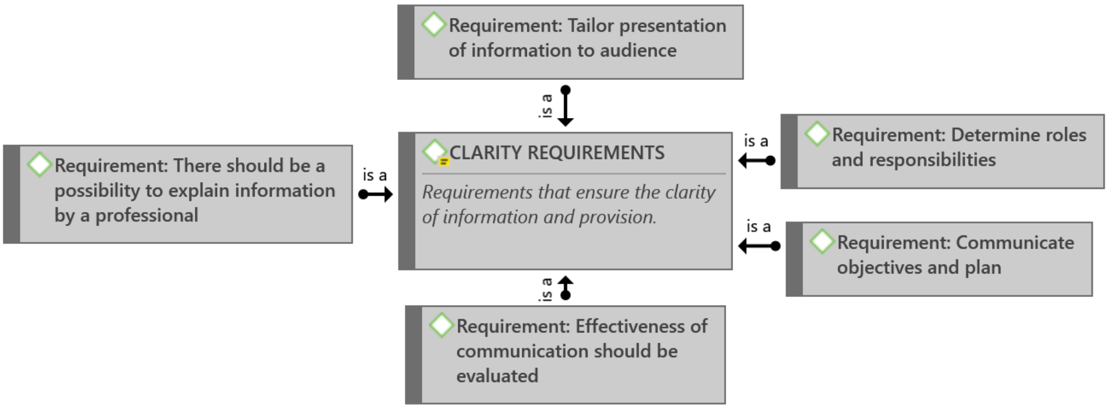

Figure 5.11: Overview of requirements for communication and presentation of information

Accuracy

The most mentioned requirements for accuracy are *standardising information- and data models* and *define value and outcome indicators*. Both these requirements refer to the principle ‘unity of language’. If data is structured according to standards, it is easier to *reuse data for different purposes*. Reusing data saves time and is less prone to human error and thus increasing accuracy. Further, underlying *IT processes should be robust*. This can be realised by automating processes to reduce human errors. In addition, *data should be validated*. An important notion by interviewees 2.1 and 2.2 is that if the receiver recognises themselves in the data it will positively influence the perceived data accuracy. Finally, there should be *multiple sources of data*. Interviewee 2.3 emphasizes the importance of multiple sources of truth. Achieving similar results with various data sets increases the perceived accuracy.

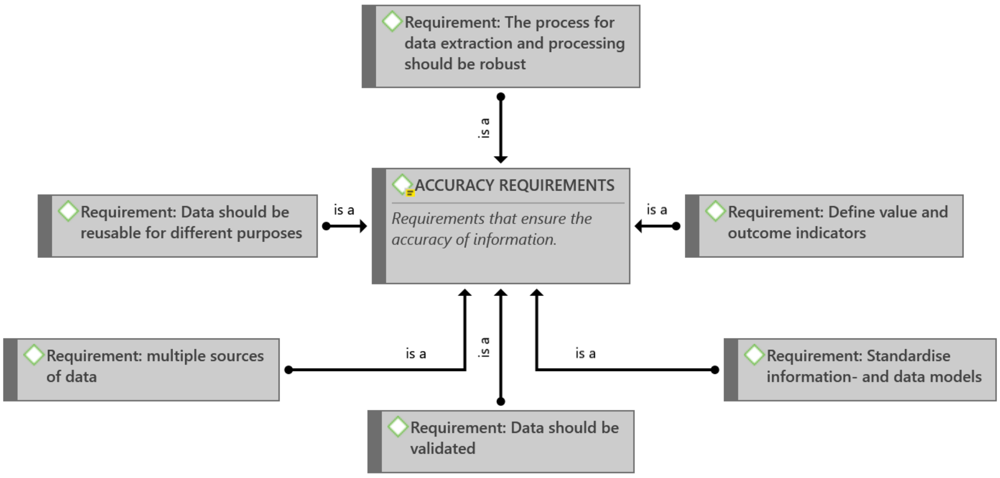

Figure 5.12: Overview of requirements for ensuring accuracy of information

5.3.4 Components Architecture

The interviewees noted many solutions to fulfil the principles and requirements mentioned above. These solutions will be discussed according to the five layers of the Nictiz model.

Organisation

The highest layer includes law and regulations, and organisational policy. Needlessly to say, all actors have to comply with the law and regulations that were set by the government. However, some current laws hamper analysis on an aggregated level. Interviewee 2.2 notes that *"In other countries, the use of medical data in the context of quality research is regulated by law. However, with the condition that it is pseudonymised. In my opinion, we have not yet sufficiently arranged this for the Netherlands."* The first component, therefore, is to add *an addendum that allows for clinical research without consulting the patient for consent*. In addition, for analysis on both aggregated as well as patient-level data, *determining IT capabilities* is essential according to interviewee 2.2.

Other important elements in this layer are the *organisational structure and roles and responsibilities of actors*. For structure, *governance of IT systems* is necessary to support people in using the systems as they were designed for. To this end, a *'go-to' point to report issues* was mentioned by interviewee 2.1 as people often do not know where to go with questions or errors. The roles and responsibilities are in line with the stakeholder analysis conducted in chapter 4. The most important notions for transparency were:

- Patients are care receivers and should be empowered to take control of their own patient journey. They are, however, not responsible for managing their health records.
- Providers are responsible for recording and managing medical data.
- Insurers should be taken a partnership role instead of a controlling one.
- The government should use its power to impose standards to steer actors in a direction for a solution.

Interviewee 2.3 expresses concerns about the relationship between insurers and providers: *"Transparency can be the means to remove all the stigmas and provide opportunities for good and sustainable solutions [...] if you want to use transparency to improve, then the power level of actors must be neutralised."* The interviewee suggested an *independent party to mediate* between insurers and providers.

Business processes

The care processes are the operational processes to realise value for the patients. For VBHC it is necessary to *tailor care processes to the needs of the patient* and *measure and evaluate the health status* frequently so that the effectiveness of the treatment can be revised. *Patient-reported outcome measures (PROM)s and Patient-reported experience measures (PREM)s* questionnaires were repeatably mentioned by all interviewees as a means to indicate the perceived health status and perceived care service experiences. Furthermore, implementing standard moments for *shared decision-making* facilitates patient-centredness. In order to make an informed decision, patients should receive outcome information of both their own situation and general outcome information for the medical condition. Interviewees 2.1 and 2.2 mention that information should be first provided face-to-face during the consult so that it can be explained in detail. This contradicts with interviewee 2.4 who argues that information should be accessible upfront so the patient can prepare for the consult.

Crucial for adding value and measuring outcomes is to have an *accurate administration*. Interviewees 2.1 and 2.2 notice that the perceived accuracy of information is influenced by whether *one recognises themselves in the data*. Several components were identified to increase trust in administration and processing of data: *audit processes*, *human verification*, and *technical verification*. Audits can either be internal or external. By human verification is meant that the data must be verifiable by the patient and clinicians. Technical verification entails checking the overall quality of the data set. This will be further discussed in the application components.

Exchanging data and information across health organisations leads to new dynamics in business processes. First, on an individual level, it enables clinicians to receive relevant information (e.g. patient history). This leads to more interaction between clinicians and *consultation within or across disciplines and organisations* is getting more common. Second, on an aggregated level, it may raise questions 'how can institution X achieve such a low rate of recidivism for population Y?'. Interviewee 2.1 mentions that it is common that *working visits* take place to learn from each other.

Interviewee 2.3 mentioned an interesting component: a *'feedback loop of understanding'*. By using feedback mechanisms clinicians can learn whether information was clear to the patient. Other way around, this is the same for information from the patients side. It is important that during consult clinicians *ask a patient questions to verify understanding*. Also, understanding can be evaluated if expectations of the treatment have been met, for example with PROMs and PREMs.

Information

Interviewee 2.1 distinguishes three types of information: (i) Outcomes, (ii) Process, and (iii) Costs. Outcomes are related to the patient's health status, process to the efficiency of activities, and costs to the monetary price. In table 5.3 the level of interest in each information type is shown per actor[2].

Table 5.3: Types of information and relevance per actor

Actor	Outcomes	Process	Costs
Patient	++	+ -	- -
Physician	++	+	-
Healthcare management	+	++	++
Insurance company	+	+	++

Following the requirements, the information presentation should be tailored to the audience. For patients, this means *simple visualisations and textual explanations* of their own health status and progression. Interviewee 2.1 and 2.4 emphasize that *being transparent to patients increases willingness to actively participate and to provide more information*, which enhances the data accuracy. Besides personal outcome information, patients are curious to see how others experienced the disease and their outcomes. Therefore, *patient-like-me* is a value-adding component for patients. Patients are less interested in the data provenance, used methods and how data was processed. It is however important to show *differences in outcomes between institutions* so that the patient can make informed decisions.

Different from patients, providers (i.e. clinicians and management) and insurers are interested in how this information is constructed and what definitions are used. That is vital for comparing information. Aggregated information can be presented *internally within the organisation* or externally where it can be used to *benchmark providers*. Analysing aggregated information and differences between them leads to new insights. Interviewee 2.2 points out that if there is a sound and valid method to present outcome information, insurers can take this into account for contracts. Transparency can therefore pave the way to value-based contracts.

For outcome information, many indicators were mentioned. While their is no common definition of the concept value, all interviewees argued that outcome indicators entail much more than just the clinical outcomes. The following indicators were mentioned:

- Clinical outcomes (e.g. mortality, complications, functional status)
- Sustainability of achieved health status
- PROM
- PREM
- Quality of life
- Life goals

Interviewee 2.3 notes that: *"There should be agreement on a process that guarantees the value of a treatment. That is currently not the case. [...] We all have elements, but there are no uniform measurement units that we everyone can use."*. This refers to the fact that there is no agreement on a definition of value which results in various components to

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[2] Indicators table 5.3: very important (++), important (+), neutral (+-), slightly unimportant (-), unimportant (- -)

measure value. A component is to determine *outcome indicator sets per medical condition*. As mentioned in chapter 2, the national programme 'outcome-based healthcare 2018-2022' and ICHOM determine disease-specific outcome indicator sets. According to interviewee 2.4 the *sets of ICHOM are outdated and complex to implement* in practice.

Fundamental to information is data. In operational processes, the *availability of patient's medical data*, for example, the medical history, is essential to provide personalised treatments. A component that can realise this is *BgZ*. To gather all this information in an efficient way, data exchange standards should be used. *HL7 FHIR / CDA* is a commonly used standard for exchanging data.

As noticed in requirements 'information- and data models should be standardised'. Components that can achieve this are using common models such as the *OMOP model* for data, *Zibs* for information, and *SNOMED-CT* for terminology. Interviewee 2.1 argues that the outcome indicators defined in the programme 'outcome-based healthcare 2018-2022' *fit approximately 80% of the Zibs*. In addition, the interviewee pointed out that the *Zib: 'problem' could be an essential component* for VBHC because it contains the diagnosis.

Application

The most important applications that were mentioned are: (i) HIS and EHR, (ii) PHE and patient portal, and (iii) a platform for quality registration. Notions about each of these applications will be discussed below.

First, for the EHR it is important that it is *easy to find where to fill out the information*, to prevent that information is put in free texts. This unstructured data is hard to process and compounds the problem of data extraction and integration. Further, there should be a *tool to report issues*. This has the advantage of

In order to facilitate data exchange among healthcare organisations, interviewee 2.4 suggests that all healthcare providers could be using a HIS from one specific supplier. On the one hand, this may prevent vendor lock-in. On the other hand, it contradicts earlier statements that providers should be able to choose their own systems because that stimulates innovation in the market. Whether the HIS supplier is the same or different it should be possible to exchange data. A suggested component is a *connection between applications* so that data can be easily extracted and reused. An *ETL process* is an important component because it is used to transform data into a readable format. For example, mapping data from 'woman' to 'female'. Finally, physicians should have the *option to withhold information* when exchanging data. For example, in case it is considered irrelevant for the patient's demand of care or when there is a risk to bias another physician.

Second, the institutional patient portal and PHE provide patients access to their own health records. Interviewee 2.4 mentions that the patient portals are insufficiently accessible. Many components were mentioned by the interviewees to increase transparency for patients: *tools to ask for explanation*s and *to report issues*, *FAQ or chatbots*, *dashboards* and/or *digital patient journeys (i.e. process)*. In addition, similar to the physician, patients should have the *option to withhold information*. In a PHE the patient has access to their medical data from different healthcare providers by using the networks of Medmij. However, insurers are not included. Including *insurance information in PHE* can add value for the patient because all health-related information is accessible via one interface.

Third, the quality registration was discussed. Currently, data is provided by healthcare providers to the quality registration institutions, where data is processed. When the quality registration provides the data back as information, it often leads to many discussions. According to interviewee 2.1, this stems from the fact that data processing is external and not transparent. The interviewee points out that: *"the closer data is processed to the source, the more trust there is in data"*. Therefore, a component is *in-house data processing*. The data that is sent to the quality registration should not be identifiable to an individual person. Ways to safeguard privacy are: *pseudonymisation*, *data randomisation* and *data perturbation*. In addition, insurers and providers should be able to access quality registration.

A final note of application is about establishing the accuracy of data because it is crucial for the perceived information quality. Hence, interviewees noted that *technical verification*, *logging of data adjustments*, and *testing information systems* are important components.

IT-infrastructure

The infrastructure is one of the most important layers for data exchange. It was noted that providers could use an *intermediary for data exchange*. For example LSP. Furthermore, interviewees 2.1 and 2.3 mention the use of a *platform that provides outcome information*, which can fulfil the requirement to analyse data on an aggregated level. Interviewee 2.1 notes that the *level of security must be aligned* in order to exchange data.

Most marked quotations involved increasing the accuracy of the data. This includes: *validation of medical equipment*, *using various databases (e.g. public institutions, PHE, Vektis (insurance data))* and *data provenance*. The latter is important for accuracy because stakeholders need to know where the data is coming from to perceive it as accurate. There were, however, no specific components mentioned to achieve this.

5.4 SUMMARY EXPERT INTERVIEW ANALYSIS

In this chapter, the findings from the semi-structured interviews were discussed and analysed. The interviews were divided into two phases: preliminary interviews and in-depth interviews. This section will provide a summary of the findings.

Preliminary interviews. The problem has been explored in more depth through interviews with experts from different backgrounds and aimed to answer subquestion 2: *"How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?"*. The interviews showed, in line with the literature review, that IT indeed is one of the major barriers for outcome measurement and thus VBHC. Another important barrier found was the low level of trust between stakeholders. Even if other IT barriers were eliminated, it is still not likely that VBHC would be a success. In fact, ill-defined outcome indicators and no uniformity of measurement procedures would only lead to more administrative efforts and there still would be mistrust on data, but then based on the achieved outcomes. For that reason, establishing a level of trust is an essential prerequisite.

Trust, trustworthiness and transparency. The analysis was scoped down to the trust issues. Trust can be defined as "the willingness to be vulnerable based upon positive expectations of the behaviour of others" (Rousseau et al., 1998). The level of trust is influenced by the perceived trustworthiness. Transparency is an antecedent of trustworthiness and can be managed through mechanisms for disclosure, clarity and accuracy. A transparent VBHC solution would provide the following benefits: (i) improve quality continuously as providers can learn from each other, (ii) improve decision-making based on data, (iii) provides an opportunity for value-based payments and (iv) increases patient empowerment.

In-depth interviews. The concept of trust and transparency were the point of focus for the in-depth interviews. The interviewees acknowledged the trust issues between stakeholders and that indeed transparency could be a part of the solution. While increasing transparency has the potential to facilitate a transition towards VBHC, it also comes with risks, such as competitive disadvantage, tendency to contrive data and privacy risks. These risks should be taken into account in the design. Further, principles and requirements to increase transparency in the architecture were captured. Finally, the interviewees mentioned a wide variety of possible components to fulfil these principles and requirements. This provides a solid basis for the design phase in order to answer subquestion 3: *"What components could be incorporated in the IT architecture to facilitate a transition towards VBHC?"*.

6 DESIGN

This chapter presents the components that can be integrated into the IT architecture to tackle IT barriers and enhance transparency. First, the architecture vision explains the objectives and how stakeholders needs are fulfilled. Next, principles and requirements are determined to guide the design efforts. Subsequently, components that realise the architecture vision are presented using the layered model of Nictiz. Finally, improvement opportunities of the architecture are discussed.

6.1 ARCHITECTURE VISION

The architecture vision aims to provide a high-level overview of the desired to-be situation. It describes the drivers for change, the objectives of the architecture and how stakeholders concerns are addressed (The Open Group, 2018). The main driver for change are the current problems the Dutch healthcare system is facing. VBHC is a candidate framework to reform healthcare from a volume-based to a value-based system.

Through literature research, it was found that current IT systems hamper a transition to VBHC. Specific deficiencies in the as-is architecture entail *a lack of patient-centredness*, *inaccessible or unavailable data*, and *complex to extract and integrate data*. Purely focusing on the technical aspects would however not lead to a successful transition as it depends on the way actors interact with it. Analysis of the semi-structured interviews revealed that *trust is a vital element* to unlock the potential of VBHC. This architecture aims to facilitate VBHC through integrating components that reduce or eliminate the IT barriers and increase transparency. The main objective and envisioned implications are described in the textbox below.

ARCHITECTURE VISION

The main objective of the architecture is: ***"to increase interoperability and transparency in healthcare systems"****. This would lead to:*

- ***Patient empowerment:*** *At the heart of VBHC is the patient. Patients should be able to make informed decisions about their patient journey. They have the right to choose a healthcare provider that fits their needs best. Access to personal outcome information and general outcome indicators is key to achieve patient empowerment.*
- ***Continuous quality improvement:*** *VBHC is about continuous quality improvement of healthcare on a personal and societal level. Operating in an isolated environment will not contribute to this vision. The architecture should stimulate providers to collaborate across the care cycle and share information. Moreover, comparing outcomes allows healthcare professionals to discuss differences and come to new insights.*
- ***Value-based contracts:*** *Transparency on outcomes can provide an opportunity to move away from ill-structured financial incentives and allow insurance companies to pay for delivered value. This encourages providers to aim for maximum value.*

6.2 PRINCIPLES

For the development of the design, the Hospital Reference Architecture (ZIRA) will be followed. ZIRA offers basic and derived principles that are based on NORA, DIZRA, TOGAF and best practices from hospitals. The five basic principles are listed in Section 4.3. ZIRA principles are the foundation for the design efforts but are tailored to the objectives of the design as outlined in the Architecture Vision. Too many principles can reduce the flexibility of the architecture that (The Open Group, 2018), hence, the most relevant principles have been selected. Principles are adjusted based on findings from the semi-structured interviews. Table 6.1 presents the selected principles. The last column refers to the sources of ZIRA principles, interview IDs or literature.

Table 6.1: Principles architecture

Principle	Statement	Source
P1: Patient's value comes first	Healthcare services are patient-centred and aim for maximum value to achieve.	ZIRA 1; (Porter & Teisberg, 2007); (1.1); (1.2); (1.3); (1.4); (2.1); (2.2); (2.3); (2.4)
P2: Unambiguous and one-time recording of data	Information is stored in a structured, uniform way that allows for interpretation and reusability for different purposes	ZIRA 3; (1.4); (1.7); (2.1); (2.2); (2.3)
P3: Quality can be derived from the care process	Stakeholders should have insight in care processes and quality of provided care	ZIRA 5; (1.2); (2.1); (2.2); (2.3); (Kroneman et al., 2016)
P4: Collaborate and continuous learning	Stakeholders learn from data and each other.	ZIRA 2; (1.1); (1.4); (1.7); (2.1); (2.2); (2.3); (2.4)

6.3 REQUIREMENTS

Bahill and Dean (2009) define a requirement as *"a statement that identifies a capability or function that is needed by a system to satisfy its customer's needs"*. The requirements are derived from the architecture vision and principles and are based on the literature review and the semi-structured interviews. They are the means to achieve the vision and state what the design should or must apply to (The Open Group, 2018).

Requirements can be either functional, describing what the architecture must or should be capable of, or non-functional describing how the architecture should behave in terms of performance and usability (Bahill & Dean, 2009). For example, for VBHC, the architecture must be capable to offer care providers patient-related (clinical) data to analyse. It should be presented with simple graphics for patients to understand. Here, the first is functional and the second is non-functional. The requirements are presented in Table 6.2. The requirements are identifiable by their ID: R (requirement) + number and the type of requirement is indicated by F (functional) or NF (non-functional).

Table 6.2: Requirements architecture

ID	Requirement	Principle(s)	Type
R1	Patients must have access to their own medical records	P1, P3	NF
R2	Patients must be able to make informed decisions	P1	NF
R3	The care process should be based on patient's care demand and individual preferences	P1	NF
R4	Patients should be informed actively by the provider (push)	P1	F
R5	Providers should be able to access medical data without permission under very special circumstances	P1	F
R6	Data must be available for analysis on a patient-level	P1, P3	F
R7	There could be a feedback loop to assess understanding	P1, P4	F
R8	Information must be stored modular	P2	F
R9	Information should be reused by information systems	P2	NF
R10	Outcome indicators should be based on disease-specific templates	P1, P2	F
R11	Information model standards must be used	P2, P3	F
R12	Terminology standards must be used	P2, P3	F
R13	Both structured and unstructured data must be exchangeable	P1, P2	F
R14	Data exchange must be based on standards	P2	F
R15	Aggregated outcome information should be publicly available	P1, P3, P4	F
R16	Data should be associated with detailed provenance	P3	NF
R17	Care providers must have access to relevant information for care provision	P1, P3	NF
R18	There should be a person or department within healthcare organisations responsible for data quality	P3	F
R19	The process for data extraction and processing should be robust and reliable	P3	NF
R20	Aggregated data must not be traceable to individuals	P3, P4	F
R21	Information systems must at least comply with law and regulations regarding information security (e.g. GDPR and NEN7510)	-	NF

6.3.1 Prioritising Requirements

The design aims to comply with all the requirements as stated in Table 6.2. Requirements can be categorised into objectives and constraints. *Objectives* are features or behaviours that the design should have or perform and *constraints* are restrictions on the design or components (Dym, Little, & Orwin, 2013). If a constraint is not fulfilled, then the design is unacceptable. To prioritise requirements, the MoScoW method is used. The priority of the requirement is categorised into the following four groups:

- 'Must' meaning that the requirement must be fulfilled.
- 'Should' meaning that it is highly desirable to fulfil this requirement.
- 'Could' meaning that it is desirable to have but not essential.
- 'Won't' meaning the requirements will not be fulfilled in this design.

To successfully design the components and realise the architecture vision, at least the 'must' requirements (e.g. constraints) should be fulfilled. There must be compliance to at least: R1, R2, R6, R8, R11, R12, R13, R14, R17, R20 and R21.

6.3.2 Metrics to Measure Achievement of Requirements

Whereas objectives can be met to a certain point of satisfaction, constraints are typically binary and are either satisfied or not. Compliance with the objective requirements will be assessed by a qualitative value analysis. A qualitative approach is selected to measure the achievement of the objectives with a point rewarding system, indicating the degree of satisfaction where 0 is unsatisfactory and 2 is very good. The achievement of constraint requirements will be assessed through a binary scale. However, some constraint requirements demand a 'yes-or-no' answer and additionally a value scale. For example, 'R1 patients must have access to their own medical records' can be answered with yes or no but requires also the degree of accessibility (no access, partial access or complete access). Table 6.3presents the metrics to measure the achievement of the requirements.

Table 6.3: Metrics to measure achievement of requirements

ID	Type	Metric
R1	M	No: No or limited access (0) Yes: Access to part of the record in different places (1) Yes: Access to complete record in one place (2)
R2	M	No: Patient does not have any information or a say in the process (0) Yes: Patient has some information and is involved in decision-making (1) Yes: Patient is well informed by multiple information sources and can take decisions during the entire care process (2)
R3	S	No: One-size fits all (0) Yes: Standard care process with evaluation (1) Yes: Care process is tailored to patient's care demand and frequently evaluated (2)
R4	S	No: Not informed about updates in record (0) Yes: Actively informed about about updates (1)
R5	S	No: No access possible (0) Yes: Access possible under special circumstances (1)
R6	M	No: No data available (0) Yes: Basic information is available (e.g. BgZ) (1) Yes: All data necessary for analysis is available in the appropriate format (2)
R7	C	No: There is no feedback loop Yes: There is a feedback loop
R8	M	No: Information is not stored modular (0) Yes: Part of the information is stored modular (1) Yes: All information is stored modular (2)
R9	S	No: Information cannot be reused (0) Yes: Information can partly be reused and partly overlaps with other information (1) Yes: Information is stored once and can be reused (2)
R10	S	No: Indicators are not based on any disease-specific templates (0) Yes: Indicators are partially based on disease-specific templates but slightly differ per provider (1) Yes: Indicators are based disease-specific templates and enable value achieved to be compared (2)
R11	M	No: No information models are used (0) Yes: Information is partially based on data and information standards (1) Yes: Information is fully based on data and information standards (2)

ID	Type	Metric
R12	M	No: No terminology standards are used (0) Yes: Terminology standards are partially used but some definitions can be ambiguous (1) Yes: Terminology standards are the norm and organisations have the same understanding of information concepts (2)
R13	M	No: Structured and/or unstructured data cannot be exchanged (0) Yes: Structured and unstructured data can be exchanged between actors (1)
R14	M	No: No exchange standards are used (0) Yes: Exchange standards are used (1)
R15	S	No: No information is publicly available (0) Yes: General outcome indicators (e.g. waiting times) are available (1) Yes: Clinical and process outcome indicators are publicly available (2)
R16	S	No: Data is not accompanied by any logging information (1) Yes: Data is accompanied with a digital signature (i.e. author and timestamp) (1) Yes: Data is accompanied by a digital signature and a logging history (2)
R17	M	No: Care providers have no access to relevant information (0) Yes: Care providers have access to minimum information for care provision (1) Yes: Care providers have access to all relevant information for care provision (2)
R18	S	No: There is no one responsible for data quality (0) Yes: There is a person or department responsible for data quality (1)
R19	S	No: Outcomes fluctuate and the system is affected by small variations in input (0) Yes: Outcomes are reliable, but is affected by human errors (1) Yes: Outcomes are reliable and the system actively indicates errors (2)
R20	M	No: There is possible information that can be related to an individual (0) Yes: Information cannot be traced back to individuals (1) Yes: Information cannot be traced back to individuals and additional state-of-the-art techniques are used (2)
R21	M	No: The design does not meet information security regulations (0) Yes: The design meets information security regulations (1) Yes: The design meets information security regulations and additional state-of-the-art security measures (2)

6.4 ARCHITECTURAL DESIGN

This section presents the to-be architecture and components to realise it. Figure 6.1 shows the high-level overview of the envisioned IT landscape. The boxes show the environments where data is created, stored and used. The arrows show how data and information flow from one environment to another through networks.

At the top of the figure, the *healthcare providers* are visualised. Healthcare providers create medical data and record this in the HIS. Data is processed into information and can be analysed through an interface. To facilitate the extraction and integration of data, a *data integration centre* is proposed. Following the suggestion of interviewee 2.1, data is processed in-house to provide insight into how data sets are constructed. The integration centre is inspired by the article Winter et al. (2018) and has the function to ingest data, nourish and transform it into commonly used structures. The integration centre generates two types of structured data sets: *personally identifiable data* (n=1 level) and *pseudonymised data* (aggregated level). The data can be transported through HL7 CDA and FHIR data exchange standards. For data exchange with the PHE the *Medmij network* is used (Medmij, 2021). The *AORTA infrastructure with the LSP* can be used to exchange data with other providers (illustrated at the left top) and to provide pseudonymised data sets to the Quality Registry.

The *PHE* is an essential application that allows the patient to view their medical data from different sources in one place. Patients can connect their PHE to the HIS of healthcare providers if, and only if, there is a care provision agreement. In addition, patients can add data and information themselves, for example, via wearables. Patients can decide to share additional information with a physician. For example, laboratory results obtained from another provider. This information is also sent via the Medmij network. It enters the data integration centre where it is transformed to readable formats. The patient can view their own patient journey in the form of a dashboard. This includes a care path (i.e. process), progression and outcome indicators. In addition, it is connected via an API to the quality registration so that they can view *'patients-like-me'*.

The *Quality Registry* extracts pseudonymised data sets from healthcare providers. In these data sets outcome indicators and process indicators are included. Outcome indicators consist of clinical outcomes and patient-reported outcomes (PROMs). The process indicators involve efficiency indicators (e.g. waiting time to first consult) and patient-reported experiences (PREMs). The Quality Registry processes the data from the provider and loads it into a database. A web service provides access to the data and is used to different interfaces to interact. For patients, a special interface is provided with visuals, infographics and textual explanations. For other stakeholders, the interface contains more detail on data provenance and how data is constructed.

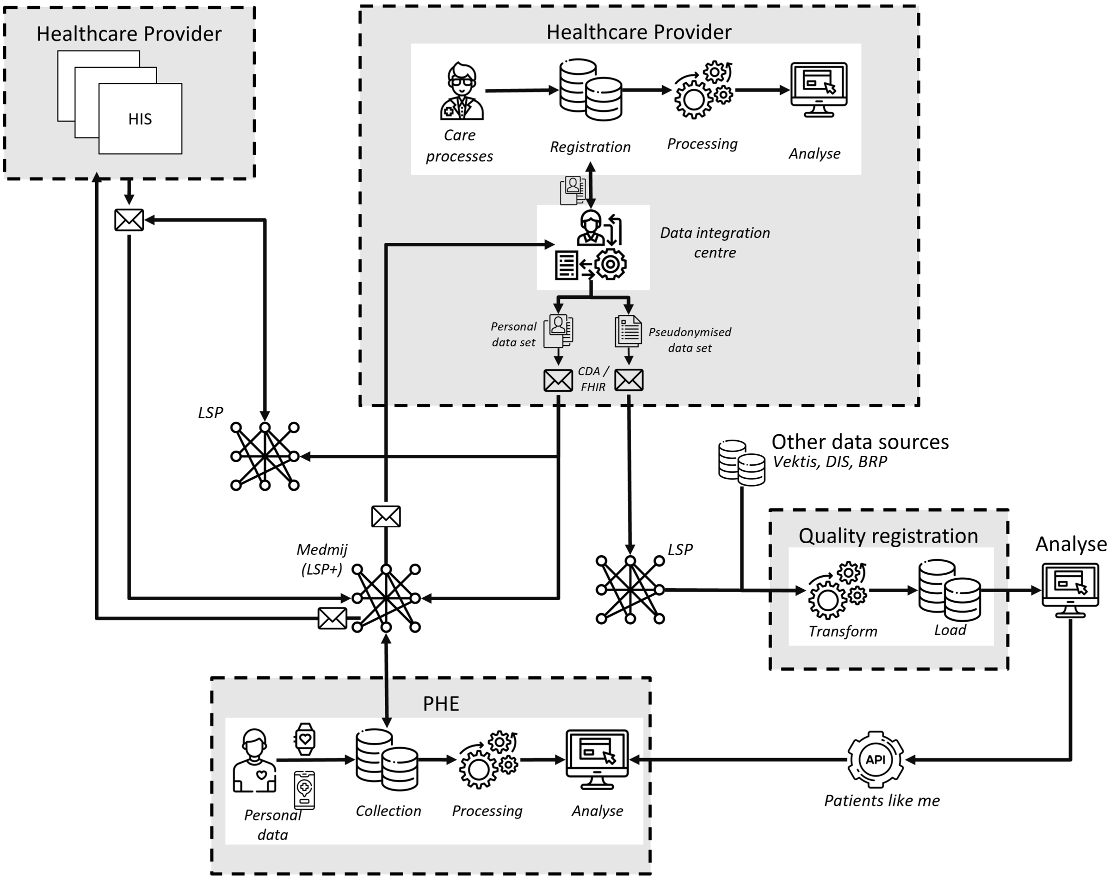

Figure 6.1: High-level overview of to-be situation

Next, the components are presented per layer. The components are identifiable through an ID: C (component) - X (name layer) + number. For example, C-O1 refers to the first components in the organisational layer.

6.4.1 Organisation

The top layer of the architecture concerns the business strategy, organisation, governance and agreements on a strategic level. Originally, Organisation and Law & Regulations are separated in the Nictiz layered model. For simplicity, these are merged in the design.

Law and regulations

To assess the quality of healthcare providers and to create a learning community, outcome indicators must be publically accessible (R15). A couple of years ago, Akwa GGZ, a quality registration institution in mental healthcare (GGZ), gained attention. They collected outcome measures and processed these into useful insights to learn from. However, there was no explicit consent from the patients. In addition, DPA concluded that data was insufficiently pseudonymised, violating several laws such as the GDPR (Dutch Data Protection Authority, 2019, p.25). To adhere to R15 - taking into account that data must not traceable to an individual person (R20) - the following component is suggested:

> C-O1: An addendum that legally arranges data analysis on an aggregated level (anonymous) without explicit permission patient

Agreements

Whereas law and regulation refer to strict compliance, agreements refer to general procedures, protocols and guidelines that have a high preference but are not mandatory. To adhere to R10, there should be disease-specific outcome indicators. What indicators are relevant to measure and evaluate during the care process? How should it be measured? And how many times? C-O2 aims to fulfil this requirement.

> C-O2: Agreement on outcome indicators and measurement methods per disease

Another agreement concerns data availability. According to the wgbo law, healthcare providers are not allowed to exchange data without the explicit consent of the patient. In emergent situations, it is desirable to have the basic medical history of the patient. For example, a patient summary. There should be a protocol to figuratively 'break the glass' and provide caregivers necessary information (R5). Whenever this option is used, patients must be informed with a notification (R4).

> C-O3: Agreement on procedures and which circumstances a caregiver can access without patient's permission ('break-the-glass')

Last, but not least, there should be agreement on standards. This component is very broad and general by purpose because there are many standards for different domains, professions, treatments, and so on. The most important standards to be agreed upon for semantic interoperability are: information standards (R11), data model standards (R11), terminology standards (R12) and exchange standards (R14).

C-O4: Agreement on standards in healthcare

Roles & responsibilities

For the design, the most important actors are considered to be the patient, healthcare provider, insurance company and the government. The HIS suppliers have both interest and power in VBHC but are not considered for the architecture. The roles and responsibilities are referred to as a component in the architecture.

C-O5: Roles and responsibilities

- Patients are partners in the care process but are not responsible for managing their own health record
- Physicians are responsible for care provision and data accuracy
- Management is responsible for communication of strategy and goals
- Insurers are partners and should facilitate learning opportunities
- Government is a facilitator (i.e. law, subsidies)

Organisational structure

To increase both the perceived clarity and accuracy of the provided information, there should be possibilities to offer feedback. Feedback can include unclear information, for example, a patient does not understand the results of a test or a physician misses certain graphs to interpret results. Further, the feedback includes reporting incorrect information. This component addresses R3 and R7. The department collects these issues and handles these or delegate them to the responsible person, department or organisation.

C-O6: In-house department for feedback on information systems

6.4.2 Business processes

The business processes are divided into care processes and supporting processes. The care processes are the operational processes within healthcare institutions to realise value for the patients. Supporting processes facilitate the care processes.

Care Processes

For VBHC it is necessary to tailor care processes to patient's health demand (R3) and let the patient be part in the decision-making process (R2). An example to illustrate this was given by interviewee 2.1: *"If you have to switch to kidney function replacement therapy. What are the effects of a kidney transplant? and how does a living donor transplant compare versus a deceased donor transplant? and how does that compare with home dialysis versus centre dialysis, or perhaps no dialysis at all, so no treatment? Dialysis is quite impactful and kidney transplantation is often not possible or does not prolong life enough. So in some cases the quality of life is even better than if you give all kinds of therapies."*

The type of treatment selected is up to the patient and physician. Every patient has different needs and wishes. For example, the elderly could prefer no treatment since it offers a higher quality of life. A standard shared decision-making moment should be incorporated into the generic care process (C-P1).

C-P1: Standard shared decision-making moment

Further, care processes can only be truly patient-centred if there is data to act upon. The health status should be measured and evaluated frequently so that the effectiveness of the treatment can be revised. This includes both clinical outcomes and patient reported outcomes (i.e. PROM, PREM). C-P2 assures that the outcome indicators (as agreed upon in C-O2) are measured throughout the process.

C-P2: Standard measurement & evaluation moments

The information that is provided to patients and their care givers should allow for validation. Validation is divided into two categories human validation and technical validation. Human validation is conducted by the stakeholders in the care process (i.e. persons with access to medical record). Patients themselves can validate information in simple forms (e.g. personal information). Physicians validate information based on experience, data in combination with context and peer consultation. In addition, a second opinion can confirm or reject earlier findings. The treating physician is end responsible for data accuracy (C-O5). To establish accurate data, the following component is necessary:

C-P3: Validation of information

Supporting Processes

If information is provided in an unclear way, one must be notified. The way information is framed influences the perceived trustworthiness (Schnackenberg & Tomlinson, 2016). Therefore, it is important to evaluate communication effectiveness (C-P4). During the consults, patients must be asked whether they understood the information clearly. For collaboration and learning, organisations can discuss interpretations and implications. These sessions can be facilitated by the independent intermediary (C-O7). In addition, evaluation can be supported through applications. For example, measuring how many times is asked for more explanation in the PHE.

C-P4: Evaluate communication effectiveness

Finally, to increase the accuracy of information, audits must be conducted (C-P5). Internal and external audits assure quality and uniformity of care processes. In addition, IT audits must be executed to evaluate information systems and the associated processes to mitigate risks regarding data reliability (R19), privacy (R20) and security (R21). Audits must be performed for healthcare organisations, HIS suppliers, PHEs, insurance companies, Quality Registry and networks.

C-P5: Audit care and IT processes

6.4.3 Information

The information components in the architecture refer to creating, storing, maintaining, transforming and reusing information elements. Component C-O4 indicated the importance of agreement on standards. This especially applies to agreements that concern information architecture. If the information has been recorded in a certain way, which is not complete or uses a different format, information cannot be exchanged the right way (Sprenger, 2019). To adhere to P2 and the associated requirements R8, R9 and R11, the following component is proposed:

C-I1: Clinical building blocks (Zib)s are the standard

For semantic interoperability, reducing ambiguity in interpretation is required. Standardisation in terminology systems helps the architecture to increase the accuracy and clarity of the information. The Zibs use SNOMED-CT and LOINC as standards to describe the information elements. Additionally, these standards show relationships between definitions, offer synonyms and layman's terms. Consequently, these are the preferred standard for architecture.

C-I2: SNOMED-CT and LOINC are standard terminology systems

If information is recorded according to the Zibs, data sets can be created. As mentioned in Section 4.3, the patient summary (BgZ) is one of those sets. For a treating physician, at least the BgZ must be available to provide care (C-I3). Also, in emergent situations, the BgZ should be available for the caregivers (C-O3). Furthermore, there should be template data sets per medical disease (C-I4). Referring back to the example of chronic kidney disease, such a data set can include diagnosis, blood values, type dialysis, datum dialysis, etc. The combination of diagnosis and treatment is referred to as the DTC code. Recording outcomes per diagnosis, treatment and DTC code could eventually provide insight into the effectiveness of treatments per population group and healthcare provider.

C-I3: BgZ is standard medical history

C-I4: Template data sets per medical disease

Aggregated outcomes on the specific diseases provide valuable insights for both physicians and patients. They can understand their diagnosis and symptoms, investigate treatment options and associated risks. In the case of chronic kidney disease, this information can, for example, include average life prolongation for a woman between 40 and 50 years that had a living donor transplant. This information is called patients-like-me and supports patients and physicians in making informed decisions. Patients-like-me information should be available in the patient's personal healthcare environment (PHE) (C-A1).

C-I5: Patients-like-me

Finally, information is tailored to the specific needs of the stakeholder (C-I6). As a result of the disease-specific templates (C-I4), relevant information can be selected relatively easily. Care providers have an overview of the relevant information (R17). How and when information is acquired is important for providers as it allows them to assess the data quality. Detailed data provenance should be associated with the information (R16) (e.g. digital signature, logging history). Care providers and patients have both access to data analysis on a patient-level (R6) and aggregated level (R15). To provide all stakeholders access to outcome indicators applications C-A1, C-A2, C-A3, and C-A4 are necessary components.

C-I6: Information provision is tailored to stakeholder

- Patient: own record, outcome indicators (clinical & patient reported), patients-like-me
- Providers: outcome indicators (clinical & patient-reported), process indicators, data set construction
- Insurers: outcome indicators (clinical & patient-reported), process indicators, data set construction

6.4.4 Application

The application layer describes the assets that store, process, reuse, and distribute information within and across different information systems and environments to fulfil the end-users needs. Figure 6.2 presented an overview of the applications, processes, services and infrastructure.

Applications

In the architecture, the current patient portal is replaced by the PHE (C-A1), because it offers the patient access to their medical data in one place (R1). While these are at the beginning of implementation Patiëntenfederatie Nederland (2021), it has huge potential to let patients be in control in their own patient journey. The PHE should offer the following services: (i) provide medical information overview (structured / unstructured), (ii) provide patients-like-me overview, (iii) withdraw and add information, (iv) view and manage access to data, (v) notification service and (v) communication service. Additionally, the PHE must offer an option to the patient to withhold irrelevant data or withdraw access at all.

C-A1: Personal Healthcare Environment

The physicians provide care and record medical information in the Electronic Health Record (EHR), the clinical information system within HIS (C-A2). Here, they have access to relevant medical information (R17) and can analyse data on a patient level (R6) via an interface. Whenever information is added or adjusted, it will be logged by the data logging service (C-A5). If this concerns information that is shared with the patient in the PHE, the patient should receive a push notification (R4). For example, when a document is uploaded. The HIS should be compliant with (inter)national standards such as ISO27001 or NEN7510 (R21).

C-A2: Healthcare Information System and Electronic Health Record

The HIS is connected to a data integration centre (C-A3). All in- and outgoing information are transferred via the integration centre, where it is transformed to the right format. For outgoing information, data is ingested from the EHR and transformed into a transportable format (HL7 CDA or FHIR) (R13, R14). Incoming information is transformed to readable formats and loaded into the local EHR. For the Quality Registration, data from the EHR is extracted in batches, pseudonymised (R20) and loaded into a data warehouse. The Quality Registration system can extract the data from the data warehouse for quality analysis. Preferably, data should be extracted once a month.

C-A3: Data integration centre

The last application is the Quality Registration system. Currently, data is collected by DICA (Dutch Institution for Clinical Auditing) and processed by Medical Research Data Management (MDRM) to assess the quality of a healthcare institution. DICA does not store or process any personally identifiable information, but MDRM does. Recently, a news article revealed that MDRM moved their databases to the cloud of Google (Wolters, Sanne, 2020). While there is compliance with law and regulation, it raises questions about privacy and security. For that reason, it was chosen to process and pseudonymise the data in-house. Another reason is that it provides trust for the providers themselves. Interviewee 2.1 noted within the organisations information can be traced back to the source.

All the data extracted from the data warehouses are transformed and loaded into the database. Data is validated for missing or unrealistic values. The quality of the batch is reported back to the healthcare organisation. The analysis performed on the data sets is publically accessible via a web-based interface (R15). Important to notice is that insurance companies can include the outcome indicators into the contract negotiations, enabling value-based contracts.

C-A4: Quality Registry System

Application Processes and Services

An application service is an explicitly defined behaviour of an application. Application processes are a sequence of behaviours in order to achieve an outcome. To adhere to R16, data adjustments should be logged and monitored. This includes for example recording of medical data by a physician or data recorded by medical instruments and equipment. Data provenance (R16) is important for end-users to assess data quality. For aggregated outcome indicators in the Quality Registration, data should be accompanied with high-level provenance, such as organisation, time period and author type (e.g. patient-reported, GP, medical specialist).

C-A5: Data logging & monitoring service

The ETL process is used to extract data from the EHR to the data integration centre, transform it into a specific format and load it in the data warehouse. Another ETL process is used to extract the data from the data warehouse to the Quality Registration.

C-A6: ETL process

Validation services serve C-P3. Information can be technically validated for missing records, input data type, format, range, etc. Additionally, data is cleansed before it is used for analysis. For example, someone's length of 400 cm is not taken into account.

C-A7: Validation services

Components C-A8 and C-A9 concern privacy and security (R20, R21). C-A8 provides all services related to identification, authentication and authorisation. The roles and responsibilities (C-O5) define the access a person or entity had. Both the PHE and HIS are using Identity and Access management services. At all times, login and access history should be logged. This increases transparency in the system and its users.

C-A8: Identity and Access Management services

For the purpose of learning (P4), data must never be traceable to individuals (21). Data is pseudonymised with state-of-the-art techniques, for example, random number generator or encryption (European Union Agency for Cybersecurity (ENISA), 2021). The level of pseudonymity and used techniques must be legally arranged (C-O1) in order to ensure maximum privacy.

C-A9: Pseudonymisation service

C-A10 is the mapping service, which is essential to create structural interoperability. A mapping service 'translates' data from one data model to another one. For example, mapping Zibs to FHIR resources (C-A11).

C-A10: Mapping service

Information Exchange

Exchanging data and information is key in the architecture. When data is exchanged, for example Zibs, it must be mapped to data exchange standards. To facilitate this, HL7 standards are used. HL7 CDA (Clinical Documentation Architecture) is designed to exchange medical data, structured and unstructured. HL7 FHIR (Fast Healthcare Interoperability Resources) is also designed to exchange medical data but with the use of reusable resources (Registratie aan de bron, 2017). Whereas CDA exchange is facilitated in the form of a document, FHIR is at resource level[1]. Using HL7 standards achieves structural interoperability. In addition, both standards refer to the use of medical terminologies, which enables semantic interoperability of shared data (Winter et al., 2018).

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[1] More technical details can be found in the architecture document vol.2 by Registratie aan de bron (2017)

C-A11: Data exchange is based upon HL7 standards

6.4.5 IT infrastructure (Technology)

The IT infrastructure is the underlying architecture layer that facilitates data exchange by networks. A widely adopted network is the AORTA network, which uses a centre point called LSP to facilitate exchange. LSP does not store any medical data, only the references where data is stored are recorded in a referral index. Every exchange transaction over the network is logged. This again never includes any medical data . The AORTA network is preferred because it supports both functionalities to push and pull information. Another benefit is that all HL7 standards are supported (Registratie aan de bron, 2017). C-T1 refers to the current LSP, CT-2 to the Medmij-certified LSP+ network. The first will be used for data exchange between providers and the Quality Registry. The latter is used exclusively for exchange between PHE and providers.

C-T1: LSP is used for data exchange between HIS and Quality Registration system

C-T2: LSP+ is used for data exchange between PHE and HIS

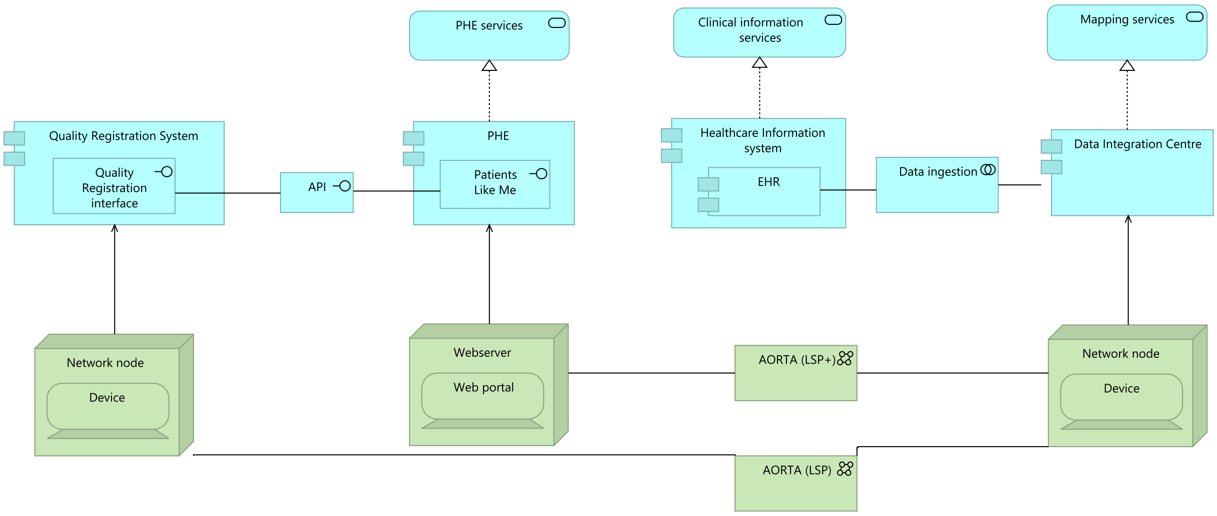


Figure 6.2: High-level overview of Application and Infrastructure layers

6.5 OPPORTUNITIES

The architectural design and components presented are mostly based upon existing components, elements and applications. Mjåset et al. (2020) argue that information technologies provide more opportunities to stakeholders than a couple of years ago. Emerging technologies, such as blockchain technology, Artificial Intelligence, and IoT, promise to transform the healthcare industry. One of the inherent characteristics of blockchain technology is transparency (Narikimilli, Kumar, Antu, & Xie, 2020), making it interesting to further investigate opportunities for future architecture.

6.5.1 Blockchain Technology for Healthcare

Blockchain technology has a distributed peer-to-peer network structure where all the nodes of the network have access to the same ledger (Narikimilli et al., 2020). Blockchain technology enables parties to trade valuable assets with each other in a trustless environment. The network follows cryptographic protocols to validate transactions, which makes a Trusted Third Party (TTP) obsolete. An advantage of removing a central intermediary is that the transaction process becomes more efficient and reduces transaction costs (Angraal, Krumholz, & Schulz, 2017). Moreover, once a transaction is stored in the blockchain it cannot be altered. The blockchain would reject maliciously modification of previous transitions and is considered to be immutable (Kuo, Kim, & Ohno-Machado, 2017). Further, there is no single point of failure, which increases the robustness and availability (Kuo et al., 2017; Narikimilli et al., 2020). Finally, a blockchain uses encryption techniques that enhances the privacy and security of data. Potential applications of blockchain in healthcare include, but are not limited to: EHR management, insurance claim process, consent management, clinical research and data provenance for the pharmaceutical supply chain (Kuo et al., 2017; Narikimilli et al., 2020).

6.5.2 Potential of Blockchain Technology for Architecture

A blockchain has several characteristics that can improve the architecture. Replacing the current decentralised network structure of AORTA with a distributed network would enhance the transaction process of requesting and receiving data. More importantly, all participating nodes in the network are independent and eliminates the control of the LSP. Additionally, *data provenance* is one of the requirements for the design (R16). If the data source is traceable and immutable, it would increase the perceived accuracy of the data.

6.5.3 Limitations of Blockchain Technology

Blockchain has much potential in healthcare. However, practical implementation faces some challenges. A blockchain can process a limited volume of transactions per time span, hence hampering scalability (Narikimilli et al., 2020). Privacy issues have been highlighted because with the transparency characteristics, 'everyone can see everything'. Even when data is anonymised, data might be traced back to a person (Kuo et al., 2017). Further, to achieve interoperability, agreement and following standards is crucial (Narikimilli et al., 2020). Soule (2020) emphasizes the importance of a standardised and structured language to improve interoperability in healthcare. While blockchain technology has the potential to be a component in the IT infrastructure layer, first steps have to be taken in standardising language, agreement on the definition of value and outcome indicators.

6.6 SUMMARY DESIGN

This chapter provided the components for the architecture to facilitate VBHC. Envisioned implications of the architecture are patient empowerment, continuous quality improvement and value-based contracts. The design efforts are guided by four main principles:

i) Patient's value comes first

ii) Unambiguous and one-time recording of data

iii) Quality can be derived from the care process

iv) Collaborate and continuous learning

Requirements are derived from the objectives and principles and based on either the literature or quotations from the semi-structured interviews. The requirements are prioritised according to the MosCoW method. The design has several constraints that must be complied with to state that the design is acceptable. The requirements are presented in Table 6.2. Binary and value scale metrics have been defined to measure the achievement of the requirements. Table 6.3 showed the metrics and will be used in Chapter 7 for verification of the requirements.

The overall design was presented with three types of environment. The first one is the HIS where the end-users are the clinicians, the second is the PHE that is used by patients and the third one is the Quality Registration and is available for all stakeholders. Several components are proposed per architectural layer to fulfil the principles and requirements. In addition, blockchain technology is a potential component to replace the decentralised network with the LSP. However, some limitations have to be addressed before this emerging technology is implemented in the design.

An overview of the components mentioned are presented in Table 6.4 and answer subquestion 3: *"What components could be incorporated in the IT architecture to facilitate a transition towards VBHC?"*.

Table 6.4: Overview requirements and components

ID	Component	Requirements fulfilled
Organisation		
C-O1	An addendum that legally arranges data analysis on an aggregated level (anonymous) without explicit permission patient	R15
C-O2	Agreement on outcome indicators and measurement methods per disease	R10
C-O3	Agreement on procedures in which circumstances a caregiver can access without patient's permission ('break-the-glass')	R5
C-O4	Agreement on standards in healthcare	R11, R12, R14
C-O5	Roles and responsibilities	R18
C-O6	In-house department for feedback on information systems	R3
Processes		
C-P1	Standard shared decision-making moment	R2, R3
C-P2	Standard measurement and evaluation moments	R2, R6
C-P3	Validation of information	R18
C-P4	Evaluate communication effectiveness	R7
C-P5	Audit care and IT processes	R18, R19, R20, R21
Information		
C-I1	Clinical building blocks (Zib)s are the standard	R8, R9, R11
C-I2	SNOMED-CT and LOINC are standard terminology systems	R12
C-I3	BgZ is standard medical history	R17
C-I4	Template data sets per medical disease	R10, R15, R17
C-I5	Patients-like-me	R2, R15
C-I6	Information provision is tailored to stakeholder	R2, R6, R15 R17
Application		
C-A1	Personal Healthcare Environment	R1, R2, R4, R6, R7, R15
C-A2	Healthcare Information System and Electronic Health Record	R4, R5, R6, R17, R21
C-A3	Data integration centre	R9, R13, R14, R16, R19, R20
C-A4	Quality Registry System	R15
C-A5	Data logging and monitoring service	R16
C-A6	ETL process	R19
C-A7	Validation services	R18
C-A8	Identity and Access Management services	R1, R17, R21
C-A9	Pseudonymisation service	R20, R21
C-A10	Mapping service	R10, R11, R14
C-A11	Data exchange is based upon HL7 standards	R9, R13, R14
Infrastructure		
C-T1	LSP is used for data exchange between HIS and Quality Registration system	R9, R13, R15
C-T2	LSP+ is used for data exchange between PHE and HIS	R1, R4, R5, R9, R13

7 EVALUATION

An important part of Design Science Research is the evaluation (Hevner et al., 2004). This chapter describes the evaluation of the architecture components as outlined in Chapter 6, to assess whether these comply with the business needs. The evaluation will be structured as follows. First, the components will be examined by assessing compliance with the requirements. Second, an expert panel is used to validate the components on efficiency and feasibility. Finally, improvements and recommendations are described.

7.1 COMPLIANCE OF COMPONENTS

The proposed components should be compliant with the requirements stated in Chapter 6. Table 7.1 presents the requirements and components to fulfil these. As indicated in Section 6.3, all constraint requirements must be fulfilled. These are presented in the second column, indicated with an 'M' (Must). Others are labelled as 'S' (Should) and 'C' (Could). At least all the requirements are fulfilled with at least one component.

Table 7.1: Compliance of requirements

ID	Type	Component(s)	Fulfilled?
R1	M	C-A1, C-A8, C-T2	Access to part of the record in different places (1)
R2	M	C-P1, C-P5, C-A1	Patient is well informed by multiple information sources and can take decisions during the entire care process (2)
R3	S	C-O6, C-P1, C-P2	Care process is tailored to patient's care demand and frequently evaluated (2)
R4	S	C-A1, C-A2, C-T2	Actively informed about about updates (1)
R5	S	C-O3, C-A2, C-T2	Access possible under special circumstances (1)
R6	M	C-P2, C-I6, C-A1, C-A2	Basic information is available (e.g. BgZ) (1)
R7	C	C-O6, C-P4, C-A1	There is a feedback loop (1)
R8	M	C-I1	Part of the information is stored modular (1)
R9	S	C-I1, C-A3, C-A11, C-T1, C-T2	Information can partly be reused and partly overlaps with other information (1)
R10	S	C-O2, C-I4, C-A10	Indicators are partially based on disease-specific templates but slightly differ per provider (1)
R11	M	C-O4, C-I1, C-A10	Information is partially based on data and information standards (1)
R12	M	C-O4, C-I2	Terminology standards are partially used but some definitions can be ambiguous (1)
R13	M	C-A3, C-A11, C-T1, C-T2	Structured and unstructured data can be exchanged between actors (1)
R14	M	C-O4, C-A3, C-A10, C-A11	Exchange standards are used (1)
R15	S	C-O1, C-I4, C-A1, C-A4, C-T1	Clinical and process outcome indicators are publicly available (2)
R16	S	C-A3, C-A5	Data is accompanied with a digital signature and a logging history (2)
R17	M	C-O3, C-I3, C-A2, C-A8	Care providers have access to minimum information for care provision (1)
R18	S	C-O5, C-P3, C-P5, C-A7	There is a person or department responsible for data quality (1)
R19	S	C-P5, C-A3, C-A6	Outcomes are reliable but is affected by human errors (1)
R20	M	C-A5, C-A3, C-A9	Information cannot be traced back to individuals and additional state-of-the-art techniques are used (2)
R21	M	C-P5, C-A2, C-A8, C-A9	The design meets information security regulations (1)

7.1.1 Verification: Compliance with Requirements

Verification involves demonstrating that the design complies with the requirements stated in Chapter 6 (Bahill & Dean, 2009). For 9 out of the 21 requirements, the 'fulfilled' column is satisfied not the be ultimate satisfactory state. Only one objective requirement has not been met to satisfactory. There are several reasons why there is not full compliance. First of all, the design shows a theoretical scenario and states that standards must be used (R11, R12, R14). The design selected the most adopted standards according to Nictiz. However, it does not mean it is *the* standard, as organisations are still free to use the standards they would like to use. The mapping service in the data integration centre is therefore of importance to map data into a readable format.

Second, using the Zibs do allow for modular data storage and increases the reusability. However, the Zibs offer a limited range of items to record. If something very specific must be recorded, a physician will likely use a free text field, making it hard to reuse (R8, R9). Another drawback of the limited coverage of items is that it may not be enough to fill a predefined disease-specific outcome template. Therefore, disease-specific templates might differ per provider (R10). This affects the validity of the outcome indicators as it does not measure all the relevant aspects.

Third, the accessibility of medical information by patients and caregivers (R1, R17) are fulfilled in an ideal world where all healthcare providers are connected to the AORTA network. Although it is widely adopted, not all providers use this network for data exchange. As mentioned in the semi-structured interviews, some do not even engage in any digital form of data exchange. Therefore, the requirement is partly complied with.

Finally, privacy (R20) and security (R22) are important aspects. Even with state-of-the-art pseudonymisation techniques, there always exists a risk that data can be traced back to individuals (e.g. patient, physician). Further, a HIS is a single point of failure, making it vulnerable to attacks. Also, security is solely focused on technical aspects, while most data breaches stem from human errors. To mitigate these risks, audits are essential to test the systems and processes thoroughly.

7.1.2 Realising objectives and principles

As can be seen in Table 7.1, all requirements have at least one component. However, that does not necessarily mean that the proposed components could realise the architecture vision and principles. P1 and P4 focus on the overarching goal of VBHC, P2 is associated with interoperability and P3 deals with trust and transparency. Each of these principles is evaluated below.

P1: Patient's value comes first

The ultimate goal of providing care services is optimal satisfaction of the patient. The PHE (C-A1) seems to be an important component for this principle and fulfils several constraint requirements (R1, R2, R6, R15). Since the patient has a full overview of the medical records from multiple institutions and the patients-like-me, they can make informed decisions together with the physician. The physician also has access to the medical records (R5, R17) by requesting information via the PHE or other providers arranged via the LSP+ (C-T2) or LSP (C-T1).

The moments of measurement, evaluation (C-P2) and shared-decision making (C-P1) provide an opportunity to re-evaluate whether the treatment fits the patient's healthcare demand. This allows patients to actively participate in the care process and tailor the process to his or her needs (R3). However, for measuring and benchmarking (patients-like-me), agreements on the definition of value and outcome indicators are necessary (C-O2). Disease-specific templates offer standardisation in what to measure and how to interpret this compared to other patients (C-I4).

The PHE enables patients to participate in the care process due to its notification service (R4) and communication service (R7). The communication service of the PHE (C-A1) is also input to the in-house department at healthcare institutions for feedback (C-O6). Evaluating communication (C-P4) with the patient can lead to insights, allowing the overall process to be tailored towards specific patients groups (R3).

P2: Unambiguous and one-time recording of data

Recording information in a structured, modular and uniform way enables reusing elements. This leads to higher accuracy and a reduced administrative burden. The Zibs (C-I1) together with SNOMED-CT and LOINC (C-I2) provide stakeholders with unambiguous data recording. Most important components to realise this is the agreement on standards (C-O4), and the agreement on outcome indicators and measurements (C-O5). If there are no agreements, other underlying components are considered to be less efficient. Reusability is facilitated through the data integration centres (C-A3) and the LSP or LSP+ intermediaries (C-T1, C-T2).

P3: Quality can be derived from the care process

Creating transparency allows stakeholders to assess the quality of provided care and increase perceived trustworthiness. Important components to assess the quality of care begin with registration in the care process itself. The measurements and evaluations (C-P2) must be stored in the EHR (C-A2). Logging and monitoring services (C-A5) accompany the data with detailed provenance. This provides internal professionals within the institution the ability to assess data accuracy. Analysis on a patient level is provided to both the caregivers and patients via the HIS (C-A2) resp. PHE (C-A1).

The Quality Registry System (C-A4) is indispensable for external transparency of quality (i.e. process and outcome indicators). The Quality Registration System extracts data (C-A6) from the data warehouse connected to the Data integration centre (C-A3). The data integration centre collects the data from the local EHR as defined by the disease-specific templates (C-I4) and pseudonymises it accordingly (C-A9). An important component is to legally arrange data analysis on an aggregated level. External stakeholders, such as insurers, can assess the quality of care through the external transparent process and outcome indicators.

P4: Collaborate and continuous learning

Quality of care can be improved by gaining new insights and comparing different approaches. Improving care services leads to a higher value, higher efficiency and lower costs. Again, an important component is the Quality Registry System (C-A4). Providers and researchers can access clinical data per medical diagnosis and use this for research and improvement projects. It is however not likely that providers will invest valuable time and money into improvements without gaining anything.

7.1.3 Compliance to Porter and Lee (2013)

In Section 4.3.7, the as-is architecture was analysed through the criteria of Porter and Lee (2013). Although the principles and requirements were partly based on these requirements, the components should be evaluated to examine the compliance to criteria. Table 7.2 presents the criteria and referring components.

Table 7.2: Compliance to criteria Porter and Lee (2013)

Criteria	Fulfilled?	Component(s)
1. Be patient-centred	Yes	C-A1, C-P1, C-P2
2. Use common data definitions	Yes	C-I2
3. Encompass different data types	Yes	C-A11
4. Be accessible to all parties involved	Yes	C-A1, C-A2, C-A8
5. Include specified medical condition templates	Yes	C-I4
6. Be easy to extract information	Yes	C-A3, C-A6, C-T1, C-T2

7.2 EXPERT PANEL SESSION: EVALUATING COMPONENTS

An expert panel is a composed group of people specifically that have expertise and opinions about a topic (Sekeran & Bougie, 2016). The panel is composed of the people from the semi-structured interviews to validate the correctness of the architecture and evaluate whether the business needs have been met. Validation is different from verification because it involves assessing the correctness and appropriateness of the design and ensures that the design satisfies the business needs (Bahill & Dean, 2009).

7.2.1 Organisation of Expert Panel

The session aims to obtain experts' thoughts, opinions and feedback on the proposed architecture. To elicit these aspects, the researcher acts as a moderator and steers the discussions. The researcher has an important role in leading the session but is not a part of the discussions. The researcher asks questions to stimulate the discussion. In addition, the researcher might use probing tactics throughout the session if feedback is unclear.

Composition of Expert Panel

Individuals who are eligible to be on the panel are: experts in healthcare and VBHC, experts in IT systems and data exchange (preferably in healthcare), experts in emerging technologies (preferably in healthcare), experts in designing EAs. The following experts have participated in the Expert Panel to evaluate the architecture and components.

Table 7.3: Overview participants Expert Panel

ID	Organisation	Expertise
1.1	Pharmaceutical company	Value-based healthcare
1.2	Healthcare provider	Healthcare management

Procedure

The session follows a scripted procedure. A detailed overview of the procedure, including topics discussed, questions and time, is presented in Appendix G. The expert session is organised as follows:

- Introduction: Topic, preliminary results
- Architecture vision: Objectives
- Architecture overview: Figure 6.1
- Components: Per architecture layer
- Opportunities: Blockchain technology
- Closing: Final remarks and discussions

7.2.2 Findings of evaluation

The findings are categorised by theme discussed in logical order. First, the architecture vision and design are discussed. Second, the discussion about the components is described.

Architecture Vision and Design

Showing the architecture overview and explained how different environments were connected, the interviewees were happily surprised that many components already exist. According to interviewee 1.2, *"It brings together new and existing components for the context of VBHC. The recognisability makes it less abstract and easy for people to understand"*.

The researcher asked about their opinion and risks about the idea for transparency. Interviewee 1.1 noted that it is risky for providers to present their outcomes publicly, because *"it is nice to be ranked among the top, however not so nice when it turns out that you, as a provider, are at the bottom"*. Even more important, the deeply rooted mistrust from providers towards insurers forms a barrier to transparency, because it could have negative consequences for the providers. Interviewee 1.2 agrees with that and emphasizes that it is all about how definitions are formed. The interviewee continues that especially for insurers it is tricky because they measure with other norms and from different perspectives.

Nevertheless, both interviewees agreed upon the fact that transparency has an indispensable value in healthcare. Interviewee 1.2 mentioned that for healthcare managers, transparency is very valuable, because in healthcare still, many professionals use their gut feeling instead of factual data. For patients, transparency is essential to make informed decisions and participate in the care process. In the discussion, interviewee 1.1 noted another risk that a patient can influence the overall outcomes by giving a 'bad grade'. It highly influences the average which may not represent the quality of the provider. If financial incentives are connected to subjective measurements, it means that individual patients have the power to demand whatever they want, even if that is unreasonable.

The researchers asked if the proposed design (Figure 6.1) could be a feasible solution and if there are any suggestions for improvement. The experts discussed further and reached a consensus that on a high level, transparency is seen as a suitable solution, but in practice, it would not be feasible to offer transparency on outcomes. Interviewee 1.2 points out that transparency can contribute to breaking the vicious circle, however, it will not solve the core problems. The architecture and components should not be seen as a solution, but rather as guidance for components that can improve the situation. Interviewee 1.1 agreed with the statement and continued that if transparency is suggested as *the* solution, people will not oversee the smaller steps that need to be taken. The experts discussed further and agreed upon a narrative: *'peeling off the layers of a union'*. Every layer represents a small step towards the core, which is a transparent value-based healthcare system.

Organisation layer

The organisational components are presented and explained to the experts. After that, the experts were asked *what are your first thoughts about the components?* In contrast with earlier findings, the experts argue that the government should not have a facilitating role, but a more active one. They decide what is covered by the basic healthcare insurance packages and therefore, the government actually can and should play a bigger role (C-O5). Additionally, the power to impose laws and regulations is also in the hands of the government. Further, insurers indeed *should* be partners, but in the current healthcare structure, this is infeasible (C-O5). An intermediary could be a solution to improve trust between stakeholders, but it should be noted that it probably will not be very effective because of the design flaws in its core.

After discussing the roles and responsibilities, the experts were asked *what components are essential for VBHC?* Interviewee 1.2 noted that arranging legally to collect data and perform the analysis is essential (C-O1). From a practical point of view, it is highly desirable not to ask consent from every patient, however, it will not be feasible due to privacy regulations such as GDPR. Even when data is pseudonymised, performing a very specific therapy or treatment can easily be traced back to a physician or patient. This risk can be mitigated by conditional restrictions to the availability of information (e.g. $n > 100$).

To the question *are you missing any components in this layer?*, interviewee 1.2 answered that it is hard to say whether you 'miss' something. The interviewee did notice not a missing component, but a component that is probably too specific. Both the experts discussed the agreements on standards (C-O4) and it was mentioned that the architecture should provide enough flexibility not to be dependent on a couple of standards. Interviewee 1.1 states that *"The pace at which medical sciences and technology development is enormous."* Therefore, there should be some kind of agreement on how to communicate and what is defined by some terms, but the information systems should not build around specific standards. Not explicitly mentioned by the experts, but this also applies to outcome indicators and measurement methods (C-O2).

Processes

For the next layer, similar questions are asked by the researcher. To the question *what are your first thoughts about the components?*, interviewee 1.2 mentioned that standardisation of measurement and evaluation moments (C-P2) is highly dependable on the kind of disease and treatment that is provided. Also, this differs for the outcome one wants to measure. It would be efficient to standardise because it increases the reliability. However, it is not completely feasible due to intermediate adjustments in the treatment plan and the different procedures per healthcare institution.

Discussing further the components, the experts indicated Besides the components, the interviewees highlighted administration time. The administrative burden is one of the challenges healthcare is facing and more measurements and personalised care would not reduce this burden. Interviewees refer to an example of Singapore and suggest appointing an information manager that records all basic medical data. The physicians can in turn directly dive into the problems of the patient.

Information

Next, the information components were discussed. To the question *of which components are essential for VBHC?* the experts continued the previous discussion on the use of standards. The experts agree that information has to be stored in a uniform and modular way so that it is easy to extract, transform and reuse (C-I1). The specific standards mentioned were therefore not considered to be feasible to impose on all providers. Information models should provide flexibility to change the predefined datasets (e.g. BgZ, or disease-specific indicators).

For information provision (C-I6), the experts agree to have a simple interface for patients including visuals and simple explanations. For providers, a more detailed interface that also focuses on the construction of data sets is more appropriate. It was mentioned not to share costs in the semi-structured interviews. Interviewee 1.2 argues however that costs are part of VBHC and that it is actually interesting to investigate correlations between the type of treatment, outcomes and costs.

Application

While presenting the application layer of the design, interviewee 1.2 mentioned that the PHE (C-A1) is an essential component to integrate into the design for VBHC. It was however pointed out that it is still in infancy and not implemented yet. Interviewee 1.1 acknowledges the usefulness of the data integration centre (C-A3) because it reduces heterogeneity problems of information systems. It allows organisations to use their own way of working and still be able to communicate. The interviewee points out that the individual differences between organisations should be not the focus point, but it should be rather general to avoid complexity. When the researcher asked whether there were any suggestions or missing components the experts pointed out that they do not have a lot of know-how on the technical aspects because they are both healthcare experts.

However, the experts did point out an important risk of the design: privacy. There is a trade-off in the design between provenance (C-A5) and pseudonymisation (C-A9) in external presentation. On the one hand, the data quality can be examined through data provenance. On the other hand, it risks the privacy of individuals, as discussed in the organisation components. Interviewee 1.2 suggests mitigating this risk for now by not being fully transparent and benchmark all providers publicly, but to have a few steps in between. For example, receive the data back in an anonymous form so that providers and insurers cannot recognise each other. Interviewee 1.1 agrees and adds: *"then providers can start to learn from the data, but it will not be involved with negative consequences initially"*.

Infrastructure

The final components were presented for the infrastructure. One of the experts admitted not to have much knowledge of the underlying infrastructure. Similar to the application layer, this is a limitation for the validation of the components. However, interestingly, interviewee 1.2 noted right away that the LSP (C-T1, C-T2) is known as a dramatically bureaucratic intermediary in the chain of data exchange. *"If you do not want to be dependent on one party that can control how you have access to data and how it is processed, you might think about a distributed solution."* The reason why interviewee 1.2 mentions a distributed network can be because of the earlier interview in which blockchain technology had a more prominent role in the research. Nevertheless, it emphasizes the fact that blockchain has the potential to be integrated into the design.

The next section will discuss the final reflections on the components and improvement suggestions.

7.3 IMPROVEMENTS & RECOMMENDATIONS

From the verification (7.1) and validation (**??**), several points of improvement can be summarised. In this section, improvements will be incorporated into the design as presented in Chapter 6. Improvement suggestions that cannot be incorporated into the design due to limited resources will be recommended for future research. The following improvements of the design are suggested:

- **Organisation.** The components in the organisational layer are all considered essential for VBHC. However, C-O1, C-O2 and C-O4 are hard to realise considering the market competition and different interests of stakeholders. There might not be agreement on standards, however, data must be able to map from one model to another. C-P1 is changed to: "Legally arrange data analysis on an aggregated level". C-O2 and C-O4 are not replaced due to their importance.
- **Process.** All components were considered to be essential for healthcare in general, but not necessarily for the architecture and VBHC. Due to the variety of care services and adjustments in the process, C-P1 and C-P2 cannot be realised. The word 'standard' is replaced by 'include' so that it allows for flexibility in care processes.
- **Information.** The interviewees advised to remain the architecture generally and not dive into specific standards. Therefore, C-I2 and C-I3 are eliminated from the component list.
- **Application.** For application, not all components were discussed. However, the interviewees suggested including a privacy officer (C-O5). As HL7 was mentioned as a specific standard, it was eliminated from the components list (C-A11).
- **Infrastructure.** The AORTA network was considered not to be feasible to create trust in the network. For the current design, the component is however incorporated since it is widely adopted by healthcare providers.

The final list of components is presented in table 7.4. Further recommendations for the design are as follows:

- **Evaluation of PHE.** While the PHE have shown high potential for the architecture to facilitate VBHC, it is still in the first phases of implementation. It is recom-

mended to further evaluate the utility of the component as it has been adopted by the general public.
- **Distributed network.** The decentralised network has the potential to be replaced by a distributed network. Further research should be done to investigate opportunities for blockchain technology to replace the current infrastructure.
- **Privacy-Utility trade-off.** There is a trade-off between privacy and utility in the design. It is recommended to further research this trade-off for the Dutch healthcare system and how it would affect VBHC. Additionally, privacy-preserving techniques, such as Multi-Party Computation, have not been considered for the design and are relevant to further investigation.

7.4 SUMMARY EVALUATION

This chapter validated the architectural design and its components. The research activities aimed to answer subquestion 4: *"What components are essential to facilitate VBHC?"*

Compliance Requirements. All the requirements as presented in Chapter 6 have been fulfilled. However, not all requirements have been met to satisfactory. The requirements R11, R12 and R14 stated to use standards and most adopted standards have been selected. However, this does not mean it is *the* standard. Second, the Zibs offer a limited range of items to record, which limits the compliance to R8, R9 and R10. Third, relevant medical records can only be accessible (R1, R17) if all providers are connected to the AORTA network. Fourth, privacy (R20) and security (R22) remain a point of issue despite the proposed components.

Compliance objectives and principles. P1 and P4 focus on the overarching goal of VBHC, P2 is associated with interoperability and P3 deals with trust and transparency. The most important component for P1 is the PHE that includes several services (e.g. communication, medical information, notifications) to increase patient empowerment. For P2, the Zibs, terminology standards and data integration centre were considered to be essential. For P3, logging and monitoring services, measurements and auditing are essential for assessing the quality of care internally. For external purposes, the quality registry system is essential. Last, for P4, also the quality registry system is important as it provides the analysis on an aggregated level. To ensure improvements projects will follow, an intermediary that stimulates improvement and collaboration is suggested.

Expert Panel. The expert panel was conducted to validate the components with the business needs. Two experts participate in the panel, with both their expertise in healthcare and VBHC. The components were discussed per architecture layer. The most important criticism included: the roles and responsibilities, law and regulations, usage of standards, administration time, privacy issues, network authority. The interviewees offered several points of feedback to improve the design. After including the improvement suggestions a final list of components was presented. Table 7.4 shows all the components per layer. Several points were not included but were recommended for design future design improvements.

Table 7.4: Overview final components

ID	Component
Organisation	
C-O1	Legally arrange data analysis on an aggregated level
C-O2	Agreement on outcome indicators and measurement methods per disease
C-O3	Agreement on procedures in which circumstances a caregiver can access without patient's permission ('break-the-glass')
C-O4	Agreement on standards in healthcare
C-O5	Roles and responsibilities
C-O6	In-house department for feedback on information systems
Processes	
C-P1	Include shared decision-making moment
C-P2	Include measurement and evaluation moments
C-P3	Validation of information
C-P4	Evaluate communication effectiveness
C-P5	Audit care and IT processes
Information	
C-I1	Clinical building blocks (Zib)s are the standard
C-I4	Template data sets per medical disease
C-I5	Patients-like-me
C-I6	Information provision is tailored to stakeholder
Application	
C-A1	Personal Healthcare Environment
C-A2	Healthcare Information System and Electronic Health Record
C-A3	Data integration centre
C-A4	Quality Registry System
C-A5	Data logging and monitoring service
C-A6	ETL process
C-A7	Validation services
C-A8	Identity and Access Management services
C-A9	Pseudonymisation service
C-A10	Mapping service
Infrastructure	
C-T1	LSP is used for data exchange between HIS and Quality Registration system
C-T2	LSP+ is used for data exchange between PHE and HIS

8 DISCUSSION

This study researched the essential components for an IT architecture to support the transition to VBHC. This chapter aims to interpret and discuss the findings and their implications. First, the research findings will be critically discussed. Second, the limitations of this study are described. Finally, the scientific and practical contributions are highlighted to close the Rigor and Relevance Cycles of Hevner's framework.

8.1 DISCUSSION ON RESEARCH FINDINGS

VBHC has been described as a potential candidate to reform the healthcare industry (Seoane et al., 2020). While the goal is value for patients, it is argued that VBHC also leads to efficiency and costs reduction and therefore addresses the challenges healthcare is currently facing. It should however be noted that these challenges can be defined as *wicked problems*. A characteristic of a wicked problem is that the proposed solution is neither true nor false, but rather good or bad. There is 'no stopping rule' and such problems will be solved until one considers the solution to be 'good enough' (Rittel & Webber, 1973).

Interviewee 1.3 emphasized the concern whether implementing Porter's VBHC model would be 'good enough': *"However, I ask myself if the impact in combination with the time we have, if that is big enough or whether other, more traditional models, could offer the same impact that we need with some more certainty."* In the traditional models that the interviewee referred to, the government plays a bigger role and manages healthcare based on costs. Such a model would be very suitable to achieve a lower expenditure, however, the effects on healthcare quality are neglected. According to interviewee 1.3: *"It is all about what you want to emphasise on"*.

Rittel and Webber (1973) argue that *"the information needed to understand the problem, depends upon one's idea for solving it"*. Indeed, the problems healthcare is facing can be explained in many different ways. If one narrows down the problem formulation to 'healthcare expenditure', it would probably result in a solution based on cost-control as mentioned by interviewee 1.3. In this study, however, we argued that there is a design flaw in the healthcare structure that provides an incentive to increase more services. By focusing on outcomes of the provided care, costs per treatment may increase but the volume of total services decrease. Therefore, VBHC is considered to be a suitable approach for a sustainable healthcare system.

The literature review and preliminary interviews revealed that IT is one of the main barriers. Current systems are not designed to facilitate semantic interoperability between healthcare institutions and thus hamper outcome and cost measurement. The Open Group (2016) argues that the interoperability problem is inherently associated with the lack of a shared and uniform language. Many institutions are, with all the best intentions, working on standardisation in healthcare. Consequently, all these 'standards' suddenly become one of the many available guidelines that architects need to take into account when designing solutions. It is doubtful whether the suggested components in this research would succeed to fulfil the objectives if there is no uniform language. Up until now, true standardised language for healthcare has not been achieved yet. This emphasizes the importance of uniform and standardised language.

Further, adding IT components is no silver bullet to achieve outcome and costs measurement. As found in the preliminary interviews, trust is essential for a transition to VBHC. Underlying factors of trust issues were not limited to human-human interaction but also involved human-machine and machine-machine interaction. As interviewee 2.1 notices: *"So what are the essential elements for value-based healthcare? I would say to organise processes in a safe and secure way. On the one hand, this includes bringing together and explaining the process to stakeholders. On the other hand, it is about technology, because without accurate and reliable data, people have no confidence in the insights you create."* To improve the as-is situation, we followed Schnackenberg and Tomlinson (2016) and aimed to increase transparency in the design to built trust between stakeholders and the information they provide.

During the in-depth interviews and expert panel session, it was validated whether transparency indeed is an appropriate solution to overcome the trust issues. Interviewee 2.1 notes that healthcare providers are cautious to be fully transparent to insurers as they are afraid that it results in negative consequences (e.g. cost optimisation). That perception is confirmed by interviewee 2.2: *"We [insurers] are seen as the ones with the money whereas providers are perceived as the helpers. If this perception does not change, I wonder if transparency will be a solution.* Also, interviewee 2.3 emphasizes this concern: *"Transparency is a part of the solution, however, there are some fundamental issues that need to be resolved first [...] healthcare providers must be offered certainty."* In the short term, transparency on outcome indicators is, therefore, an unrealistic solution. However, it is argued by the interviewees that if power differences are neutralised, transparency is a part of the solution to improve healthcare. While there is no single best answer to a wicked problem, increasing transparency has a high potential to offer improvements in the long run.

Coming back to the quote *"there are some fundamental issues that need to be resolved first"*. Indeed, there are power differences, misaligned interests and some stakeholders even have a negative attitude towards a transition to VBHC. One of the underlying reasons is money. Many stakeholders are profiting from the current situation and do not want that to change. For a transition, actors must have an incentive to engage in measuring outcomes and be rewarded based on that. The government has an important role in implementation as they have both power and interest in improvements for healthcare. They have the power to impose regulations or stimulate stakeholders with financial incentives. Often insurers are seen as 'the bad guy' that limit resources for providers, but they are restricted to law and regulations as well. Consequently, the government should reduce or eliminate such barriers and facilitate conditions necessary for successful implementation.

While a true value-based system is not expected in the short term, components can be implemented step-by-step as incremental improvements. For instance, usage of the PHE or agreement on what standards to use. Interviewee 2.3 mentioned that: *"We cannot plan everything into detail. We have to start hands-on and learn by doing. No one knows what the exact implications are of data exchange and transparency"*. By continuously evaluating the steps taken, there comes a day where we agree that a solution is good enough.

8.2 LIMITATIONS

The quality of the design is heavily dependent on the quality of the data collection and analysis. The literature found in the electronic databases depend on the searching terms and therefore relevant literature might have been missed. In addition, not all articles were freely accessible and selection criteria could have excluded relevant literature. The access to relevant literature is thus a limitation.

Another limiting factor was the data collected through the semi-structured interviews. In both the interviews, the experts were introduced to the topic and research. Familiarising interviewees with concepts or explaining preliminary findings could have biased the experts and influenced their answers. Further, a sample size of 7 preliminary interviews and 4 in-depth interviews do not represent the entire healthcare landscape and reduce the generalizability of the research. To mitigate the limitation, a wide variety of experts have been selected for the interviews.

Since the research is conducted by only one researcher, data analysis depends on the judgement and interpretation of the researcher. This forms a risk to the validity of the analysis. The quotations, codes and categories attached to the transcripts are prone to the subjectivity of the researcher and influences the results of the analysis. In turn, these analyses were the starting point of the design and influence the quality of the proposed components. Although data triangulation reduces the risk of subjectivity in establishing the principles and requirements for the design, intercoding between more researchers would have increased validity.

Finally, the evaluation of the designed artefact is a crucial step in design science research (Hevner et al., 2004). Only two experts were available for the expert panel session. Since both experts have their expertise in the healthcare side, they had less expertise in the technology side. This limits the validity of the research findings. Furthermore, the components have been evaluated using descriptive evaluation methods. This influences the extend to demonstrate the ‘goodness’ and ‘efficacy’ of the design (Hevner et al., 2004).

8.3 CONTRIBUTIONS

8.3.1 Scientific Contributions

To identify and position the scientific contributions, the framework of Gregor and Hevner (2013) is referred to. Gregor and Hevner (2013) explain that a knowledge contribution must be significant - with respect to the current state of knowledge - and interesting. Figure 8.1 illustrates the Knowledge Contribution Framework for design science research and consists of four quadrants. The contributions of this research can be positioned as *Improvement* because new knowledge has been developed to solve known problems. The challenges described in Chapter 1 are known problems. The combination of IT architecture and VBHC were however scarcely described in the literature. The proposed components are new solutions to improve the status quo.

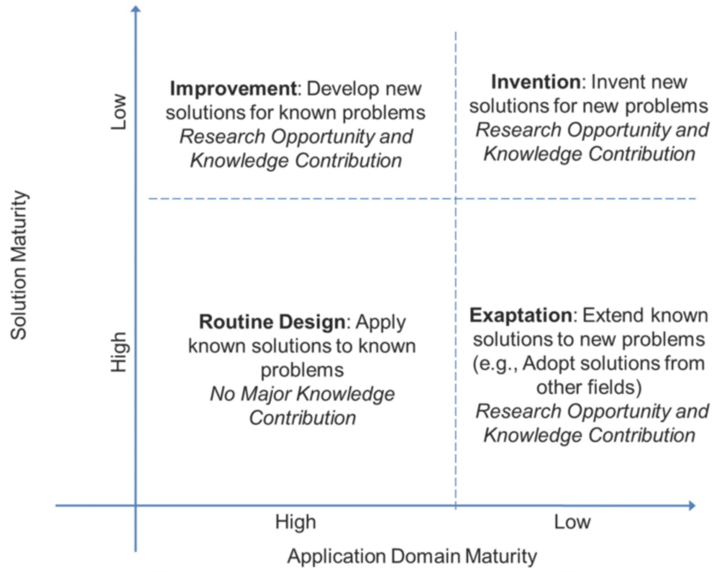


Figure 8.1: DSR Knowledge Contribution Framework. Adapted from Gregor and Hevner (2013)

This research contributes to the knowledge base by identifying barriers that hamper the implementation of value in healthcare. For successful implementation, we argue that trust between stakeholders, especially between providers and insurers, is essential. These new insights shed another light on the transition towards VBHC and provide new research opportunities in both IT oriented research areas as well as healthcare management-oriented research areas.

In line with these findings, components for a value-based IT architecture have been proposed. Together with the principles and requirements, this research offers a knowledge contribution for designing IT architectures in healthcare contexts. In addition, the evaluation contributed to the scientific literature because it examined which components are efficient and feasible to integrate into the current architecture for VBHC.

8.3.2 Managerial Contributions

The fact that there is no single best answer to a wicked problem explains the tremendous amount of initiatives, projects and innovations in healthcare. Stakeholders regard the problem from their own point of view and, consequently, fail to identify other potential barriers. For policymakers and healthcare managers this research provides insight into barriers and enablers for VBHC in a broad and holistic way. In addition, the repeated emphasis on the importance of trust creates understanding and awareness that can be the focal point for innovative agents.

This research addresses the business needs to find out what the essential components are to move towards value-based healthcare. The overview of the principles, requirements and components can be used by architects to help to design architectural solutions in the future. To the best of our knowledge, an overview of these elements is not available in the literature yet.

8.3.3 Societal Contributions

On an individual level, this research is contributing to society by proposing components for a more efficient and patient-centred healthcare system. The components allow individuals to be in control of their own care process and to tailor care provision to the specific needs based on available data. In addition, it allows patients to assess healthcare providers and treatments which enables one of the core principles of regulated competition: freedom of choice. After all, value for patients is the overarching goal (Porter & Teisberg, 2007). On a high level, a well-functioning healthcare system makes an indispensable contribution to a vital labour market, economy and society (SER, 2020). Continuous learning improves the quality of healthcare services and contributes to the overall population health. Moreover, improvements in healthcare quality and efficiency may lower total expenditure and reduces the deficit in the current sustainability balance, allowing future generations to benefit from the same governmental services.

9 CONCLUSIONS

This chapter provides the conclusions of the research and aims to answer the research questions stated in Chapter 1. Subsequently, recommendations are provided for managers and researchers. A reflection on the research and study programme will conclude this chapter.

9.1 CONCLUSIONS

This study researched the essential components for an IT architecture to facilitate the transition to VBHC. As states in Chapter 1, the objective of this study is *"to identify and design the essential components for a value-enabling IT architecture for the Dutch healthcare system"*. To achieve the research objective, the Information Systems research framework of Hevner et al. (2004) was followed. This framework was used to understand the problems, execute design activities, and evaluate those. To establish both rigour and relevance in the design, both the environment and knowledge base were used as input.

The research consisted of two parts. First, to capture the business needs and applicable knowledge, exploratory research methods were used. As a result of the research activities, new insights and perspectives on the situation are developed. This provided an understanding of the current problems and led to opportunities for the design. Second, components were designed using an architectural layered approach. The components were validated by descriptive evaluation methods.

Following from the objective, the main question formulated was: *"What are the essential components for an IT architecture to facilitate value-based healthcare in the Netherlands?"*. The answer this question, four sub-questions were formulated. Each of the sub-questions will be answered separately.

Subquestion 1:"What is the state-of-the-art literature of IT architecture in the context of healthcare, and VBHC?"
VBHC is a candidate framework to improve the quality of healthcare. The side effect of VBHC is that better healthcare services will eventually reduce the costs of care. Dutch healthcare actors acknowledge the potential of VBHC and have been implementing the framework. Implementation of VBHC involved six mutually interdependent steps: (i) Organise into integrated practice units, (ii) Measure outcome & costs, (iii) Move to bundled payments, (iv) Integrate care delivery systems, (v) Expand geographic reach, and (vi) Build an enabling IT platform. It was found that the IT element has an indispensable value in the successful implementation of VBHC. Despite the importance, the current IT systems are characterised by high heterogeneity and lack interoperability, hampering the transition to VBHC.

A literature review was conducted to find the state-of-the-art literature for IT architecture in the context of VBHC. It can be concluded that there is little research conducted on the combination of research areas. This emphasises the existing knowledge gap in the literature. For that reason, literature search activities have been broadened to healthcare. Although little research was found for the specific purpose of VBHC, much research could be found on data exchange, data integration and interoperability in healthcare, which complied with some of the basic criteria of a value-enabling IT platform. Several architectures were found on data exchange and integration in healthcare, but none were found for VBHC. To conclude, there is a noticeable gap in the state-of-the-art literature about how IT should be designed for VBHC to overcome current barriers.

Subquestion 2: "How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?" The answer to this subquestion contributed to an in-depth understanding of the problem. Two research approaches have been used to answer the subquestion. First, an environmental analysis had been performed consisting of organisational systems, people, and technical systems. Second, semi-structured interviews with 7 experts in the field of healthcare were conducted to validate findings of the environmental analysis and scrutinize the problem in more depth.

The current Dutch healthcare system is characterised by regulated competition with a purchasing market, insurance market and provision market. *Freedom of choice* is an essential element for a properly working market. In reality, however, there is little information available to critically assess which healthcare services fit best, hampering individuals to make informed decisions. The stakeholder analysis revealed that the government, insurance companies and overarching interests groups, large healthcare providers and HIS suppliers have both power and interest in VBHC. Patients, smaller healthcare providers and research institutions have high interest but less power to steer for changes.

The as-is situation of the technical systems was analysed using the *layered framework of Nictiz*. Following the criteria for an enabling IT platform, specific deficiencies in the as-is architecture have been found. First, there is a *lack of patient-centredness*, because patients do not have their medical records in one place. Second, *data is inaccessible or unavailable*. Third, *data is complex to extract and integrate* from multiple sources because of the lack of standardisation. This hampers the reusability of data and possibilities to measure outcomes across the care cycle.

Purely focusing on the technical aspects would however not lead to a successful transition as it depends on the way actors interact with it. Analysis of the semi-structured interviews identified barriers related to IT, organisation & policy, relationship and implementation. The interviews revealed that VBHC requires trust and collaboration. When there is no trust, actors will continue to have a suspicious attitude and the need for control. Even if there were IT capabilities to measure outcomes and IT systems would be interoperable, it would not solve the root causes of the problems.

In conclusion, a lack of interoperability and a lack of trust are two aspects that hamper a transition towards VBHC.

Subquestion 3: "What components could be incorporated in the IT architecture to facilitate a transition towards VBHC?"

As it was found that interoperability and trust were necessary, a second round of semi-structured interviews were conducted. The concept of trust and transparency were the point of focus for the in-depth interviews. The interviewees mentioned a wide variety of principles, requirements and components, which was used as a basis for the design activities.

The to-be architecture was based on the as-is situation and several components have been proposed to deal with the current deficiencies found in the analysis. The objective of the architecture was *to increase interoperability and transparency in healthcare systems*. The reference architecture ZIRA had been followed for the design activities. In addition, 4 principles and 23 requirements were formulated based on the reference framework, literature and interviews to guide the design.

A high-level overview of the to-be architecture was presented and subsequently the components to realise this. Components were presented according to the layered framework of Nictiz. In total 31 components have been presented to facilitate VBHC and deal with interoperability and transparency. An overview can be found in Table 6.4.

Subquestion 4:"What components are essential to facilitate VBHC?"

This question aims to validate the components found in the previous subquestion and evaluate which are essential for VBHC. First, the components have been evaluated by their compliance with the objectives, principles and requirements. The most essential components to realise the principles are: the PHE for patients, the HIS for providers, the Zibs, terminology standards, data integration centre, logging and monitoring services, measurements and evaluation, auditing IT and care processes, the quality registry system and an intermediary that stimulates improvement and collaboration are suggested.

Second, an expert panel validated the components facilitated through discussions. The expert panel reached a consensus that transparency in healthcare would contribute to solving several problems, but it will not solve the core problems that lie within the healthcare structure. Furthermore, full transparency does not facilitate trust but instead has adverse effects. The most important criticism on the components included: the roles and responsibilities, law and regulations, usage of standards, administration time, privacy issues, network authority. The interviewees offered several points of feedback to improve the design. After including the improvement suggestions a final list of components was presented. Table 7.4 shows all the essential components per layer.

9.2 FUTURE RESEARCH

Throughout this research, several opportunities for future research have been identified. These are categorised in future research for the design and VBHC.

Design

As identified in Chapter 8, the research has some limitations. The components were based upon the findings of the literature review and semi-structured interviews but selected by the judgement of the researcher. Although an expert panel validated the components, the expertise was as varied as in the semi-structured interviews. This causes a risk to the validation of the components. Therefore, it is highly recommended to validate the components with a variety of experts.

The PHE had shown high potential for the architecture to facilitate VBHC, as it allows for patients to be empowered in the care process. Since the implementation is still in its infancy, it is recommended to further evaluate the utility of the component as it has been adopted by the general public. Further, the opportunity of a distributed network can increase trust in the network. Further research should be done to investigate opportunities for blockchain technology to replace the current infrastructure.

Privacy remains an important aspect of healthcare. However, it hinders the ability to analyse data and continuously learn and improve care services. The trade-off between privacy and utility in the context of VBHC can contribute to the improvement of care while safeguarding privacy. It is recommended to further research this trade-off for the Dutch healthcare system. Additionally, privacy-preserving techniques, such as Multi-Party Computation, have not been considered for the design and are relevant to further investigation.

Finally, semantic interoperability is key for the design. Truly interoperable systems can however only be established through the use of a shared and uniform language. It is recommended to research which standards have the highest potential to facilitate the architecture components.

Value-based Healthcare

Transparency is an essential element for VBHC as it enables stakeholders to assess the quality of care and provides learning opportunities. Immediately turning to a full transparent healthcare system is, however, doomed to fail. Several experts mentioned that implementation should be a phased, step-by-step, transition. It is recommended to research the implementation of transparency in healthcare which covers these steps and future scenarios.

A final recommendation is to research the appropriateness of VBHC in the current healthcare system. Many problems stem from the organisational structure in which incremental changes are not likely to improve the status quo.

9.3 REFLECTION

During the research, much time was dedicated to get familiar with the topic and to formulate the problem the 'right' way. The literature review and preliminary interviews revealed many different perspectives on the problems in healthcare which increased the complexity of the thesis significantly. It was only after thorough data analysis, that the huge amount of qualitative data could be structured logically. By using a systematic approach for the qualitative data analysis, barriers to VBHC could be identified. While most of the time of the research was spend on literature research and data collection, I feel that this was necessary to reveal the bigger picture and show the complexity of the problem and the environment.

Although part of the problem lies within IT, I would not argue that it is the root cause of the problem. The thorough analysis made me realise that the problem healthcare is facing right now is much bigger than I would imagine at the beginning of this thesis project. Throughout the interviews, the common thread was about collaboration, trust and improving healthcare together. According to the interviewees, trust and collaboration are hard to establish. I have been asking myself the question *why is it so hard to establish?* and *why is it so hard to make radical improvements instead of small incremental steps?* Of course, in a competitive market, organisations are profit-oriented and have their own agenda, which hampers trust-based relationships and collaboration. On the other hand, competition drives innovation and quality improvement. Then *would competition based on outcomes, as Michael Porter argues, be the solution?* It can be part of a solution, but it is probably naive to think VBHC is a silver bullet to 'fix healthcare'.

Several elements throughout this thesis can be part of a bigger whole to improve healthcare. However, all these elements face the struggle of the structure of the current healthcare system. An interoperable system cannot be established if actors do not reach a consensus, competition based on outcomes will result in similar discussions as there is now between insurers and providers, and transparency may only exacerbate the situation. Reflecting on this thesis process, I would argue that the current healthcare structure - and the roles that are inherently associated with it - need to be revised. There is a trade-off between competition and government regulation. Of course, a whole new healthcare structure is not realistic, but partial changes, for example in the financial structure, would change the market dynamics and might offer more potential for VBHC. And if that happens, I hope the proposed architectural components can offer insights and guidance to policymakers, healthcare managers and architects.

9.4 LINK TO MANAGEMENT OF TECHNOLOGY

A typical MoT thesis is identified by researching how organisations can use technology to contribute and improve to their envisioned objectives, such as customer satisfaction or profitability. This thesis is positioned between a management perspective, incorporating the dynamics of a multi-actor environment, and a technical perspective, utilising technology to realise business needs. The thesis is based on the knowledge and skills I have developed through the MoT curriculum. Most importantly, the courses Technology Dynamics (MOT1412), Research Methods (2312) and Master Thesis Preparation (MOT2004) have been of indispensable value for conducting the thesis. Furthermore, the knowledge and skills taught in the course I&C Architecture (SEN1611) were extensively used throughout the thesis. The unique perspective that MoT provided had allowed me to analyse the problems holistically and contributed to the essential components for a transition towards VBHC.

BIBLIOGRAPHY

Adema, Y., & Van Tilburg, I. (2019). *CPB Vergrijzingsstudie 'Zorgen om morgen'.* Retrieved January 2, 2021 from CPB Netherlands Bureau for Economic Policy Analysis Website: https://www.cpb.nl/sites/default/files/omnidownload/CPB-Vergrijzingsstudie-2019-Zorgen-om-morgen.pdf.

Adler-Milstein, J., DesRoches, C. M., Furukawa, M. F., Worzala, C., Charles, D., Kralovec, P., ... Jha, A. K. (2014). More than half of US hospitals have at least a basic EHR, but stage 2 criteria remain challenging for most. *Health affairs (Project Hope)*, *33*(9), 1664–1671. doi: https://doi.org/10.1377/hlthaff.2014.0453.

Almodovar, M. (2015). Information management and hospital enterprise information systems. In P. R. Barach, J. P. Jacobs, S. E. Lipshultz, & P. C. Laussen (Eds.), *Pediatric and congenital cardiac care: Volume 2: Quality improvement and patient safety* (p. 377-386). Springer. doi: https://doi.org/10.1007/978-1-4471-6566-8_31.

Alnofeye, J., Hasan, M., & Abstract, A. (2019). Impact and Implementation of information and communication technology in Value Based Health Care: A systematic Review. *Merit Research Journal of Medicine and Medical Sciences*, *7*(9), 339–347. doi: https://doi.org/10.5281/zenodo.3470911.

Angraal, S., Krumholz, H. M., & Schulz, W. L. (2017). Blockchain technology: Applications in health care. *Circulation: Cardiovascular Quality and Outcomes*, *10*(9), 1–3. doi: https://doi.org/10.1161/circoutcomes.117.003800.

Bahill, A. T., & Dean, F. F. (2009). Tradeoff decisions in system design. In A. P. Sage & W. B. Rouse (Eds.), *Handbook of Systems Engineering and Management* (2nd ed., pp. 205–267). John Wiley & Sons, Inc.

Bakx, P., O'Donnell, O., & van Doorslaer, E. (2016). Spending on Health Care in the Netherlands: Not Going So Dutch. *Fiscal Studies*, *37*, 593–625. doi: https://doi.org/10.1111/j.1475-5890.2016.12114.

Barry, M. J., & Edgman-Levitan, S. (2012). Shared Decision Making — The Pinnacle of Patient-Centered Care. *New England Journal of Medicine*, *366*(9), 780–781. doi: http://doi.org/10.1056/nejmp1109283.

BDO. (2018). *Zorginfarct dreigt: Radicaal ander businessmodel voor ziekenhuizen.* Retrieved February 17, 2021 from BDO Website: https://www.bdo.nl/nl-nl/perspectieven/benchmark-ziekenhuizen-2018-sector-vereist-radicaal-nieuw-businessmodel-bmz18.

Berwick, D. M., Nolan, T. W., & Whittington, J. (2008). The triple aim: Care, health, and cost. *Health Affairs*, *27*(3), 759–769. doi: https://doi.org/10.1377/hlthaff.27.3.759.

Bharosa, N., & Janssen, M. (2015). Principle-based design: A methodology and principles for capitalizing design experiences for information quality assurance. *Journal of Homeland Security and Emergency Management*, *12*(3), 469–496. doi: https://doi.org/10.1515/jhsem-2014-0073.

Björnberg, A., & Phang, A. Y. (2018, February 25). *Euro Health Consumer Index 2018 Report.* Retrieved March 12, 2021 from Health Powerhouse Website: https://healthpowerhouse.com/media/EHCI-2018/EHCI-2018-report.pdf.

Bodenheimer, T., & Sinsky, C. (2014). From triple to quadruple aim: Care of the patient requires care of the provider. *The Annals of Family Medicine*, *6*(12), 573-576. doi: https://doi.org/10.1370/afm.1713.

Bryson, J. M. (2004). What to do when stakeholders matter: Stakeholder Identification and analysis techniques. *Public Management Review*, *6*(1), 21–53. doi: https://doi.org/10.1080/14719030410001675722.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*(1). doi: https://doi-org.tudelft.idm.oclc.org/10.1007/BF00988593.

Da Luz Júnior, S. H., Silva, F. I., Albuquerque, G., Medeiros, F., & Lira, H. (2020, July). Enterprise architecture in healthcare systems: A systematic literature review. *Lab: Software Engineering Lab*, 1-21. doi: http://dx.doi.org/10.17632/44bygxg8w3.1.

Dutch Data Protection Authority. (2019, December 16). *Rapport naar aanleiding van onderzoek gegevensverwerking SBG.* Retrieved June 18, 2021 from Dutch Data Protection Authority (DPA) Website: https://autoriteitpersoonsgegevens.nl/sites/default/files/atoms/files/rapport_bevindingen_sbg_en_akwa_ggz.pdf.

Dym, C. L., Little, P., & Orwin, E. J. (2013). *Engineering Design: A Project-Based Introduction* (4th ed.). United States of America: John Wiley & Sons, Inc.

EIT Health. (2020, June). *Implementing value-based health care in europe: Handbook for pioneers.* (Director: Gregory Katz). Retrieved June 18, 2021 from EIT health Website: https://eithealth.eu/wp-content/uploads/2020/06/Implementing-Value-Based-Healthcare-In-Europe.pdf.

Epstein, R. M. (2000). The science of patient-centered care. *The Journal of family practice*, *49*(9), 805–807. PMID: https://pubmed-ncbi-nlm-nih-gov.tudelft.idm.oclc.org/11032204/.

European Commission. (2019, June 26). *Expert panel on effective ways of investing in health. opinion on defining value in "value-based healthcare".* doi: 10.2875/872343. Retrieved February 25, 2021 from European Commission Website: https://ec.europa.eu/health/sites/default/files/expert_panel/docs/024_defining-value-vbhc_en.pdf.

European Union Agency for Cybersecurity (ENISA). (2021, January). *Data Pseudonymisation Techniques: Advanced Techniques & Technical analysis of cybersecurity measures in data protection and privacy.* doi: 10.2824/860099. Retrieved July 12, 2021 from European Union Agency for Cybersecurity Website: https://www.enisa.europa.eu/publications/data-pseudonymisation-advanced-techniques-and-use-cases.

Feeley, T. W., Landman, Z., & Porter, M. E. (2020). The Agenda for the Next Generation of Health Care Information Technology. *NEJM Catalyst Innovations in Care Delivery*, *1*(3), 1–26. doi: https://doi.org/10.1056/CAT.20.0132.

Garai, A., Pentek, I., Adamko, A., & Nemeth, A. (2017). Methodology for clinical integration of e-health sensor-based smart device technology with cloud architecture. *Pollack Periodica*, *12*(1), 69-80. doi: https://doi.org/10.1556/606.2017.12.1.6.

Gaver, S. B. (2010). *Why doesn't the federal enterprise architecture work?* Retrieved March 30, 2021 from ECH website: https://www.ech-bpm.ch/sites/default/files/articles/why_doesnt_the_federal_enterprise_architecture_work.pdf.

Goodman, S. (2017). *The Income Elasticity of Demand for Health Insurance* (Doctoral dissertation, University of California, Berkeley, Department of Economics). Retrieved March 30, 2021 from University of California Website: https://ap.lc/xKars.

Gordon, W. J., & Catalini, C. (2018). Blockchain Technology for Healthcare: Facilitating the Transition to Patient-Driven Interoperability. *Computational and Structural Biotechnology Journal*, *16*, 224–230. doi: https://doi.org/10.1016/j.csbj.2018.06.003.

Gray, M., & Jani, A. (2016). Promoting triple value healthcare in countries with universal healthcare. *Healthcare Papers*, *15*(3), 42–48. PMID: https://pubmed.ncbi.nlm.nih.gov/27009586/.

Gregor, S., & Hevner, A. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly*, *37*, 337-356. doi: https://doi.org/10.25300/MISQ/2013/37.2.01.

Guyatt, G., Cairns, J., Churchill, D., Cook, D., Haynes, B., Hirsh, J., ... Tugwell, P. (1992). Evidence-based medicine: A new approach to teaching the practice of medicine. *JAMA*, *268*(17), 2420-2425. doi: https://doi.org/10.1001/jama.1992.03490170092032.

Haghighathoseini, A., Bobarshad, H., Saghafi, F., Rezaei, M., & Bagherzadeh, N. (2018). Hospital enterprise Architecture Framework (Study of Iranian University Hospital Organization). *International Journal of Medical Informatics*, *114*, 88-100. doi: https://doi.org/10.1016/j.ijmedinf.2018.03.009.

Harris, N., Fitzgerald, J., Chai, A., Radford, K., Ross, A., Carr, L., & Vecchio, N. (2018). The application of triple aim framework in the context of primary healthcare: A systematic literature review. *Health Policy*, *122*(8), 900-907. doi: https://doi.org/10.1016/j.healthpol.2018.06.006.

Hassaart, F. (2011). *Incentives in the diagnosis treatment combination payment system for specialist medical care* (Doctoral dissertation, Universiteit Maastricht). doi: 10.26481/dis.20111104fh. Retrieved March 18, 2021 from Maastricht University: https://bit.ly/3ijnakl.

Hevner, A. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems*, *19*(2), 87-92. Retrieved from https://www.researchgate.net/publication/254804390

Hevner, A., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105. doi: https://doi.org/10.2307/25148625.

Hielkema-Raadsveld, F. (2016, February 22). *Hoe plukt u de vruchten van LOINC, SNOMED CT en UCUM?* Retrieved June 10, 2021 from Nictiz Website: https://www.nictiz.nl/whitepapers/hoe-plukt-u-de-vruchten-van-loinc-snomed-ct-en-ucum-2/.

ICTrecht. (2019, september 27). *Advies opslag medische data in de cloud.* Retrieved June 17, 2021 from Dutch governmental Website: https://www.rijksoverheid.nl/documenten/rapporten/2019/10/08/advies-opslag-medische-data-in-de-cloud.

Ilin, I., Lepekhin, A., Ershova, E., & Borremans, A. (2020). IT and technological architecture of healthcare organization. *IOP Conference Series: Materials Science and Engineering*, *1001*(2020). doi: https://doi.org/10.1088/1757-899x/1001/1/012141.

Ilin, I., Levina, A., Lepekhin, A., & Kalyazina, S. (2019). Business Requirements to the IT Architecture: A Case of a Healthcare Organization. In *International scientific conference energy management of municipal facilities and sustainable energy technologies* (p. 287-294). doi: https://doi.org/10.1007/978-3-030-19868-8_29.

Institute of Medicine (IOM). (2001). Improving the 21st-Century Health Care System. In *Crossing the quality chasm: A new health system for the 21st century* (p. 39-60). National Academies Press. doi: http://doi.org/10.17226/10027.

Institute of Medicine (IOM). (2010). Institute of Medicine (US) Roundtable on Value & Science-Driven Health Care: CH2 Stakeholder perspective on value. In P. Yong, L. Olsen, & J. McGinnis (Eds.), *Value in health care: Accounting for cost, quality, safety, outcomes, and innovation* (p. 27-38). National Academies Press (US). doi: http://doi.org/10.17226/12566.

Janssen, M. (2009). Framing Enterprise Architecture: A meta-framework for analyzing architectural efforts in organizations. In G. Doucet, J. Gøtze, P. Saha, & S. Bernard (Eds.), *Coherency management: Architecting the enterprise for alignment, agility, and assurance* (p. 107-126). International Enterprise Architecture Institute. Retrieved from TU Delft Website: https://research.tudelft.nl/en/publications/framing-enterprise-architecture-a-meta-framework-for-analyzing-ar.

Janssen, R., Stam, P., Visser, J., de Vries, D., & Wijnker, J. (2017). Blockchaintechnologie in de gezondheidszorg. *ESB*, *102*(4752), 394–397. Retrieved January 5, 2021 from Tilburg University Website: https://pure.uvt.nl/ws/portalfiles/portal/17518490/2017_08_09_Janssen_R.T.J.M.pdf.

Johannesson, P., & Perjons, E. (2014). *An Introduction to Design Science*. Springer. doi: https://doi.org/10.1007/978-3-319-10632-8.

Kaplan, R. S., & Porter, M. E. (2011). How to solve the cost crisis in health care. *Harvard Business Review*, *89*(9), 46-52, 54, 56-61. PMID: https://pubmed-ncbi-nlm-nih-gov.tudelft.idm.oclc.org/21939127/.

Klaassen, N., & Bremmer, D. (2019, March 3). *Ook jouw medische data liggen nu bij Google.* Retrieved June 17, 2021 from Algemeen Dagblad Website: https://www.ad.nl/binnenland/ook-jouw-medische-data-liggen-nu-bij-google~abcb3f6a/.

Kooijman, M., Brabers, A., & de Jong, J. (2018, August 29). *Solidariteit in de Zorg: Een onderzoek naar de bereidheid om voor anderen te betalen onder de algemene bevolking in 2013, 2015 en 2017.* Retrieved March 24, 2021 from Nivel Website: https://www.nivel.nl/nl/publicatie/solidariteit-de-zorg-een-onderzoek-naar-de-bereidheid-om-voor-anderen-te-betalen-onder. Nivel.

Kroneman, M., Boerma, W., van de Berg, M., Groenewegen, P., de Jong, J., & van Ginneken, E. (2016). *The Netherlands: health system review. Health system in transition.* Copenhagen: WHO Regional Office for Europe. Retrieved February 18, 2021 from WHO website: https://apps.who.int/iris/bitstream/handle/10665/330244/HiT-18-2-2016-eng.pdf.

Kuo, T. T., Kim, H. E., & Ohno-Machado, L. (2017). Blockchain distributed ledger technologies for biomedical and health care applications. *Journal of the American Medical Informatics Association*, *24*(6), 1211–1220. doi: https://doi.org/10.1093/jamia/ocx068.

Lopez-Fresno, P., Savolainen, T., & Miranda, S. (2018). Role of trust in integrative negotiations. *Electronic Journal of Knowledge Management*, *16*(1), 13–22. Retrieved from https://academic-publishing.org/index.php/ejkm/article/view/1112.

Maassen, E. F., Schrevel, S. J., Dedding, C. W., Broerse, J. E., & Regeer, B. J. (2017). Comparing patients' perspectives of "good care" in Dutch outpatient psychiatric services with academic perspectives of patient-centred care. *Journal of Mental Health*, *26*(1), 84–94. doi: https://doi.org/10.3109/09638237.2016.1167848.

Mandemaker, A. (2019, May 1). *Nieuwe topman CZ: 'Solidariteit zorgstelsel in gevaar'.* Retrieved March 23, 2021 from Eindhovens Dagblad website: https://www.ed.nl/eindhoven/nieuwe-topman-cz-solidariteit-zorgstelsel-in-gevaar~a4299435/. Eindhovens Dagblad.

Marzorati, C., & Pravettoni, G. (2017). Value as the key concept in the health care system: how it has influenced medical practice and clinical decision-making processes. *Journal of Multidisciplinary Healthcare*, *2017*(10), 101-106. doi: https://doi.org/10.2147/JMDH.S122383.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An Integrative Model of Organizational Trust. *Academy of Management Review*, *20*(3), 709–734. doi:

https://doi.org/10.2307/258792.

Medmij. (2021, April 30). *MedMij Afsprakenstelsel 1.4.0.* Version V1.4.0. Retrieved June 12, 2021 from Medmij Website: https://afsprakenstelsel.medmij.nl/.

Meijboom, G., & Klein Wolterink, G. (2020, September 17). *Informatiestandaarden: Basis voor gegevensuitwisseling in de zorg.* Retrieved June 8, 2021 from Nictiz website: https://www.nictiz.nl/wp-content/uploads/Informatiestandaarden-basis-voor-gegevensuitwisseling-in-de-zorg.pdf. Nictiz.

Ministry of Public Health Welfare and Sport. (2015, October 29). *Letter to parliament: 'Samen Beslissen'.* Retrieved March 30, 2021 from Dutch governmental Website: https://www.rijksoverheid.nl/documenten/kamerstukken/2015/10/29/kamerbrief-over-samen-beslissen.

Ministry of Public Health Welfare and Sport. (2018a, July 2). *Outcome-Based Healthcare 2018-2022.* Retrieved February 17, 2021 from Dutch governmental Website: https://www.government.nl/documents/reports/2018/07/02/outcome-based-healthcare-2018-2022.

Ministry of Public Health Welfare and Sport. (2018b, April 19). *Rechtmatige zorg: Aanpak van fouten en fraude 2018-2021.* Retrieved February 15, 2021 from Dutch governmental Website: https://www.rijksoverheid.nl/documenten/publicaties/2018/04/19/programma-rechtmatige-zorg.

Ministry of Public Health, W., & Sport. (2016, January). *Healthcare in the Netherlands.* Retrieved February 15, 2021 from Dutch governmental Website: https://english.zorginstituutnederland.nl/about-us/publications/publications/2016/01/31/healthcare-in-the-netherlands.

Mjåset, C., Nagra, N. S., & Feeley, T. W. (2020). Value-Based Health Care in Four Different Health Care Systems. *NEJM Catalyst Innovations in Care Delivery*. doi: https://doi.org/10.1056/CAT.20.0530.

Mot, E., Stuut, K., Westra, P., & Aalbers, R. (2016, March 30). *Een raming van de zorguitgaven 2018 - 2021.* Retrieved March 23, 2021 from CPB Netherlands Bureau for Economic Policy Analysis Website: https://www.cpb.nl/publicatie/een-raming-van-de-zorguitgaven-2018-2021.

Mulders, R. (2020, August 26). *Clinical Document Architecture (CDA) Fast Healthcare Interoperability Resources (FHIR) Aanvullend of opvolgend?* (Tech. Rep.). Veenendaal: Stichting HL7 Nederland.

Narikimilli, N. R. S., Kumar, A., Antu, A. D., & Xie, B. (2020). *Blockchain Applications in Healthcare – A Review and Future Perspective* (Vol. 12404 LNCS). Springer International Publishing. doi: https://doi.org/10.1007/978-3-030-59638-5_14.

Nictiz. (2020a, September 28). *Health and care information models (zorginformatiebouwstenen).* Retrieved June 10, 2021 from Nictiz Website: https://zibs.nl/.

Nictiz. (2020b, July 20). *Medmij information standards.* Retrieved June 10, 2021 from Nictiz Website: https://informatiestandaarden.nictiz.nl/wiki/MedMij:V1.0_Standards.

NORA. (2019, May 22). *Nederlandse overheid referentie architectuur (nora) online.* Retrieved June 10, 2021 from NORA Website: https://www.noraonline.nl/wiki/NORA_online.

Osei-Tutu, K., & Song, Y.-t. (2020, 01). Enterprise Architecture for Healthcare Information Exchange (HIE) Cloud Migration. In *2020 14th international conference on ubiquitous information management and communication (imcom)* (p. 1-8). doi: https://doi.org/10.1109/IMCOM48794.2020.9001677.

Oxford Reference. (2006). *The Oxford Dictionary of Sports Science & Medicine* (3rd ed.). Oxford University Press. doi: 10.1093/acref/9780198568506.001.0001.

Patiëntenfederatie Nederland. (2021, February). *Laat PGO's vliegen - PGO on air* (Tech. Rep.). Utrecht: Patiëntenfederatie Nederland. Retrieved July 5, 2021 from Patients Federation Website: https://www.patientenfederatie.nl/downloads/rapporten/772-pgo-on-air-jaarbericht-2020-laat-pgo-s-vliegen/file.

Peng, C., Goswami, P., & Bai, G. (2019). A literature review of current technologies on health data integration for patient-centered health management. *Health Informatics Journal*, *26*(3), 1926–1951. doi: https://doi.org/10.1177/1460458219892387.

Porter, M. E. (2010a). Measuring health outcomes: the outcome hierarchy (appendix 2 to Porter (2010)). *The New England Journal of Medicine*, *81*, 2477–2481. doi: https://doi.org/10.1056/NEJMp1011024.

Porter, M. E. (2010b). What Is Value in Health Care? *The New England Journal of Medicine*, *363*, 2477–2481. doi: https://doi.org/10.1056/NEJMp1011024.

Porter, M. E., & Lee, T. (2013). The Strategy That Will Fix Health Care. *Harvard Business Review*, *91*(10), 50-70. Retrieved from https://hbr.org/2013/10/the-strategy-that-will-fix-health-care

Porter, M. E., & Teisberg, E. O. (2006). *Redefining Health Care: Creating Value-Based Competition on Results*. Harvard Business Review Press. (Book available at Harvard Business Review Store: https://store.hbr.org/product/redefining-health-care-creating-value-based-competition-on-results/7782)

Porter, M. E., & Teisberg, E. O. (2007). How Physicians Can Change the Future of Health Care. *JAMA*, *297*(10), 1103-1111. doi: https://doi.org/10.1001/jama.297.10.1103.

Przyrowski, C. (2018). The GDPR and its Effects on the Management of Private Health Information at different Healthcare Providers – A Case Study. In *11th IBA Bachelor Thesis Conference.* Enschede: University of Twente. Retrieved from http://essay.utwente.nl/75322/1/Przyrowski_BA_BMS.pdf

Putera, I. (2017). Redefining Health: Implication for Value-Based Healthcare Reform. *Cureus*, *9*(3), e1067. doi: https://doi.org/10.7759/cureus.1067.

Registratie aan de bron. (2017, April 20). *Architectuur vol.2 Technische implementatie van Zib's* (Tech. Rep.). Utrecht: Registratie aan de Bron. Retrieved June 1, 2021 from Registratie aan de Bron Website: https://www.registratieaandebron.nl/architectuurdocument.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a General Theory of Planning (original wicked issues). *Policy Sciences*, *4*, 155–169. doi:https://doi.org/10.1007/BF01405730.

RIVM. (2018, April 19). *Zorgkosten naar leeftijd en geslacht.* from Vektis open data. Retrieved January 2, 2021 from Dutch public healthcare Website: https://www.volksgezondheidenzorg.info/onderwerp/zorgverzekering/cijfers-context/huidige-situatie#node-zorgkosten-naar-leeftijd-en-geslacht.

Ross, J. (2003). Creating a strategic it architecture competency: Learning in stages. *MIS Quarterly Executive*, *2*(1), 1–23. doi:https://doi.org/10.2139/ssrn.416180.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of Management Review*, *23*(3), 393–404. doi: https://doi.org/10.5465/AMR.1998.926617.

Sackett, D. L., Rosenberg, W. M., Gray, J. A., Haynes, R. B., & Richardson, W. S. (1996). Evidence based medicine: what it is and what it isn't. *BMJ*, *312*(7023), 71–72. doi:

https://doi-org.tudelft.idm.oclc.org/10.1136/bmj.312.7023.71.

Salleh, A. (2021, June 9). *Healthcare information systems.* Retrieved June 12, 2021 from Website: https://drdollah.com/hospital-information-system-his/.

Schnackenberg, A. K., & Tomlinson, E. C. (2016). Organizational Transparency: A New Perspective on Managing Trust in Organization-Stakeholder Relationships. *Journal of Management*, *42*(7), 1784–1810. doi:https://doi.org/10.1177/0149206314525202.

Sekeran, U., & Bougie, R. (2016). *Research Methods For Business: A Skill Building Approach* (7th ed.). Chichester: John Wiley & Sons.

Seoane, F., Traver, V., & Hazelzet, J. (2020). Value-driven digital transformation in health and medical care. *Interactive Process Mining in Healthcare*, 13–26. doi:https://doi.org/10.1007/978-3-030-53993-1_2.

SER. (2020, June). *Zorg voor de toekomst. Over de toekomstbestendigheid van de zorg* (Tech. Rep.). Den Haag: Socicaal Economische Raad. Retrieved March 20, 2021 from SER Website: https://www.ser.nl/-/media/ser/downloads/adviezen/2020/zorg-voor-de-toekomst.pdf.

Skipr. (2016, April 4). *Santeon en Menzis maken werk van waardegedreven zorg.* Retrieved February 22, 2021 from Skipr Website: https://www.skipr.nl/nieuws/santeon-en-menzis-maken-werk-van-waardegedreven-zorg/.

Slavitt, A. (2018, November 8). The Triple Aim Must Overcome the Triple Threat. *JAMA Forum Archive.* doi:10.1001/jamahealthforum.2018.0044. Accessible at https://jamanetwork.com/.

SNOMED-CT. (2015, May 21). *Data Analytics with SNOMED CT.* Retrieved June 8, 2021 from Nictiz Website: https://www.nictiz.nl/rapporten/data-analytics-with-snomed-ct/. IHTSDO.

Soule, D. (2020, April 22). *The Biggest Barriers to Healthcare Interoperability.* Retrieved July 12, 2021 from Health Catalyst Website: fromhttps://www.healthcatalyst.com/insights/healthcare-interoperability-barriers-solutions. Health Catalyst.

Sprenger, M. (2019, October 7). *Electronic Information for Health and Care Services* (Tech. Rep.). The Hague: Nictiz. Retrieved June 8, 2021 from Nictiz Website: https://www.nictiz.nl/rapporten/electronic-infromation-for-health-and-care-services/.

Statics Netherlands (CBS). (2020a, June 11). *Care expenditure 5.2 percent up in 2019.* Retrieved December 30, 2020 from CBS Website: https://www.cbs.nl/en-gb/news/2020/24/care-expenditure-5-2-percent-up-in-2019.

Statics Netherlands (CBS). (2020b, December 16). *Forecast: Population growth unabated in the next 50 years.* Retrieved December 19, 2020 from CBS Website:https://www.cbs.nl/en-gb/news/2020/51/forecast-population-growth-unabated-in-the-next-50-years.

Statics Netherlands (CBS). (2020c, September 25). *Life expectancy increased in 2019.* Retrieved January 2, 2021 from CBS Website:https://www.cbs.nl/en-gb/news/2020/39/life-expectancy-increased-in-2019.

Stepovic, M. (2019). GDP Growth and Health Care Expenditures Worldwide. *The Open Pharmacoeconomics & Health Economics Journal*, *7*(1), 9–18. doi:https://doi.org/10.2174/1874129001907010009.

The Open Group. (2016, February). *Healthcare Interoperability (W163)* (Tech. Rep.). San Francisco, CA: Author. Retrieved June 11, 2021 from The Open Group Website: https://publications.opengroup.org/white-papers/w163.

The Open Group. (2018, April). *The togaf standard, version 9.2* (Tech. Rep.). San

Francisco, CA: Author. https://pubs.opengroup.org/architecture/togaf9-doc/arch/index.html.

Thuan, N. H., Drechsler, A., & Antunes, P. (2019). Construction of design science research questions. *Communications of the Association for Information Systems*, *44*(1), 332–363. doi: 10.17705/1CAIS.04420.

Tseng, E. K., & Hicks, L. K. (2016). Value Based Care and Patient-Centered Care: Divergent or Complementary? *Current Hematologic Malignancy Reports*, *11*(4), 303–310. doi: https://doi.org/10.1007/s11899-016-0333-2.

van de Poel, P. (2018, August 15). *Zorginstituut kiest ichom als routekaart naar transparante zorg.* Retrieved June 15, 2021 from Skipr Website: https://www.skipr.nl/nieuws/zorginstituut-kiest-ichom-als-routekaart-naar-transparante-zorg/. Skipr.

Van Duivendijk, I., & Hutink, H. (2018, August 30). *ICHOM als instrument voor Uitkomstgerichte Zorg in Nederland.* Retrieved June 8, 2021 from Nictiz Website: https://www.nictiz.nl/wp-content/uploads/2018/08/Onderzoeksrapport-ICHOM-Nictiz-1.pdf.

van Manen, J., Meurs, P., & van Twist, M. (2020, March 4). *De aangekondigde ondergang. Onderzoek naar de faillisementen van het MC Slotervaart en de MC Ijsselmeerziekenhuizen.* Retrieved February 15, 2021 from Dutch governmental Website: https://www.rijksoverheid.nl/onderwerpen/faillissement-mc-slotervaart-en-mc-ijsselmeerziekenhuizen/onafhankelijke-onderzoekscommissie.

Vreugdenhil, M. M., Ranke, S., De Man, Y., Haan, M. M., & Kool, R. B. (2019). Patient and health care provider experiences with a recently introduced patient portal in an academic hospital in the Netherlands: Mixed methods study. *Journal of Medical Internet Research*, *21*(8), e13743. doi:https://doi.org/10.2196/13743.

VvAA. (2020, July 30). *[Ont]Regelmonitor 2020.* Retrieved February 15, 2021 from VvAA Website: https://www.vvaa.nl/voor-leden/nieuws/nationale-ontregelmonitor-2020.

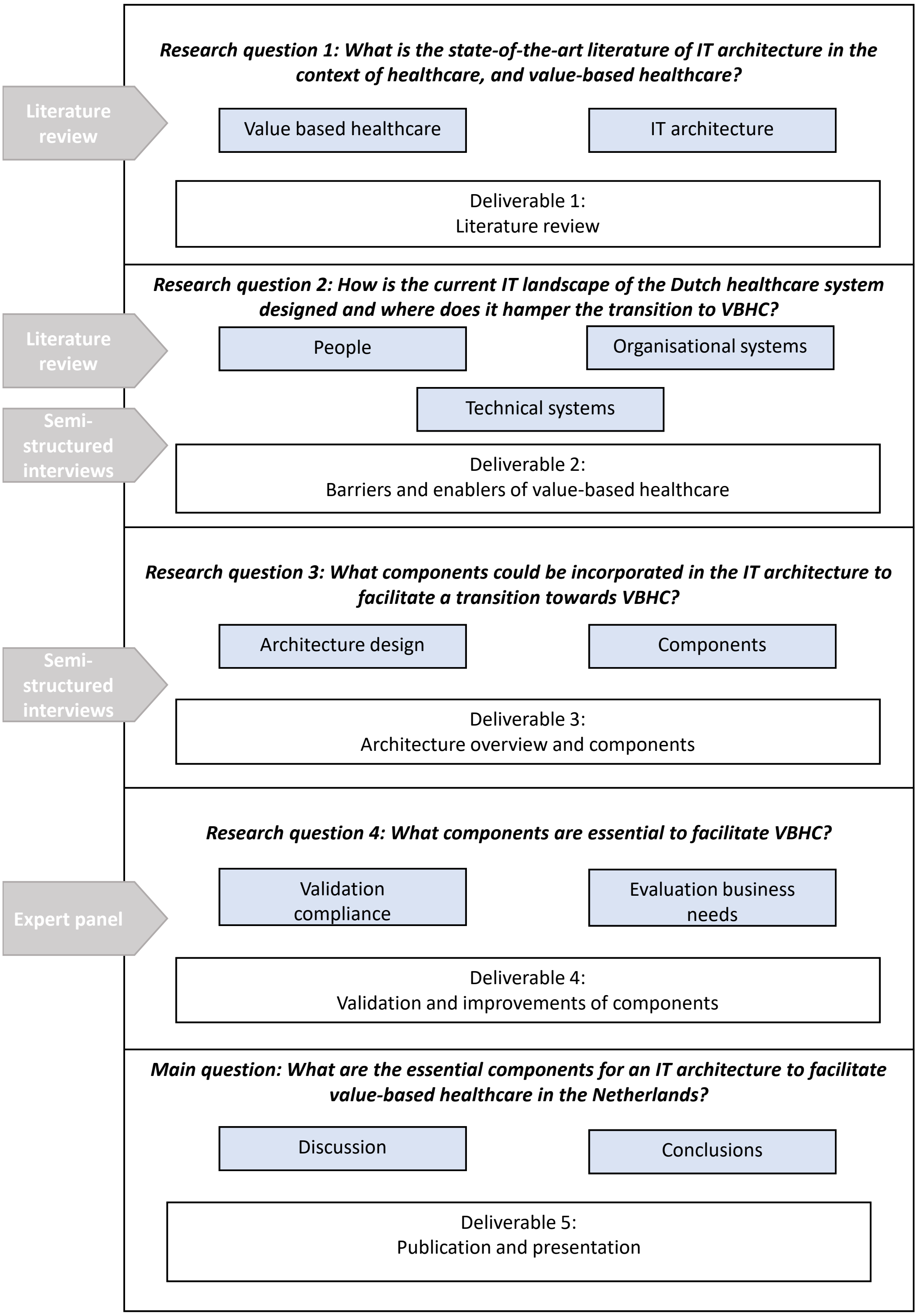
Winter, A., Stäubert, S., Ammon, D., Aiche, S., Beyan, O., Bischoff, V., ... Löffler, M. (2018, 07). Smart medical information technology for healthcare (smith). *Methods of information in medicine*, *57*, e92-e105. doi: https://doi.org/10.3414/ME18-02-0004.

Wolters, Sanne. (2020, June 5). *Nederland komt verpleegkundigen tekort.* Retrieved March 16, 2021 from Algemeen Dagblad Website: https://www.ad.nl/werk/nederland-komt-duizenden-verpleegkundigen-tekort-het-is-2020-geef-ze-flexibiliteit~a60decd5/.

APPENDICES

A

RESEARCH DIAGRAM



Research question 1: What is the state-of-the-art literature of IT architecture in the context of healthcare, and value-based healthcare?

Research question 2: How is the current IT landscape of the Dutch healthcare system designed and where does it hamper the transition to VBHC?

Research question 3: What components could be incorporated in the IT architecture to facilitate a transition towards VBHC?

Research question 4: What components are essential to facilitate VBHC?

Main question: What are the essential components for an IT architecture to facilitate value-based healthcare in the Netherlands?

B BACKGROUND VALUE IN HEALTHCARE

To get a better understanding of the concept of *value*, a literature study was conducted. Influential theories and key definitions will be discussed.

B.1 EVIDENCE-BASED MEDICINE

One of the first frameworks that incorporated the patients' values was EBM. 'Evidence' in healthcare already dates back to around 1600, but in the late 90s, the term *Evidence-Based Medicine* was introduced first. Originally EBM was developed to teach clinicians how they could improve decision-making about individual patients based on the research evidence (Guyatt et al., 1992).

Later, the EBM triad have been developed and integrated the experience of the clinician, the most relevant scientific literature and the patients' values to guide decision-making. Figure B.1 visualises the EBM triad. Sackett et al. (1996) defines the EBM as *"the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."* Here patients' values are defined as "the unique preferences, concerns and expectations each patient brings to a clinical encounter and which must be integrated into clinical decisions if they are to serve the patient" (Sackett et al., 1996).

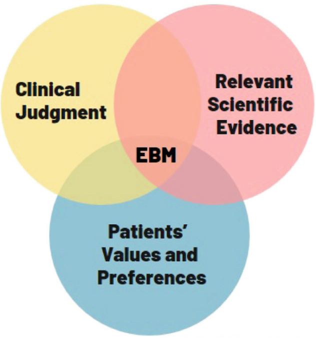


Figure B.1: Evidence Based Medicine Triade. Adopted from Seoane et al. (2020).

Despite the benefits of evidence-based treatments, it fails to provide a true indication of clinical effectiveness (Marzorati & Pravettoni, 2017). Another paradigm, PCC, started to gain attention. In PCC, patients actively participate in the clinical decision-making and in the evaluation of the care process.

B.2 PATIENT-CENTRED CARE

Similar to EBM, PCC requires clinicians to focus beyond the disease-oriented model and incorporate the patient's experience and needs (Barry & Edgman-Levitan, 2012). However, PCC go further and include not only the patient's preferences but include the patient as a decision-maker. This is also known as shared decision-making.

The IOM includes PCC as one of six domains of quality in healthcare and defines it as *"care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions"* (Institute of Medicine (IOM), 2001, p. 40). The Picker institute identified 8 dimensions of PCC: patient preference, emotional support, physical comfort, information and communication needs, continuity and transition, care coordination, involvement of family and friends, and access to care (Tseng & Hicks, 2016).

The IOM organised a workshop for patients, clinicians, payers, policymakers to analyse the perspectives on value (Institute of Medicine (IOM), 2010). From an economic point of view, the value was perceived as a clinical benefit achieved per money spent. However, from the patient's point of view, value in care is the ability of healthcare to both treat the disease and satisfy the patient's needs. The achieved health status is not limited to the disease but involves also the quality of life (QoL) (Marzorati & Pravettoni, 2017). The QoL factors are often objectified into pain, cognitive and physical functioning.

Throughout the years, shared decision-making got increasingly important. According to Maassen et al. (2017) there are two reasons for the popularity of PCC. First, medical specialists are morally obligated to respect the autonomy of the patient. Second, studies have shown that treatments with PCC improved the recovery, emotional health and significantly reduced diagnostic test and referrals two months later (Epstein, 2000). Consequently, PCC increases the perceived quality of care while reducing the costs at the same time.

B.3 HEALTHCARE SYSTEMS BASED ON VALUE

Later, more holistic frameworks were suggested to simultaneously increase value in care and deal with the sustainability challenge (Seoane et al., 2020)[1]. These emerging healthcare delivery models acknowledge the complexity of the healthcare landscape and offer frameworks to organise the process of care around the concept of value (Marzorati & Pravettoni, 2017). Frameworks that are widely known and adopted in different healthcare systems are Value-based Healthcare, Triple Aim and Triple Value.

B.3.1 Value-Based Healthcare

In 2006, Porter and Teisberg published their work '*Redefining Health care*' and introduced the concept of value-based competition. As explained in Section 1.3, Porter and Teisberg (2006) argue that competition itself is not the problem, but the nature of competition is. They argue that the problems the healthcare sector is facing stem from the zero-sum competition, which can be defined as "A competition in which one participant wins totally and another loses without gaining any objectives" (Oxford Reference, 2006). In a positive-sum competition, on the other hand, providers would be financially stimulated to deliver high-quality care in more efficient ways, which is, in turn, beneficial for patients and payers.

Porter and Teisberg (2007) determine three guiding principles that lead to a value-based healthcare system: (1) The goal is value for patients, (2) Organise medical practices around medical conditions and care cycles, and (3) Outcomes and costs must be measured across the care cycle. Porter and Teisberg (2006) defines value as *"healthcare outcomes achieved per dollar spent"*. By "health outcomes", the authors mean the health outcomes achieved which matters to the patient. Outcomes are considered beyond the disease and incorporate also the process of recovery and the sustainability of the outcomes (Porter, 2010b). By "costs" it meant the total costs to achieve the health outcomes (Porter, 2010b).

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[1] See Section 1.1: Sustainability of Dutch Healthcare System

The VBHC framework has however some limitations. First of all, the definition of value is relatively limited, which reduces the holistic concept to a cost-efficiency question (Seoane et al., 2020). Indeed, when comparing this definition to the definitions from the IOM workshop, it comes closest to the economic perspective. Second, VBHC centres the disease instead of the patient, which makes the care process highly complex if a patient suffers from multiple conditions (Putera, 2017). Third, the underlying assumption that competition on value will increase the quality and reduces costs is based on a patient that rationally chooses a healthcare provider. However, this assumption might not hold for healthcare since patients might not search for the best care, but for example, close to their home. In addition, even if information about quality is widely available, the interpretation might differ per person.

B.3.2 Triple Aim

Berwick et al. (2008) introduced the *Triple Aim* framework, which is focused on improving public health and a higher quality of healthcare for lower costs. In concept, the triple aim is very similar to VBHC, but the health outcomes are not limited to a specific disease and the care process (Seoane et al., 2020). The primary objective of the framework is to improve the value and quality of healthcare across three dimensions: population health, experience of care and per capita costs. Figure B.2 illustrates the triple aim.

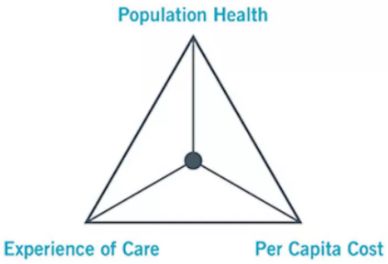

Figure B.2: Triple Aim. Adopted from the Institute for Healthcare Improvement.

Bodenheimer and Sinsky (2014) found that primary care struggled with the implementation of the triple aim because the stressful work life of the clinicians hampered achieving the three aims. Clinicians or physicians that suffer from burnouts and dissatisfaction cause the lower experience of care, reduced outcomes and increase costs. Therefore, Bodenheimer and Sinsky (2014) recommend extending the triple aim to a *Quadruple Aim* and including to *experience the care team*.

In a study on the implementation of the triple aim, Harris et al. (2018) found that the majority of providers were unable to implement the framework because of: unclear definition of population, unavailability of data, and no dedicated data management. Besides the difficulty of implementation, there are other critiques on the triple aim framework. Slavitt (2018) points out that the framework does not include the variances in healthcare quality, for example, based on income or geographic location, which limits the ability to allocate resources proportionally. In addition, there is no incentive for providers to improve the population health or experience of care, as it does not result in higher revenue. If there is no incentive for a radical change, the framework may not be suitable to solve the healthcare challenges in the long run.

B.3.3 Triple Value

Gray and Jani (2016) proposes a link between value-based healthcare and population healthcare and suggested the *Triple Value* healthcare paradigm as the way to reform healthcare systems. The paradigm based on personal value (patient's values are used for decision making to optimise value for themselves), technical value (resources are used optimally) and allocative value (resources are allocated optimally and equitably) (Gray & Jani, 2016).

The Expert Panel on effective ways of investing in Health (EXPH) extends the paradigm to a *Quadruple Value* by incorporating the societal value. This fourth value involves the impact of the care intervention on social cohesion, solidarity, mutual respect, equity and recognition of diversity (European Commission, 2019). The societal value is rather a perspective than a toolkit to enhance outcomes. Consequently, they define VBHC as *"comprehensive concept built on four value-pillars: appropriate care to achieve patients' personal goals (personal value), achievement of best possible outcomes with available resources (technical value), equitable resource distribution across all patient groups (allocative value) and contribution of healthcare to social participation and connectedness (societal value)."*

B.3.4 Reflection on value in healthcare

One of the first models that incorporated 'value' from a patient perspective was EBM. Together with the relevant scientific evidence and clinical judgement, clinical decision-making has improved significantly. Although EBM involved patient's values, the provided care is not individualised but established on population-based evidence. This may not represent every patient, which called for a shift towards patient-centredness. PCC goes one step further and incorporates the patient in the decision making and evaluation of the care process.

More holistic frameworks have risen to respond to the sustainability challenges of healthcare. Whereas VBHC is more disease-oriented, the Triple Aim and Triple Value are patient-oriented. Value in VBHC is achieved by improving outcomes that matter to the patient while reducing costs. The Triple Aim focuses not on an individual patient, but rather improves population health. The Triple Value links the two paradigms and proposes personal value, technical value and allocative value.

A commonality is that all frameworks revolve around improving healthcare outcomes and quality of life for patients, increasing efficiency and reducing costs. According to Seoane et al. (2020), implementation of such frameworks can only be achieved by the availability of accurate and valid information. Porter (2010b) even argue that "outcomes are the true measures for quality in healthcare". Despite the importance of outcomes, it is complex to express outcomes in a unified way.

C IMPLEMENTATION OF VBHC

This appendix describes the implementation framework of Porter and Lee (2013). Further, the implementation status for the Netherlands will be discussed per implementation step.

C.1 IMPLEMENTATION FRAMEWORK

1. Organize into IPU

Healthcare delivery should be organised around the patient to coordinate the care process. For example, patients suffering from lower back pain can be referred from physician to different kinds of medical specialists such as a neurologist or a rheumatologist. Healthcare delivery then is fragmented and duplication of medical interventions, delays, and inefficiencies are almost inevitable. An Integrated Practice Unit (IPU) is a multidisciplinary team that delivers specialist care, organised around the medical condition (Porter & Lee, 2013).

Although IPUs seem a valid solution in theory, in practice it may complicate the healthcare delivery system even more. A limitation of VBHC is if patients suffer from multiple conditions, the care process and outcome measurement become complicated (Putera, 2017). An integrated delivery system where healthcare professionals work closely together, especially in the case of chronic diseases, may derive higher value than freestanding IPUs.

2. Measure costs and outcomes for every patient

According to Porter and Lee (2013) rigorous measurement of both outcomes and costs is necessary to improve and excel. At the core of VBHC are the outcomes that matter to the patient. Outcomes should be condition-specific, cover multiple aspects and measured across the full cycle of care. Outcomes can be divided into the following tiers and dimensions (Porter, 2010a):

1. Health status achieved: defined by mortality and the degree of health and, or recovery.
2. Nature of cycle and recovery: defined by time to achieve recovery (e.g. cycle time of diagnosis, treatment plan, care initiation and duration of treatment) and disutility of the care process (e.g. missed diagnosis, failed treatment, anxiety, discomfort, complications, retreatment, and errors).
3. Sustainability of health: defined by recurrences of the original disease and possible new health problems as a consequence of the treatment itself.

These three tiers are very broad and should be specified to particular medical conditions. For example, the outcome measures for the dimension degree of health/recovery for a patient with breast cancer can be 'breast preservation', while for a patient with acute knee arthritis the 'level of pain' is of more importance (Porter, 2010a). The ICHOM provides standardised outcomes sets for specific health conditions and play an important role in the adoption outcome measurement (European Commission, 2019; Mjåset et al., 2020).

On the other hand, the costs to achieve that outcome must be measured across the full cycle of care (Porter & Lee, 2013). The cost include all of the human resources, supplies, and supporting services that are involved to achieve the outcomes. If care processes for each medical condition are standardised, providers can use the time-driven activity-based costing (TDABC) to assign costs accurately (Kaplan & Porter, 2011). Currently, the cost structure of healthcare activities in the Netherlands is already based on activity-based costing, but including time would provide a better overview on the cost allocation. IT can facilitate TDABC by automatically capturing the activity, resources and time for each care process (Feeley et al., 2020). This can be linked to other data such as staff salaries, supply costs, and facility costs, to accurately allocate costs.

3. Move to bundled payments for care cycles

In the current healthcare structure, providers are rewarded for the healthcare services that are provided to the patient. This structure connects services (e.g. x-rays, physical therapy consults) to payments, regardless of the outcomes achieved. Porter and Lee (2013) describe that bundled payment - a payment tied to the overall care for a specific medical condition provided by an IPU - would match VBHC best. This type of payment motivates IPUs to improve efficiency and outcomes and rewards them for excellent value achievements.

4. Integrate care delivery systems

The organisation of healthcare delivery should be matched to providers and their expertise. Overall the IPU should coordinate all the healthcare activities. Concentrating volume is key to improve value because scarce resources can be allocated better and more expertise can be developed. To organise delivery systems carefully, organisations must define the scope of services, concentrate volume in fewer locations, choose the right location for each service and integrate the care across locations (Porter & Lee, 2013).

5: Expand Geographic Reach

Porter and Lee (2013) propose to create centres of high expertise to take care of complex medical conditions. The expertise centres are located strategically and collaborate with smaller centres located regionally. The Netherlands has 8 academic medical centres, where patients are to referred for the most complex medical conditions (Mjåset et al., 2020). These academic hospitals collaborate with smaller hospitals and providers, which provide often less complex care and low-cost services.

6: Build an Enabling Information Technology Platform

The aforementioned 5 strategic steps towards a high-value healthcare delivery system should be supported by an IT platform (Porter & Lee, 2013). If the IT infrastructure that is not organised in the right way, limited benefits from the previous steps can be gained. Feeley et al. (2020) discusses the evolution of healthcare IT systems and explains that medical data is siloed which hampers outcome and cost measurement. For a healthcare IT system to enable value it must:

- Be patient-centred
- Use common data definitions
- Encompass different data types
- Be accessible to all parties involved
- Include specified medical condition templates
- Be easy to extract information

C.2 IMPLEMENTATION IN THE NETHERLANDS

Besides the academic interest in the concept of value in healthcare, it also got increasingly adopted and refined by healthcare providers and payers globally (Feeley et al., 2020). Mjåset et al. (2020) studied the implementation of value-based healthcare in four different healthcare systems: Massachusetts (USA), the Netherlands, Norway, and England (UK). They assessed the implementation status following the elements of the strategic framework as defined by Porter and Lee (2013). See Appendix C.1 for the elements. They have found that elements of the theoretical framework function better in some health care systems than others. The scope of this research is the Dutch healthcare system and, therefore, analysis on the implementation will be limited to the Netherlands. Table C.1 presents the implementation status per element.

C.2.1 Recommendations for implementation

Mjåset et al. (2020) provided several recommendations to drive the implementation of VBHC further. A key enabler mentioned was the *involvement of the government*. As the providers, insurers and patients may have different interests, it is too complex for these stakeholders to lead the transition. Another essential aspect is the *culture among providers*. The culture at one of the pioneers, Santeon, is to collect, discuss and learn from data to improve healthcare, which can accelerate the diffusion of VBHC. Finally, the *improvement of the IT infrastructure* was mentioned as a key enabler for VBHC. IT systems across the care cycle should be integrated so that, for example, primary care and specialty care can collaborate in a more efficient way. With emerging technologies, the healthcare industry is getting more improvement opportunities for IT.

	Strategic step	**Implementation status**
1.	Organize into IPU	There are some providers that drive the implementation of VBHC. "The development seems to have come closest to what constitutes an IPU" (Mjåset et al., 2020). The Santeon group, consisting of seven hospitals, is one of the pioneers in the Netherlands and operates on some elements as an IPU.
2.	Measure outcomes & cost	In 2018, the Ministry of Public Health Welfare and Sport set the ambition that outcome information must be available for 52 disorders. The outcome data will be based on standards of the ICHOM to accelerate the availability of outcome information. It is important that data is collected, analyzed and shared in the same way (Ministry of Public Health Welfare and Sport, 2018a). The outcome standards are based on both PROMs and PREMs. Whereas PROMs measure the healthcare status achieved, the PREMs measure the experience of the care process and services.
3.	Bundled payments	Large Dutch insurance companies, like Zilveren Kruis, Menzis, CZ and VGZ, are already experimenting with value-based payment models on a small scale. For example, Menzis combines a base price per case unit, medical products used and the outcomes achieved (EIT Health,2020 p. 51). However, the majority of payments are still based on the DTCs.
4.	Integrate Delivery systems	The government supports providers to collaborate and provide *the right care at the right care setting*. Interviewee 1.6 mentioned that this is one of the challenges healthcare is facing. Patients are referred back and forth, without getting actual treatment. ZorgDomein is a platform in the Netherlands that connects demand, the referrers (e.g. GPs), and supply, the providers (e.g. medical specialist).
5.	Geographic reach	The Dutch health care has eight independent academic hospitals spread across the country, acting as tertiary referral centres for the most complex patients. Highly specialised treatments are provided in these academic hospitals whereas less complex treatments are provided in general hospitals or independent treatment centres (ZBC).
6.	IT platform	In order to achieve the governments' objectives of outcome-based healthcare, several projects are ongoing. Naturally, a set of indicators per disease must be available to achieve this goal. The generic data sets of ICHOM will be used as guidance (Van Duivendijk & Hutink, 2018). These should be streamlined with the healthcare information blocks (Zibs). The Zibs are the data standards used to achieve semantic interoperability on an information-level (Meijboom & Klein Wolterink, 2020). Projects such as Medmij[1], VIPP[2] and Registratie aan de bron[3] also use the data standards. While there are many ongoing projects regarding interoperability and standardisation, not all criteria of Porter and Lee (2013) are satisfied yet.

Table C.1: Overview of implementation status of VBHC in the Netherlands

D

STAKEHOLDER ANALYSIS

Stakeholder category	Role	Interest(s)	Interest(s)	Power	Power
Patients	Consume medical care	High	High-quality and patient-centred care, reasonable premiums, accessibility of care	Low	Little to no power to initiate changes in healthcare system.
Patient organisations (patient federation)	Represents the interests of patients for specific medical conditions, provides information to patients and third parties	High	High-quality care, reasonable premiums, accessibility of care	Medium	Collective power to address issues for patients, not specific for VBHC.
Large healthcare providers (e.g. Academic hospitals, general hospitals, etc.)	Providing care services that are covered under the Healthcare Insurance Act (Zwv). Care services include: diagnosis, treatment and evaluation.	High	Providing high-quality care, positive and stable business case	Medium	Certain power to discuss policies and innovations.
Small healthcare providers (e.g. medical specialistic treatment centres, independent clinicians, etc.)	Providing care services that are covered under the Healthcare Insurance Act (Zwv). Care services include: diagnosis, treatment and evaluation.	High	Providing high-quality care, positive and stable business case	Low	Little to no power in the healthcare system. Needs to collaborate for power.
Insurance companies	Fulfilling the duty of care, which includes: (i) purchasing health services covered by basic health insurance	Medium	Providing care with a good balance in quality and price.	High	Power to determine which providers are selected for a contract. Authority to set rules and conditions for access to care services (e.g. referral letter)
Overarching interest group insurers (Zorgverzekeraars Nederland, ZN)	Representing the common interests of insurance companies in the Netherlands.	Medium	Policy-making about health insurance (legitimacy, contracts, basic insurance, etc.)	High	Power to initiate or withheld decision in new policies.
Health information systems (HIS/XIS) suppliers	Provide information systems for healthcare contexts	Medium	Profits, level of adaptation/usage, innovation	Medium	Determine the content and speed of new releases of systems.

Stakeholder category	Role	Interest(s)	Interest(s)	Power	Power
The Dutch government (incl. Ministry of Public Health Welfare and Sport)	End-responsible for providing high-quality care that is affordable and accessible to every Dutch citizen. Tasks include, but not limited to: (i) Determine public health targets; (ii) Facilitate healthcare actors; (iii) Define the content of the basic health insurance package	High	Affordable, accessible and qualitative care for all citizens.	High	Authority to impose obligations to market players. Power to change maximum costs prices for care services.
Dutch Healthcare Authority (NZa)	(i) Supervises the purchasing, insurance and provision market; (ii) Regulates the proper functioning of the regulated competition; (iii) Determines maximum tariffs	Low	Compliance with law and regulations	Medium	Authority to impose obligations to market players. Power to change maximum costs prices for care services.
Health Care Inspectorate (Inspectie Gezondheidszorg en Jeugd, IGJ), National Healthcare Institute (ZiNL)	(i) Supervises the quality, affordability and safety of healthcare; (ii) Stimulates quality improvement and provide advise on innovations; (iii) Advising the Ministry on the content of the basic benefit package	Low	Compliance with law and regulations	Medium	Authority to impose obligations to market players.
Nictiz	Responsible for development, management and distribution of healthcare standards.	Medium	Standardisation, innovation, interoperability of IT in healthcare	Medium	Little to medium power to initiate change in healthcare by providing knowledge.
VZVZ	Responsible for facilitation of (medical) data exchange via LSP	High	Secure and efficient exchange of data	Low	Determine the content and speed of new releases of systems.
HL7, IHE, Edifact	Providing standards for data exchange	High	Profits, level of adaptation/usage, innovation	Low	Determine the content and speed of new releases of standards.
Overarching interest group for IT suppliers (OIZ)	Representing the common interests of IT suppliers in the Netherlands.	Low	Standardisation, innovation	Low	Little to no power to make decisions regarding VBHC implementation.
Dutch Data Protection Authority (DPA)	Responsible for supervision of compliance with the legal rules of the GDPR.	Medium	Compliance with law and regulations.	Medium	Authority to impose penalties and obligations to market players.
Dutch Institute for Clinical Auditing (DICA)	Responsible for executing quality analysis in healthcare. Provides healthcare providers with insights in quality and feedback.	High	Accessible data and information	Low	Little to no power to make decisions regarding VBHC implementation.
Projects and initiatives (Medmij, ViPP, Registratie aan de Bron, Outcome-based healthcare 2022, ICHOM)	Executing projects to improve communication, patient-related and outcome related information provision	High	Standardisation, innovation, interoperability of IT in healthcare	Medium	Power is related to the level of adaptation of standards and methods proposed.

Table D.1: Stakeholder analysis for VBHC

E INTERVIEW PROTOCOL: PRELIMINARY INTERVIEW

Introduction
I'd like to thank you for willing to participate in this interview as part of my master thesis. First I will introduce myself, the research and the objective of today's interview.

- Introduction researcher & study. My name is Floor de Jonge, and I am a master student in Management of Technology at TU Delft. At the moment I am conducting my thesis. As part of my thesis, I am pursuing an internship at PwC's Risk Assurance department. In my thesis, I focus on value-based healthcare. Value-based healthcare aims to maximize the outcomes for the patient. It is assumed that if providers are rewarded for their services based on the outcomes, quality will rise and costs will reduce. A prerequisite for value-based healthcare is outcome and cost measurement over the full cycle of care. However, the current IT landscape impedes the transition to value-based healthcare.
  This study tries to find out how the IT for healthcare providers can be designed to enable value-based healthcare. This includes for example data exchange between providers, outcome and cost measurement over the full care cycle, and reimbursement.
- Goal interview. The goal of this interview is to [understand the current situation, identify problems of healthcare] / [to derive practical experience and requirements for a value enabling information system].
- Confidentiality. This interview and all answers given to any questions will remain confidential. All personally identifiable information will be removed before processing and presenting the data. However, to support the notes, I would like to record the interview. Is that okay with you?
- Time duration. This interview is planned to last about [30 - 60] minutes. If the time is running short, I may interrupt you to be able to finish the questions.
- Other. Before we start the interview, do you have any questions in advance? If any questions (or other questions) arise at any point during the interview, please feel free to ask them.

A. Background Interviewee

1. How long have you been working in your present position?
2. Can you briefly describe your role and responsibilities?

B. Healthcare situation

1. What are the main challenges for the healthcare industry according to you?
2. *Optional: What are the challenges for your organisation in the short and long term?*

C. Healthcare & IT

1. How would you describe the current IT landscape in healthcare?
2. To what extent does IT play a role in the healthcare processes?
3. How is information of healthcare processes currently exchanged between stakeholders?

D. Relationship between stakeholders

1. To what extent does trust play a role between the different stakeholders?
2. What role should the government play?

E. Other subjects

1. Are there other things that we have not covered, but are relevant to consider?

F INTERVIEW PROTOCOL: IN-DEPTH INTERVIEW

Introduction[1]
A. Background Interviewee

1. How long have you been working in your present position?
2. Can you briefly describe your role and responsibilities?

B. Value-based healthcare

1. What are your experiences with value-based healthcare?
2. Considering value-based healthcare, what do you think are essential elements for implementation?

C. Trust, trustworthiness and transparency
During some first phase interviews, it was found that trust is an issue between the different stakeholders. In addition, mutual trust and collaboration between stakeholders is a prerequisite for value-based healthcare. Unfortunately, trust in itself cannot be managed, as this is perceived by the trustee. A dimension of trust is trustworthiness, which is also perceived by the trustee. A dimension of trustworthiness is transparency which can be managed by an organisation.

1. To what extent can the procedures, care process or outcomes be observed by third parties? For example, are the methodologies used for medical interventions visible to others?
2. What would be the effect of transparency on the relationship between stakeholders? Think about win-win situations or risks.

As mentioned before, transparency can be managed to some extent. The following questions will cover the mechanisms to do that.

D. Managing: Disclosure of information
The first mechanism is 'Disclosure' and is defined as the extent to which relevant information is received timely. For the information to be transparent, it must be openly shared. Besides transferring information it must be documented and communicated appropriately. Other associated words are: *visibility, availability, accessibility,* and *observability* refer to aspects of open information sharing, the term real-time suggests timeliness.

1. Considering disclosing information, what information is mainly relevant for:
   - Providers?
   - Insurers?
   - Patients?
   - Other stakeholders (e.g. government)?
2. Which information is currently not disclosed but is required to assess value? (e.g. not visible, accessible or available)
3. What information can be shared openly between stakeholders? And which information not?
4. How could the information be disclosed while ensuring patients' and physicians' privacy?
5. What do you consider timely received? What timeframe should be used for stakeholders to base decisions on? (for example, insurers to determine annual prices)
6. What technical elements and standards are essential for data exchange to consider?

E. Managing: Clarity of information
'Clarity' is defined as the perceived level of lucidity and comprehensibility of information received from a sender. Also referred to by other literature as understandability, coherence and interpretability of data.

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[1] See Appendix E for the content of the interview introduction.

1. To what extent do you consider coherent and understandable data representation could enhance the perceived trustworthiness?
2. According to you, what is the most appropriate way to disclose relevant information to the stakeholder groups (e.g. platform, mobile application, updates, etc.)?
3. Which elements are essential to include when presenting information? (e.g. timestamps, data sources)
4. How should one be able to check whether the information is understood correctly by the recipient?

F. Managing: Accuracy of information
The last mechanism is 'Accuracy' and is defined as the perceived correctness of the information. Information cannot be considered transparent if it is purposefully biased or contrived. Accuracy is unique to disclosure and clarity in that it is about information reliability rather than completeness or understandability.

1. How can the correctness of medical data be verified?
2. To what extent do professionals trust data from other sources (machines, humans)?
3. Could the patients play a role in increasing the accuracy of data? For example, verifying personal information? Please explain your answer.

G. Trade-offs

1. For an information system that discloses relevant information about processes, outcomes and costs to stakeholders in healthcare, how would you look at the following trade-offs?
    - Privacy vs. Traceability
    - Ease-of-use vs. Security
    - Development vs. Maintenance

H. Other subjects

1. Are there other things that we have not covered, but are relevant to consider?

G | EXPERT PANEL SESSION

A. Background information

- Introduction researcher & study. My name is Floor de Jonge, and I am a master student in Management of Technology at TU Delft. At the moment I am conducting my thesis. As part of my thesis, I am pursuing an internship at PwC's Risk Assurance department. My thesis focused on the necessary IT elements to enable outcome measurement, a prerequisite of VBHC.
  During the preliminary interviews, it was found that VBHC requires collaboration and trust in the relationship. Also, some interviewees mentioned that insight in outcomes and processes could enhance the level of trust. Indeed, transparency is somehow related to trust. For the in-depth interviews managing transparency was therefore the focus.
  Using the information from the interviews and literature, I have developed an IT architecture. The goal of the IT architecture is to unlock the potential of VBHC and accelerate diffusion across the Netherlands.
- Goal session. The goal of this session is to evaluate the appropriateness of the model. By the means of discussion I will capture your thoughts, opinions and feedback.
- Confidentiality. This interview and all answers given to any questions will remain confidential. All personally identifiable information will be removed before processing and presenting the data. However, to support the notes, I would like to record the interview. Is that okay with you?
- Time duration. This session is planned to last about 60 minutes. If the time is running short, I may interrupt you to be able to finish the questions.
- Other. Before we start the interview, do you have any questions in advance? If any questions (or other questions) arise at any point during the interview, please feel free to ask them.

B. Architecture Vision
The main objective of the architecture is: *"to increase interoperability and transparency in healthcare systems"*. This would lead to:

- Patient empowerment: At the heart of VBHC is the patient. Patients should be able to make informed decisions about their patient journey. They have the right to choose a healthcare provider that fits their needs best. Access to personal outcome information and general outcome indicators is key to achieve patient empowerment.

- Continuous quality improvement: VBHC is about continuous quality improvement of healthcare on a personal and societal level. Operating in an isolated environment will not contribute to this vision. The architecture should stimulate providers to collaborate across the care cycle and share information. Moreover, comparing outcomes allows healthcare professionals to discuss differences and come to new insights.

- Value-based contracts: Transparency on outcomes can provide an opportunity to move away from ill-structured financial incentives and allow insurance companies to pay for delivered value. This encourages providers to aim for maximum value.

C. Architecture
Present Architecture overview (see Figure 6.1.)

D. Questions Experts
Background

1. How long have you been working in your present position?

2. Can you briefly describe your role and responsibilities?

Transparency, trust and value-based healthcare

1. What is your first thoughts about a higher transparency to enable value-based healthcare?

2. Do you think transparency could be the solution to the low level of trust between stakeholders?

EA model

1. What are your first thoughts on the model?
2. Could this model be a solution to enable value-based healthcare?
    - Do you think that outcome and costs measurement could be established?
    - To what extent do you think stakeholders would use the information on this platform?
    - What are the treats for adoption of such a solution?
3. What are the risks of the model?
4. What could be improvements to the model?

Per layer the following discussion questions are

- What are your first thoughts about the components?
- Could these components offer a way to facilitate VBHC?
- Which components, if there are any, are essential for VBHC?
- What components are feasible to realise in the short or long term future?
- Are you missing any components in this layer?

Other subjects
Are there other things that we have not covered, but are relevant to consider?

H CODE BOOK

Code Groups	Code	Grounded	Density
APPLICATION	Application: Digital patient journey (i.e. process)	1	1
APPLICATION	Application: Providing information in different ways	1	2
APPLICATION	Application: Testing information systems	5	2
APPLICATION	Application: Processing data in-house leads to higher level trust in data	4	1
APPLICATION	Application: Simple interface with ability to get more details by clicking through	3	3
APPLICATION	Application: Tool for clinicians to report issues	4	2
APPLICATION	Application: Tool for patients to report issues	3	3
APPLICATION	Application: Analysis on reported issues and unclarities	1	2
APPLICATION	Application: Connection between platform and HIS	1	3
APPLICATION	Application: Enhance clarity by FAQ or chatbots	1	2
APPLICATION	Application: Data processing model	3	1
APPLICATION	Application: ETL	1	5
APPLICATION	Application: Ways to ensure privacy of individuals	2	1
APPLICATION	Application: Technical verification of data accuracy	3	3
APPLICATION	Application: Providers (AGB) and insurers should have access to platform	1	1
APPLICATION	Application: Data should be extracted in batches	2	4
APPLICATION	Application: Easy to find where to fill out information	1	2
APPLICATION	Application: EHR	1	3
APPLICATION	Application: Option to withold information	2	1
APPLICATION	Application: Patient portal does not suite needs	1	1
APPLICATION	Application: Include insurance information in PHE	1	1
APPLICATION	Application: Dashboard for patients (n=1)	2	1
APPLICATION	Application: Tool to ask for clarity	2	3
APPLICATION	Application: PHE	3	8
APPLICATION	Application: logging of data adjustments	3	2
CHALLENGES	Challenge: Healthcare expenditure rises	2	4
CHALLENGES	Challenge: Fast changing laws and regulations	3	3
CHALLENGES	Challenge: Positive business case providers	4	6
CHALLENGES	Challenge: COVID-19	2	2
CHALLENGES	Challenge: healthcare demand rises	2	6
CHALLENGES	Challenge: Administrative burden	8	6
CHALLENGES	Challenge: complexity of care	3	2
CHALLENGES	Challenge: Shortage on labour market	4	5
CHALLENGES	Challenge: Sustainability of healthcare	1	4
CHALLENGES	Challenge: Availability of information	1	0

Code Groups	Code	Grounded	Density
CHALLENGES	Challenge: working pressure	2	3
CHALLENGES	Challenge: Loneliness	2	2
CONCERNS	Concerns: Data ownership	3	1
CONCERNS	Concern: Certainty that participants will not be exploited	2	0
CONCERNS	Concerns: Impact of VBHC	3	1
CONCERNS	Concerns: Ethical discussions about the added value of treatments	3	0
CONCERNS	Concerns: transparency in short term	3	0
CONCERNS	Concerns: Complex to implement VBHC	1	1
CONCERNS	Concern: Relationship providers and insurers	2	0
ENABLERS	IT solution: PHE	3	0
ENABLERS	IT solution: MedMij label provides network for secure data exchange	2	0
ENABLERS	Enabler: Regional collaborations encourage data exchange	1	0
ENABLERS	IT solution: Personal Health Train	2	0
ENABLERS	Implementation enablers	0	2
ENABLERS	Enabler: IT solutions	7	5
ENABLERS	IT solution: XDS	2	0
ENABLERS	Enabler: Standardisation	4	0
ENABLERS	Enabler: Different financial stimulus	2	3
ENABLERS	Enabler: Reliable and real-time data	7	1
ENABLERS	Enabler: Multiple-year contracts	1	1
ENABLERS	IT solution: Automating processes	2	1
ENABLERS	Enabler: One party must take the lead	2	0
ENABLERS	Enabler: exchange best practices	3	2
ENABLERS	IT solution: Benchmark providers	9	2
ENABLERS	Enabler: Intrinsic motivation of healthcare professionals	2	0
ENABLERS	Enabler: Changing mindset	5	1
ENABLERS	Enabler: Determine objectives and communicate	3	1
ENABLERS	Enabler: mutual trust	3	1
ENABLERS	IT solution: One platform to communicate with different stakeholders	4	1
ENABLERS	IT solution: Wrappers & APIs	1	1
FINANCE	Contracts: terms & conditions	4	8
FINANCE	Contracts: Quality is a secondary term	3	1
FINANCE	Contracts: Shared savings model	3	2
FINANCE	Contracts: Contracting process	2	3
FINANCE	Finance: Contracts	0	5
FINANCE	Finance: Legitimacy of claim	0	5
FINANCE	Control to assess legitimacy of claim	5	3
FINANCE	Finance: Perverse financial stimulus	6	5
FINANCE	Information needed to assess claim	5	1
FINANCE	Contracts: Bundled payments	2	2
FINANCE	Claim process	3	1
FINANCE	Contracts: outcome-based contracts are complex to execute	4	3
FINANCE	Insurance companies need to justify reimbursements	4	1

Code Groups	Code	Grounded	Density
IMPLEMENTATION BARRIERS	Barrier: solutions will be developed if there is enough demand	1	0
IMPLEMENTATION BARRIERS	Barrier: Implementation time	2	1
IMPLEMENTATION BARRIERS	Barrier: Full transparency is a risk	3	0
IMPLEMENTATION BARRIERS	Implementation barrier: Little resources to improve quality	2	3
IMPLEMENTATION BARRIERS	Implementation: Acceptance of technology	9	1
IMPLEMENTATION BARRIERS	Barrier: There is too much freedom to create solutions	1	0
IMPLEMENTATION	Implementation: Pilots	1	0
IMPLEMENTATION	Implementation: Collaboration Nictiz, government and providers	1	0
IMPLEMENTATION	Implementation: Insurers have the power to steer innovation	4	0
IMPLEMENTATION	Implementation: Government should take more control	1	0
IMPLEMENTATION	Implementation: One party must take the lead	2	0
IMPLEMENTATION	Implementation: Environment to trust	1	0
IMPLEMENTATION	Mindset: Motivation to innovate is higher than to evaluate	1	0
IMPLEMENTATION	Implementation: Start hands-on and learn in the process	3	0
IMPLEMENTATION	Insurers can facilitate learning sessions between providers	1	0
IMPLEMENTATION	Implementation: Providers and insurers should have the same goals	3	0
IMPLEMENTATION	Implementation: Phased introduction of transparency	6	0
IMPLEMENTATION	Mindset: Be transparent to learn from each other	6	0
IMPLEMENTATION	Implementation: Market players should be drivers	4	0
IMPLEMENTATION	Implementation: Time to implement VBHC	4	1
IMPLEMENTATION	Implementation: Government should have a facilitating role	9	0
IMPLEMENTATION INFORMATION	Enabler: Start with in a small test environment Information: Sustainability of outcomes achieved should be visible	1 1	1 1
INFORMATION	Information: Presentation for patients	17	2
INFORMATION	Information: Presentation for insurers	13	1
INFORMATION	Information: Presentation for providers	12	1
INFORMATION	Information: General ratings are not enough to base decisions on	1	1
INFORMATION	Information: Patients are more willing to provide data if they see it back	3	1
INFORMATION	Information: For the government real-world data vs. trial data would be interesting	1	1
INFORMATION	Information: Not sharing costs	5	1
INFORMATION	Information: Internal organisation analysis	7	1
INFORMATION	Information: Patients like me	7	2
INFORMATION	Information: OMOP data model	1	1
INFORMATION	Information: BgZ could facilitate patient history	2	1
INFORMATION	Information: Outcome indicators set per medical diagnosis	3	5
INFORMATION	Information: Data models should revolve around care instead of finance	1	1

Code Groups	Code	Grounded	Density
INFORMATION	Information: Presentation of information	1	11
INFORMATION	Information: HL7 FHIR / CDA as transport standard	3	2
INFORMATION	Information: Benchmark providers	4	3
INFORMATION	Information: Availability of patient history	3	2
INFORMATION	Information on organisation-level motivates clinicians to participate	1	1
INFORMATION	Information: Presentation of information must be consistent	1	1
INFORMATION	Information: Data for outcome indicators	10	3
INFORMATION	Information: Zibs fit the outcome indicators well for 80%	2	1
INFORMATION	Information: Zib 'problem' could be an essential element for outcome measurement	1	2
INFORMATION	Information: Determine population group	5	2
INFORMATION	Information: Using Zib and SNOMED	9	4
INFORMATION	Information: ICHOM is outdated and complex	1	1
INFRASTRUCTURE	Technology: Use data from PHE	1	1
INFRASTRUCTURE	Technology: Level of security should be aligned	1	3
INFRASTRUCTURE	Technology: validation of medical equipment	1	1
INFRASTRUCTURE	Technology: Use data from Basic Person Administration	1	2
INFRASTRUCTURE	Technology: Intermediary for data exchange (e.g. LSP)	3	1
INFRASTRUCTURE	Technology: A platform that provides outcome information	3	2
INFRASTRUCTURE	Technology: Use data from public institutions	1	1
INFRASTRUCTURE	Technology: Data provenance	8	3
INFRASTRUCTURE	Technology: Use data from insurer (Vektis database)	3	1
IT BARRIERS	IT barrier: Complexity of administering value	4	3
IT BARRIERS	IT barrier: Data quality is questionable	2	7
IT BARRIERS	IT barrier: unity of language	4	0
IT BARRIERS	IT barrier: Lack of interoperability	4	5
IT BARRIERS	IT barrier: Fragmented IT landscape	8	2
IT BARRIERS	IT barrier: Data is not accessible	5	3
IT BARRIERS	IT barrier: Manual interaction required	6	2
IT BARRIERS	IT barrier: Data is not reused	3	2
ORGANISATION	Organisation: Organise 'go-to' point for feedback of systems	1	1
ORGANISATION	Organisation: Structure and responsibilities	1	5
ORGANISATION	Organisation: Contracts can be based on outcome indicators	1	1
ORGANISATION	Organisation: Allow analysis on aggregated level for research (law)	1	1
ORGANISATION	Organisation: A mediating party could neutralise power differences	1	1
ORGANISATION	Organisation: Patient cannot be responsible for managing health record	1	1
ORGANISATION	Organisation: Provide positive stimulus for accurate administration	3	1
ORGANISATION	Organisation: Insurers should be partners instead of control institutions (role)	4	1
ORGANISATION	Organisation: Governance of IT systems	2	2
ORGANISATION	Organisation: Patients are partners (role)	2	1

Code Groups	Code	Grounded	Density
ORGANISATION	Organisation: Government could impose standards on actors	2	1
ORGANISATION	Organisation: Determine IT-capabilities	1	1
ORGANISATION	Organisation: Responsibility of healthcare professionals to register	1	1
ORGANISATIONAL BARRIERS	Barrier: Accurately administrating is time consuming	2	0
ORGANISATIONAL BARRIERS	O&P Barrier: Ambiguous definiton of value	1	3
ORGANISATIONAL BARRIERS	Barrier: Uniform KPIs and procedure to measure outcomes	4	3
ORGANISATIONAL BARRIERS	O&P: Privacy legislation	5	1
ORGANISATIONAL BARRIERS	Barrier: Information from other providers in the chain is not freely accessible	1	0
ORGANISATIONAL BARRIERS	O&P barrier: Healthcare structure	4	4
ORGANISATIONAL BARRIERS	O&P barrier: Fragmentation of healthcare industry	3	3
ORGANISATIONAL BARRIERS	Barrier: physicians do not want to rely on second-hand data	1	0
ORGANISATIONAL BARRIERS	O&P barrier: Law and regulations	1	5
PROCESS	Process: Evaluate care services with PROM & PREM	5	2
PROCESS	Process: Verification by clinicians	2	2
PROCESS	Process: Tailor care process to patient needs	5	1
PROCESS	Process: Accurate administration	4	8
PROCESS	Process: Consultation between clinicians within and across discipline	1	1
PROCESS	Process: Feedback loop of understanding	2	4
PROCESS	Process: Ask check questions to patient for understanding	2	1
PROCESS	Process: Provide outcome information before consult	1	1
PROCESS	Process: Verify if other party understands the data	1	1
PROCESS	Process: Shared decision-making moment	5	3
PROCESS	Process: First explanation in consult, then provision of outcome indicators	3	3
PROCESS	Process: Audit processes	4	2
PROCESS	Process: Measure and evaluate health status (n=1)	6	2
PROCESS	Process: Work visits	1	1
PROCESS	Process: Care processes	0	7
PROCESS	Process: Patient should be able to verify information	4	2
PROCESS	Process: Human verification of data accuracy	3	3
RELATIONSHIPS BARRIERS	Relationship barrier: Lack of transparency	6	3
RELATIONSHIPS BARRIERS	Relationship: Interference of insurance companies	3	1
RELATIONSHIPS BARRIERS	Relationship: Healthcare provider has low bargaining power	4	3
RELATIONSHIPS BARRIERS	Relationship barrier: Low level of trust	6	5
RELATIONSHIPS BARRIERS	Relationship: Misaligned interest	9	4

Code Groups	Code	Grounded	Density
RELATIONSHIPS BARRIERS	Relationship: Competition hampers collaboration	1	0
RELATIONSHIPS BARRIERS	Relationship barrier: Perceived image	6	2
RELATIONSHIPS BARRIERS	Personal interests conflict	2	1
REQUIREMENTS	Principle: Unity of language	4	3
REQUIREMENTS	Principle: Continuous learning	10	4
REQUIREMENTS	Requirement: Define value and outcome indicators	5	4
REQUIREMENTS	Principle: Information quality is traceable	5	4
REQUIREMENTS	Principle: Maximise value for patient	15	5
REQUIREMENTS	Requirement: Patients should be in control in their own patient journey	4	5
REQUIREMENTS	Requirement: Tailor presentation of information to audience	1	5
REQUIREMENTS	Requirement: Patients should be informed when their data is consulted	3	1
REQUIREMENTS	Requirement: Data should be validated	0	7
REQUIREMENTS	Requirement: Providers should be able to access medical data without permission under very special circumstances	1	1
REQUIREMENTS	Requirement: Determine roles and responsibilities	2	5
REQUIREMENTS	Principle: Comply to law and regulations	2	3
REQUIREMENTS	Requirement: Patients should be able to make an informed decision	5	5
REQUIREMENTS	Requirement: Analysis on patient-level	5	6
REQUIREMENTS	Requirement: Standardise information- and data models	6	8
REQUIREMENTS	Requirement: multiple sources of data	4	5
REQUIREMENTS	Requirement: There should be a possibility to explain information by a professional	3	4
REQUIREMENTS	Requirement: The process for data extraction and processing should be robust	4	6
REQUIREMENTS	Requirement: Automating processes to reduce human errors	3	1
REQUIREMENTS	Non-functional requirements	0	3
REQUIREMENTS	Principle: Balance technology and human interactions	4	2
REQUIREMENTS	Requirement: Communicate objectives of data collection and analysis	4	1
REQUIREMENTS	Requirement: Effectiveness of communication should be evaluated	3	5
REQUIREMENTS	Requirement: Choosing own IT systems	3	1
REQUIREMENTS	Requirement: Analysis on aggregated level	4	9
REQUIREMENTS	Requirement: Ability to exchange data	3	6
REQUIREMENTS	Requirement: Actors must have access to relevant data	8	6
REQUIREMENTS	Requirement: Communicate objectives and plan	4	2
REQUIREMENTS	Requirement: Ensure information security	6	3
REQUIREMENTS	Requirement: Ensure privacy of individual persons	4	3
REQUIREMENTS	DISCLOSURE REQUIREMENTS	0	7
REQUIREMENTS	ACCURACY REQUIREMENTS	0	8

Code Groups	Code	Grounded	Density
REQUIREMENTS	Principle: Information is clear and understandable	4	5
REQUIREMENTS	Requirement: Data should be reusable for different purposes	4	2
REQUIREMENTS	Level of maturity in IT systems influences willingness to develop	1	0
REQUIREMENTS	CLARITY REQUIREMENTS	0	7
REQUIREMENTS	Requirement: One should recognise themselves in the data	5	1
RISKS OF TRANSPARENCY	Risk: Possibility to trace data back to individual	1	0
RISKS OF TRANSPARENCY	Risk: Data is never 100% comparable	2	0
RISKS OF TRANSPARENCY	Risk: Lack of support of physicians for full transparency	2	0
RISKS OF TRANSPARENCY	Risk: Unrecognisable data can lead to excessive need to check data	1	0
RISKS OF TRANSPARENCY	Risk: Transparency can lead to cost reduction	2	0
RISKS OF TRANSPARENCY	Risk: Transparency can lead to more interaction and questions	1	0
RISKS OF TRANSPARENCY	Risk: Transparency can lead to competitive disadvantage	2	0
RISKS OF TRANSPARENCY	Risk: more medical interventions to check information quality	2	0
RISKS OF TRANSPARENCY	Risk: Noticing that regulation is not strict enough	1	0
RISKS OF TRANSPARENCY	Risk: Data could be contrieved for egocentric motives	3	0
RISKS OF TRANSPARENCY	Risk: Accuracy of outcome indicators	1	0
RISKS OF TRANSPARENCY	Risk: Reusability of data can lead to bias of physician	1	0
TRUST THEORY	If transparency increases, less law and regulation are necessary	1	0
TRUST THEORY	Ability to provide high-quality care and benevolence influence contractual agreement	1	0
TRUST THEORY	Physicians are vulnerable when sharing outcome information	1	0
TRUST THEORY	Transparency leads to feeling of responsibility to do well	1	0
TRUST THEORY	Transparency leads to higher perceived ability	1	0
TRUST THEORY	Disclose information so that people can form own judgement	1	0
TRUST THEORY	Clarity can increase level of trustworthy data	2	0
TRUST THEORY	Perception of information quality is influenced by ability trustee	3	0
TRUST THEORY	Experience with IT systems influences the level of trust in data and processes	1	0
TRUST THEORY	Transparency can lead to increased perception of benevolence	1	0
TRUST THEORY	Trust in the IT systems is a prerequisite for trust in data	2	0
TRUST THEORY	Transparency lead to mutual understanding	2	0
TRUST THEORY	Transparency could lead to reason less from assumptions and more on data	1	0