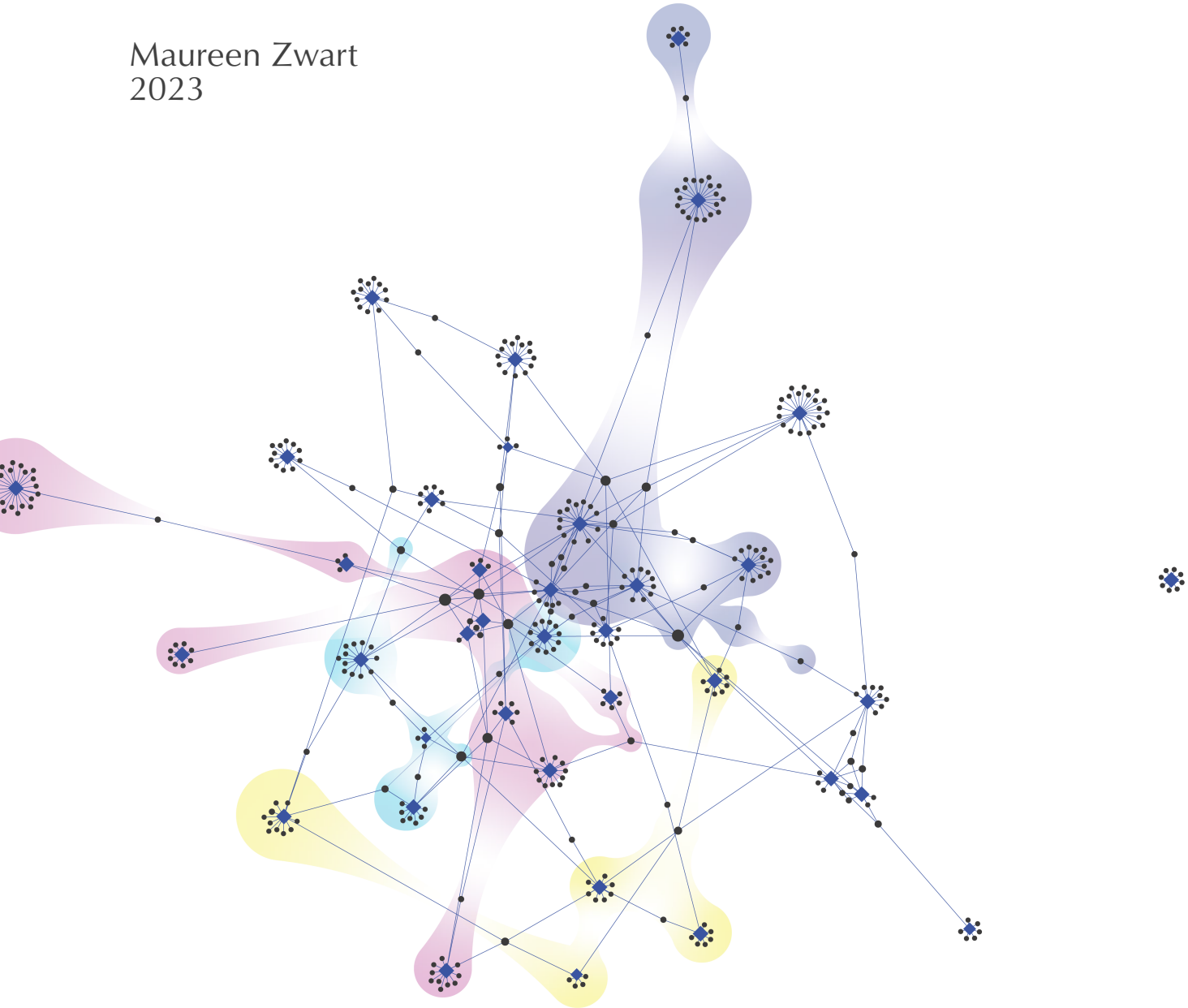
Communication is Care

Requirement-Based Platform Architecture Design to Enable Pharmacists' and General Practitioners' Interoperability Needs in Dutch First-Line Healthcare

MSc Thesis in Complex Systems Engineering and Management

Maureen Zwart
2023



Sanday

TU Delft

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Communication is Care

Master thesis submitted to Delft University of Technology
In partial fulfilment of the requirements for the degree of
MASTER OF SCIENCE
in **Complex Systems Engineering & Management**
Faculty of Technology, Policy and Management

by

Maureen Zwart

Student Name	Student Number
Maureen Zwart	4563204

To be defended in public on August 24, 2023

Chair (TU Delft):	Dr. Ir. G.A. (Mark) de Reuver
First Supervisor (TU Delft):	Dr. Ir. G.A. (Mark) de Reuver
Second Supervisor (TU Delft):	Dr. S.M. (Samantha) Copeland
Supervisor (Sanday):	Ir. G.H. (Gijs) van der Wielen, MBA
Project Duration:	February 2023 - August 2023
Faculty:	Technology, Policy and Management

TU Delft

Preface

With writing this preface, I come to the end of seven years of studying in Delft, my time at the faculty (especially PC A in the last half year), TB cafe, study breaks, the not-so-tasty cappuccinos from the coffee machine, and six months of full-time work for this study. This study taught me to fully delve into a subject, to listen carefully, to stay motivated, to iterate, to structure, to prioritise, and to trust and enjoy the individual process of writing a master thesis.

I want to thank all the participants who contributed to my research. Collaboration in achieving goals is incredibly important to me. Your involvement enriched my research with valuable insights. Special thanks to the pharmacists and GP assistants who helped me initially. Thanks to the GPs who showed their support and interest but could not participate due to an overfull agenda. Thanks to the marketing team at Sanday for the assistance in distributing my survey and for the invite to the Mosadex Experience. Thanks to everyone who filled out my survey. Your contributions provided valuable data. Finally, thanks to the product owners and platform architects who kept motivating me in the final design phase.

One year ago, I stumbled upon the PhD topic of Gijs van der Wielen (guided by Mark de Reuver) through the CoSEM graduation list. The focus on healthcare and IT immediately caught my interest. My first meetings with Gijs were inspiring. Gijs, I want to thank you for your boundless enthusiasm. Your passion for the field and motivation to improve (first-line) healthcare truly radiate, even through a screen. During my exchange in Turin, before I officially started my thesis, we often had a quick call to refine my research proposal, which was very helpful. Furthermore, I appreciate your guidance in the past six months. Your talks always provided clarity and new ideas for my research process. Mark, thank you for your sharp academic perspective and for explaining the appropriate scientific methods for quantitative and qualitative interpretation. Your insights elevated my research and helped me make precise analyses. Furthermore, I want to thank my second supervisor at the TU Delft, Samantha Copeland. Samantha, you provided excellent guidance in making my project more understandable from an 'outsider's perspective'. Also, your advice on structuring the various processes and outcomes was invaluable to me in the final weeks. Together, you all supported and guided me from different perspectives, and I am highly grateful for that.

Lastly, I want to thank my family, friends, *de laatste loodjes*, Du Roch, and boyfriend. Your support and company played an essential role during my graduation period. I am happy that I could combine my thesis work with enjoyable dinners, parties, vacations, weekend getaways, runs, bike rides, and chillings on the couch with all of you. I really value your positive energies.

Now that I have expressed my gratitude to everyone, the only thing left for me is to introduce you, as the reader, to my thesis, *Communication is Care*. It all started with the desire to gain deeper insights into a platform-based information system in Dutch first-line healthcare. Through exploration, I was drawn to the specific goal of improving *communication*. After delving into designing this communication improvement, I returned to a new refreshing platform-based perspective. Delving into the details and zooming out gives a complete overview of the effect and possibilities of a technology-based intervention in a socio-complex context.

I encourage you to make use of, pass along, and be motivated by the insights offered. My primary intrinsic drive is to improve healthcare, but the conclusions may also apply to other domains. I hope this thesis offers insightful information and serves as an idea to improve communication and platform-based ecosystems both within and outside the healthcare domain.

Here's to good health!

Maureen Zwart
Rotterdam, August, 2023

Executive Summary

Situation

Healthcare systems are under pressure from an ageing population and limited resources. The lack of interoperability and data portability between information systems (IS) in Dutch first-line healthcare results in delayed and incorrect treatment of patients and a lack of innovation. A platform-based information system (PBIS) supporting first-line healthcare is suggested to improve innovation and interoperability. Earlier research on requirements focused on the IS supplier perspective. Literature on design principles of ISs state that local acceptance should be addressed for the successful implementation of an IS. To create local acceptance of the PBIS, the current users of ISs need to be heard. This research focuses on the patient- and healthcare professional-dependent requirements for a PBIS and the translation of these requirements into architecture design.

Question

First, due to research constraints, *healthcare professionals* was scoped to pharmacy employees and GP practice employees (in the thesis, still referred to as HCPs), and patients were included through the perspective of the HCPs and literature instead of directly. Mapping the environment resulted in the importance of considering *interoperability* as a means of developing an IT intervention in the Dutch healthcare domain. The following research question is answered in this master thesis:

How should the requirements, meeting patients and healthcare professionals' needs regarding interoperability, be incorporated in the digital architecture design of a platform-based information system supporting Dutch first-line healthcare?

Approach

The approach needed to create a technology solution in a socio-technical context. This is supported by the Design Science Research Methodology (DSRM). DSRM consists of six activities: (1) problem identification and motivation, (2) defining the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. The six activities resulted in five sub-research questions. The sub-research questions and activities are placed in design cycles to show the relevance of the sub-question within the DSRM.

Preliminary research supported both the *problem identification and motivation* and *defining the objectives for a solution*. Interoperability experts were consulted to gain insights into the term interoperability in the context of healthcare professionals. It was determined that using the term interoperability directly for healthcare professionals was inappropriate. Instead, the layers of Nictiz were identified as a suitable framework to provide information on interoperability from a healthcare professional perspective. Next, a focus group was organised to delve deeper into the current usage of systems and interactions, assess attitudes towards the existing system, and generate new ideas. The focus group highlighted that communication-related to care around the medication process, both with patients and among healthcare professionals, was inefficient and inadequate in meeting interoperability needs.

Based on the focus group's findings, a series of statements were formulated, further discussed and refined through semi-structured interviews with two field experts. The interviews resulted in the rejection of one statement and some adjustments to others. The purpose of these discussions was to prepare the statements for the survey. The survey's main objective was to validate the statements from the focus group on a larger scale. This assessment was done based on a Likert scale. Additionally, the survey aimed to gather new insights by providing respondents with an open-answer box, allowing them to express their thoughts more freely.

The results of the survey were quantitatively and qualitatively researched and validated. The quantitative analysis provided insights into the ranking and assessment statistics of the requirements, as well as providing insights for the validation based on statistical T-tests, ANOVA tests and Tukey-HSD tests. These statistical tests were used to construct conclusions on dissimilarities between target groups (based on demographic variables asked in the survey). The clarifications on the open-answer box were analysed qualitatively, using an open coding and axial coding approach to outline the cores of the clarifications. Both analyses defined tensions among the participants, used as additional insights on the shift of IS ecosystem to the PBIS ecosystem, revealing the consequences of the intervention. The analysis provided a list of validated statements for further statement formalisation and platform architecture design.

Results

The statements were constructed by categorising the findings from the focus group based on the interoperability layers *organisation policy*, *care process*, *information* and *application*. The assessment of the statements resulted in requirements for each statement and additional requirements by analysing the clarifications of the respondents.

The formalisation and categorisation of the requirements, following a System Requirement Structure (SRS) design, outlined the requirements are found in five dimensions: (1) HCP participation, (2) access regulation, (3) clear and concise content, (4) agreement support, and (5) patient-participation. These five branches of the SRS were used to create platform modules. The low-level requirements of all branches were compared and added to the platform module based on overlapping functionalities or user needs. This process resulted in five platform modules to be realised by the platform design, namely: (1) communication module, (2) code implementation module, (3) patient engagement module, (4) reward module, and the (5) complementor integration module. The platform architecture includes these modules and complementor management, audit logging, and monitoring. The architecture is created following a layered approach, including the business, business processes, information, and technology layer. To improve modularity, an internal- and external API strategy is applied.

The platform architecture was designed based on evaluation interviews with four platform architects in different domains. The evaluation resulted in improvements based on clarity, level of detail, and new ideas from brainstorming between the researcher and the interviewees. This study's design provided insights into the effects of a platform-based solution. The consequences of the intervention can be found in the *technology* and *stakeholder* context. In the technology domain, the solution was most valuable as a platform-based ecosystem. The platform-based ecosystem offers vast possibilities for expansion internally and through the integration of external IoT and AI solutions, presenting both opportunities and challenges. The platform-based *information system* perspective adopted in the beginning is extended to envision a comprehensive platform-based *ecosystem*, positioned platform cores and modules, an overarching platform, and connected systems. However, the implementation faces challenges concerning stakeholder incentives and responsibilities, impacting feasibility negatively. To enhance feasibility, governance measures, careful schedule and budget planning, and alignment of stakeholder interests are recommended for successful implementation.

Contribution

The practical contribution of this research lies in two areas. Firstly, the designed platform addresses the need to improve communication within the healthcare domain, offering a communication service that can significantly enhance efficiency and collaboration among healthcare providers and patients. The insights and requirements from various perspectives can also be applied to enhance communication practices in other healthcare lines and countries. Secondly, the platform-based ecosystem design provides valuable insights into the roles, responsibilities, and interactions among different stakeholders, serving as a blueprint for developing similar ecosystems in other domains. The design also aligns with the Communication Platform as a Service (CPaaS) concept, offering the potential for further exploration in other industries.

Additionally, the research contributes to the scientific literature by addressing the research agenda on digital platforms by providing a comprehensive overview of how platform-based ecosystems can be conceptualised and designed in the healthcare sector. The findings can guide further research on feasibility, financial implications, and governance in platform-based ecosystems. The study's value also extends to other domains, such as education and government, where ISs play a crucial role. Moreover, this study found that the interoperability layers can be applied and adapted within the healthcare context and potentially in other IS ecosystems, providing strong guidance and support for designing platforms and services. The research design demonstrates the relevance and applicability of interoperability layers, and with further experimentation, these layers may have broader applicability across different domains. Overall, the study's positioning in Design Science Research (DSR) places it as an *improvement* for communication and an *exaptation* for the platform-based ecosystem, with potential for reuse and further research in various domains and contexts. The academic contribution also entails identifying knowledge gaps that must be explored in the future: the *next steps*.

Next Steps

Several areas need further research to enhance the development of the platform-based ecosystem and communication service. Firstly, understanding the patient's perspective through focus groups or interviews can provide valuable insights into communication preferences and platforms. Secondly, detailed research on communication variety in healthcare and specifying platform content and user details will ensure successful implementation. Thirdly, following the Architecture Development Method (ADM) cycle can optimise the business, information, and technology architecture, cost-sharing decisions and stakeholder governance. Additionally, exploring governance frameworks like the Institutional Analysis and Development (IAD) framework will facilitate feasible implementation. Lastly, developing new design principles and guidelines for digital platform (ecosystem) design will better support the platform-based ecosystem's growth and refinement.

Policymakers can focus on three key areas to drive improvements in healthcare practices. Firstly, standardising communication. Policymakers can create national agreements to ensure the widespread implementation of these standards. Secondly, offering financial incentives or subsidies to healthcare organisations embracing platform-based ecosystems can facilitate initial deployment and enhance participation. Collaborating with critical stakeholders to design a sustainable funding strategy will ensure growth and maintenance. Lastly, policymakers can create an implementation programme (such as the VIPP programme focused on enhancing medical information accessibility between healthcare providers and patients), including planning, providing sufficient information, providing frequent updates, and providing clear responsibilities.

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Nomenclature

Table 1 lists the abbreviations that are used in this master thesis report. Some abbreviations are based on the Dutch translation, since those are commonly used Dutch abbreviations (in healthcare context). Table 2 show the symbols and its definition.

Table 1: The abbreviations used in this report.

Abbreviation	Definition
ADM	Architecture Development Method
API	Application Programming Interfaces
BD	Behaviour Diagram
BSN	*Burgerservice Nummer* (Citizen Service Number)
BR	Boundary Resources
COV	*Controle over Verzekeringsgegevens* (Insurance Information Control)
CPaaS	Communication Platform as a Service
DEST	Digital Ecosystem
DS	Design Science
DSRM	Design Science Research Methodology
EA	Enterprise Architecture
GPA	General Practitioner's Assistant
GP	General Practitioner
HCP	Healthcare Professional
II	Information Infrastructure
IS	Information System
PBIS	Platform Based Information System
PHA	Pharmacists Assistant
PH	Pharmacist
PGO	*Persoonlijke Gezondheidsomgeving* (Personal Health Area)
POH	*Praktijk Ondersteuner Huisarts* (GP supporter)
RFS	Requirement Formalisation Structure
SRS	Systems Requirement Structure
TOGAF	The Open Group Architecture Framework

Table 2: The symbols used in this report.

Symbol	Definition
σ	Standard Deviation
Δ	Delta

1

Introduction

This master's thesis research was conducted at the Delft University of Technology, faculty of Technology, Policy and Management. The study is supported by the involvement of Sanday, an IT provider with the aim of connecting HCPs. This thesis seeks to contribute to the knowledge base of a (platform-based) information system (IS) in Dutch (first-line) healthcare. By researching the interaction between patients, general practitioner (GP) practices and pharmacies following a design approach, insights have been achieved into the embodiment of a platform-based IS (PBIS). This Chapter introduces the context of the research project by outlining the current situation in Section 1.1 and existing literature on interventions for improving the situation in Section 1.2. Outlining the context of the current situation sheds light to the knowledge gap that is answered by this study. At the end of the Chapter, a reading guide is provided for this thesis report.

1.1. Problem Introduction

In Dutch healthcare, ISs (IS) support the daily processes of healthcare professionals (HCPs) working for a healthcare organisation. They also potentially support care by creating interoperability and data portability between HCPs (Kuipers, 2023). ISs could release pressure on available resources and healthcare employees if the IS ecosystem is efficiently fitted. However, especially during the COVID-19 pandemic and in the case of hundreds of Dutch hospital incidents, some with death as a result, it became painfully clear that this is not the case. Healthcare professionals struggle with the poor availability of information and difficulty accessing electronic patient data from other HCPs (Jason, 2020; Koomen, 2022), and nationwide countries struggle with the ISs used in healthcare (Aanestad & Jensen, 2011; Lenert & McSwain, 2020).

1.1.1. Current Situation

Currently, HCPs are supported by their type of IS. For example, GPs have their General Practitioners' IS (HIS, Dutch: *Huisartsen Informatiesysteem*), while pharmacists use a Pharmacists' IS (AIS, Dutch: *Apothekers Informatiesysteem*). The current ecosystem of ISs causes multiple inefficiencies. Firstly, IS suppliers can obtain power within the market by entering long-term contracts with HCPs, who can therefore switch suppliers with difficulty (Kuipers, 2023). Secondly, IS suppliers build multiple, similar ISs, which causes over-development and heterogeneity in user connections. 78% of healthcare managers indicate that this heterogeneity causes communication errors affecting patients' care processes (de Boer & Bosman, 2018). Furthermore, the inefficiency becomes clear, considering the poor interoperability and data portability between multiple ISs (Kuipers, 2023). For example, if HCPs fail to access the data available in an IS of other HCPs, they are left to retype information manually. Data is sometimes re-entered up to 40 times during an entire patient treatment process, making health care twice as time-consuming (Koomen, 2022). Inconveniences within the healthcare IT resulted in 61 calamities in 2018, meaning serious injuries or death (Inspectie Gezondheidszorg en Jeugd, 2018).

The scarcity of healthcare resources is the reason this inefficiency is becoming problematic. Currently, this scarcity results from pressure on healthcare caused by an ageing population (Rijksinstituut voor Volksgezondheid en Milieu, 2019), an increase in chronic patients (European Commission, 2019), and increasing costs (Zorginstituut Nederland, 2022). Another consequence is the shift of treatment by hospitals to treatment by first-line healthcare, resulting in a more independent patient (Flinterman et al., 2018), which increases the pressure on healthcare employees, of whom more than half feel underpaid for their work (Pater, 2021).

Furthermore, first-line healthcare innovation is lagging due to multiple hindering factors. First, the current Dutch IT health market has to deal with risks of vendor lock-ins, meaning healthcare providers strongly depend on the IT supplier since there are significant switching costs (Deloitte Nederland, 2022). This results in a situation where healthcare parties are reluctant to switch, reducing the chances of market share for new IT vendors with potentially innovative systems. Secondly, the poor integration with technological innovations. Technological innovations like IoT, machine learning, blockchain technologies, etc., could contribute to a more intelligent and autonomous healthcare system (The Economist, 2019). This will ensure that healthcare moves with the time and pressure on the healthcare system decrease. Thirdly, the privacy and security of patient data cannot be neglected. Furthermore, the strategic behaviour of stakeholders within the domain is affecting (Deloitte Nederland, 2022).

1.1.2. Common Perspectives on Improving the Current Situation

Literature shows different perspectives on improving the current situation. The solutions for problems within the healthcare market are introduced mainly focusing on three areas: *openness*, *interoperability*, and *standardisation*. This Section discusses the three terms, the idea behind them, how they're related, and how they are expected to affect the current situation.

Openness

On September 2022, the need for improvement is denoted by Kuipers (2023), the Minister of Health, Welfare and Sport. Kuipers (2023) outlines the importance of good IT-healthcare systems, supporting the work of healthcare providers through data exchange. Supported by the research of Deloitte Nederland (2022), he addresses the wish for an open and fair health-IT market. He outlines his motivation for cooperation, establishing frameworks and increasing control of ICT in healthcare (Kuipers, 2023). The openness of the health IT market is an essential means for this vision.

Openness can be interpreted differently considering different application areas of the term *openness*. First, the desired openness, as proposed by Kuipers (2023), is associated with the openness of the health IT market. In his letter, he denotes the importance of "open and available data" for patients through, for example, a Personal Health Environment (PGO, Dutch: *Persoonlijke gezondheidsomgeving*). He also applies openness to the availability and usage of standards and Application Programming Interfaces (APIs). Here, open indicates that the APIs and standards are available for everyone to improve their use. Open IT systems have the potential to foster greater competition within the IT health market by breaking away from the prevalent closed systems that often lack access to additional functionalities provided by third parties. However, there are barriers to attaining openness in healthcare systems, both technical and non-technical. The fragmentation of users, systems, and IS suppliers is among the reasons contributing to this limited openness. Concerns about data breaches and data dissemination arise from worries about how IT suppliers and healthcare providers use, store, and analyse sensitive data.

Furthermore, more technically, the legacy systems in place, developed long ago, present a significant hurdle to achieving cooperation in terms of openness. These legacy systems often lack the opportunity to communicate with newly developed IT systems, hindering seamless integration and data exchange (Glynn, 2023). The communication between or integration of systems is also described as the *interoperability* between systems. Interoperability is critical for enabling an open system regarding accessibility and availability.

Interoperability

Interoperability is a term which is used frequently in new cooperating technology systems. The overarching principle within multiple definitions of interoperability (which are discussed in Chapter 3) is the communication between organisation units. Interoperability can be achieved by blending existing technologies in correctly by providing communication between the new technology and existing technology components (Aanestad et al., 2017). An example of an interoperability-based solution is provided by Gottumukkala (2023), who applied design science to create a design for interfacing between two ISs (an acute care facility using Epic EHR and a long-term care facility using PointClickCare EHR). He created an appropriate artefact to be placed between two separate ISs, called a standard-based interoperability solution. His solution successfully enables a bidirectional data exchange between the two systems and opens opportunities for exchanging additional data elements (Gottumukkala, 2023).

This example shows that communication between healthcare organisations can be improved by creating intermediate solutions. However, creating intermediate solutions for multiple pairs of ISs is a time-consuming process. Because there are many different systems, which would have to be linked per solution, the success of such a solution for the entire domain is questionable. Furthermore, the standardisation challenges, Gottumukkala (2023) also encountered, must be considered. These challenges result from the need for standardised data through the interoperability solution since the system can only exchange data provided and received in the same form by the systems involved.

Standardisation

Standardisation, in this context, refers to the consistent processing and exchange of medication data based on established agreements among network participants. It is a necessary prerequisite for achieving interoperability. Placing greater emphasis on improving standardisation efforts would be a significant stride towards enhancing interoperability. Improving communication between existing healthcare systems requires the involvement of a central entity responsible for data standardisation. In the Netherlands, this role is fulfilled by multiple institutes such as NHG, MedMij and others (see Chapter 3). Integrating overarching data standards into ISs is crucial for enhancing interoperability in healthcare. The Dutch government has prioritised this by introducing standardisation agreements within the comprehensive healthcare agreement of September 2022. These agreements enable the utilisation of healthcare provider information by other providers when the information adheres to standardised formats (Ministerie van Volksgezondheid Welzijn en Sport, 2022). An example of a Dutch initiative is the National Access Point (LSP, Dutch: *Landelijk Schakelpunt*). The LSP provides access to information from other healthcare providers in a standardised form. However, compliance with nationally recognised information standards is required to access this information, showing one of the challenges arising with standardisation solutions.

It is important to note that while standardisation plays a crucial role in facilitating interoperability, it does not yield explicit positive outcomes. First, developing new standardisation solutions is time-consuming and can still lead to the over-development of two types of systems: ISs *and* standardisation systems. Second, solely relying on it for innovation regarding ISs is not sufficient. A standardisation solution does not directly improve the ease of using new technologies, such as IoT, AI, etc. if it is not included from the start of development. Initially, standardisation as a solution between two ISs considering the same type of data, for

example, patient's healthcare data, does not support new technologies to be used in the system. Therefore, innovation needs to be considered additionally to align with the innovation goals of Dutch first-line healthcare.

The above discussion of *openness*, *interoperability* and *standardisation* leads to the following conclusion. Openness includes creating more transparency and symmetrical availability of data. However, challenges arise considering privacy and connecting the systems. System connection is also described by interoperability, the "communication" between two (or more) systems. Interoperability solutions are often between two systems and must be created repeatedly for other systems pairs. Focusing on interoperability between two systems is time-consuming, but it can ensure successful communication. A requirement for interoperability solutions is that data is standardised, meaning connected systems send and receive data in the same form. The focus areas of these solutions are mainly on existing systems and how they connect. Improving the connection can positively affect the current problems by increasing efficiency and decreasing the pressure on healthcare resources. However, it does not solve the problem of easily connecting new technologies to accelerate innovation by keeping the healthcare domain moving with the times.

Improving the current situation does need to focus on the introduced improvement perspectives, but the insufficient focus on innovation asks for an extension of improvements for the current situation. Section 1.1.3 outlines the scope of this study and introduces an additional solution on which this study mainly focuses.

1.1.3. Thesis Scope

The current situation described in Section 1.1.1 outlines the challenges of an ageing population and chronic diseases, primarily affecting first-line healthcare due to the front-line nature of the first-line. This study focuses on first-line healthcare as it is presumed to contribute to keeping the elderly at home for as long as possible and helping the chronically ill fast and efficiently, leaving more space within hospitals for acute and complex care (KNMP, 2023). This responsibility makes the first-line healthcare system relevant to this study. First-line healthcare includes directly accessible healthcare, including general practitioners, pharmacies, dentists, physiotherapists, social workers and district nurses (Rijksoverheid, n.d.). Patients can consult them by themselves without a referral.

HCPs in first-line healthcare use ISs to store patient data, appointments and other information to support policy, planning, public health and personalisation of care (Sheikh et al., 2021). ISs enable information management and exchange. Large-scale ISs are integrated with other technical and non-technical elements (Aanestad & Jensen, 2011). Multiple types of ISs exist, such as the AIS and HIS. Not only the HCPs use ISs, but in recent years systems supporting patient self-management are arising as well (NEXUS, 2021). These patient systems are not only coupled to first-line healthcare but have a more general purpose of information provision considering any healthcare process. Furthermore, for example, smart monitoring systems (use of sensors) are available to patients, supporting home monitoring of their condition. The high number of ISs available for healthcare professionals, patient systems, and new technologies asks for a connection solution.

This study explores a platform-based information system (PBIS) to support Dutch first-line healthcare, including all involved systems. The justification for investigating a PBIS as a potential solution is subsequently explained. Platform design offers opportunities for competition by facilitating various technical innovations (Tiwana, 2014). De Reuver et al. (2018) highlight the significance of studying digital platforms across different architectural levels and industry applications, including their utilisation within healthcare, such as web-based mobile health platforms that support user-centred care (Morita et al., 2019). Additionally, De Reuver et al. (2018) suggest conducting further research on platform design.

However, implementing a platform-based architecture can encounter complexities by political dynamics and strategic behaviour due to the involvement of multiple parties in the design process, making creating a platform challenging (Van der Wielen et al., 2022). Allocating ownership within the ecosystem requires additional efforts to ensure its functional efficiency, adding further difficulty to implementing a platform. Nevertheless, the potential of a digital platform in IS architecture should not be overlooked. When discussing the openness of a platform, it is considered how the platform opens up its components and to whom it grants access to these components (K. Boudreau, 2010; Eisenmann et al., 2008). Platform openness encompasses the extent to which external entities can utilise, create services for, or derive value from a platform (Benlian et al., 2015; K. J. Boudreau & Hagiu, 2008). A digital platform can enhance openness, interoperability, modularity, and innovation simultaneously (Baldwin & Woodard, 2008; Haux, 2006).

A platform-based infrastructure is a conceptual blueprint of the digital ecosystem (DEST) (Constantinides et al., 2018). A DEST is a collection of actors connected digitally while being diverse and heterogeneous (Diana & Torrance, 2019; Dong et al., 2010). In the case of a PBIS, the DEST involves one (or multiple) stable digital platforms as a core and supporting services as complementors (Jacobides et al., 2018). Complementors participating on the platform are intended to innovate and bring new technologies to the platform due to competition (Parker et al., 2016; Tiwana et al., 2010). As visualised in Figure 1.1, the contribution of the complementors to users is found in creating customer value through innovative solutions (a). An increase in the value also contributes to the generation of platform growth (c), since more users and complementors want to use/connect to the platform. The relation between platform complementors and owners is based on knowledge resources (b) (Deilen & Wiesche, 2021). In this study, the complementors can be independent ISs, patient systems, and (new) technologies supporting and expanding the functionalities provided by the platform.

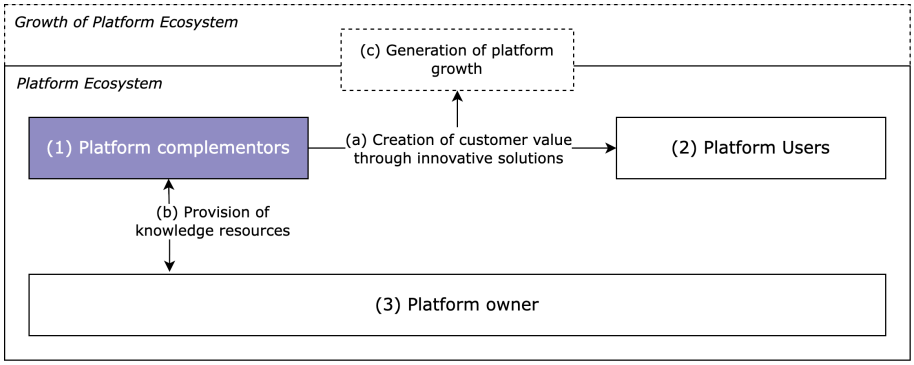
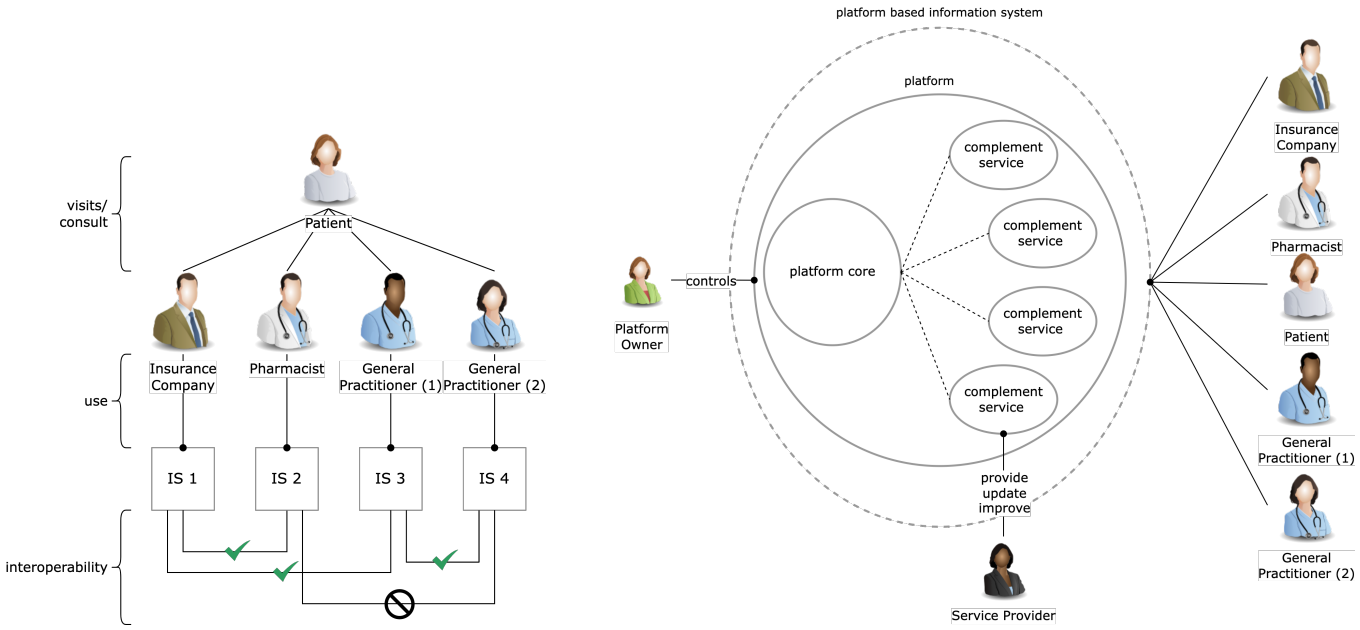


Figure 1.1: Visualisation of the Contribution of Complementors in Platform Ecosystems by Deilen and Wiesche (2021).

The representation of implementing a PBIS as part of Dutch first-line healthcare is shown in Figure 1.2. In Figure 1.2a specifically, it can be seen the ISs of different healthcare organisations do not always connect properly. A switch from GP 1 (IS 3) to GP 2 (IS 4) might be possible since their cooperation is sufficient. But if the patient's PH (IS 2) and GP 2 (IS 4) do not connect sufficiently, this would still cause inefficiencies. Looking at Figure 1.2b, it can be seen the users are connected to the PBIS, which can resolve ISs' cooperation failures. Concluding, the PBIS can improve the interoperability among the HCPs and patients, and new technologies such as IoT and AI can expand the possibilities for exploiting the potential contribution of a better healthcare system (Haghi Kashani et al., 2021). From these perspectives, a PBIS is seen as a potential solution to the current challenges considering the efficiency of processes and the innovation of the domain.



(a) Current IS Ecosystem. **(b)** PBIS Ecosystem.

Figure 1.2: Representations of Current IS- and PBIS Ecosystem in Dutch first-line healthcare.

1.2. Defining the Knowledge Gap

A literature review is conducted to provide insights into a PBIS as a solution for the IS ecosystem of the Dutch first-line healthcare system. Appendix A details the search strategy, including search strings for the literature review.

1.2.1. Results Literature Review

This Section discusses aspects found in the literature on the *design* of a PBIS. Literature was first conducted to research how (general) ISs are currently designed.

Information Systems

Designing an IS already involves many challenges. Hanseth and Lyytinen (2004) stress the importance of considering the socio-technical "installed based" as a starting point to avoid ignoring the current situation resulting in system failure. The challenges can be addressed by ensuring the system's modularity (Hanseth & Monteiro, 1998). The modularity can, even more, support the consideration of the installed base by the fragmentation of systems. To guide the process of designing ISs, Hanseth and Lyytinen (2010) provided design principles resulting from two design problems in IS design: the *bootstrap problem* and the *adaptability*

problem. The design principles are shown in Table 2.1 in Chapter 2. The bootstrap problem refers to creating a novel IS, respecting the installed base as mentioned earlier (Hanseth & Lyytinen, 2004). The adaptability problem refers to the further growth and expansion of the IS. This study highlights the relevance of connecting ISs with a digital platform and adding additional functionalities. Moreover, considering IS in complex healthcare systems needs more attention (Aanestad & Jensen, 2011). Aanestad and Jensen (2011) researched two possible approaches to designing an IS by assessing two examples of Danish applications: the bottom-up and top-down approaches. They concluded that small-scale starting and concentrating on the healthcare context and involved users positively influence the design of IS in complex healthcare systems (Aanestad & Jensen, 2011).

The literature on ISs outlined some crucial areas of concern when designing ISs. These insights are relevant to the design process. But what should be the result of these design processes? One solution for designing the IS ecosystem structure is using architectural design. Architectural design provides an opportunity to visualise the new service(s), installed base, their relation and further relevant components for the realising understanding of the new IS ecosystem for multiple purposes, such as business teams and developing teams.

Architecture Design

Architecture design guides the design process of a system by dealing with unmeasurable non-quantitative tools and guidelines based on practical lessons (Janssen, 2021a). In 1987, Zachman (1987) provided the literature with the first framework, valuable to architecture design in ISs. Nowadays, modular architectures focus on the reuse of models, a shorter development time and dealing with complexity (Janssen, 2021b). In this study, architecture design is seen as a means to visualise the components needed to support first-line healthcare in a PBIS ecosystem.

The literature shows example solutions regarding architecture design components in healthcare ISs. Moner et al. (2006) explain the use of the Dual Model architecture to maintain a homogeneous representation of the Electronic Health Record (EHR). Marcos et al. (2015) show how the HL7 Virtual Medical Record (vMR) standard can be used to design a data integrator component, and Jayaratne et al. (2019) researched the architectural design of a patient-centred healthcare delivery model for medical practices in Australia. In these three examples, the researchers also experimented with their design and showed that the architectural design successfully guided the design process.

The importance of architectural design has been picked up earlier in the literature on PBIS design. Architecture design is not always straightforward because all stakeholders have different incentives and interests. For an IS used within 1 organisation, bringing the stakeholders together is still important but less complicated than when more organisations are involved in the system. In the case of a PBIS, as described in Section 1.1.3, multiple parties are involved in the same system. This has motivated van Hattum (2020), Groeneveld (2021), and Kong (2023) to investigate a variety of perspectives towards architecture design for a PBIS.

PBIS Architecture

They focused on extending knowledge to support the exploration of a PBIS supporting Dutch first-line healthcare. Firstly, van Hattum (2020) researched the trade-offs of considering an open digital platform architecture and discussed them with IS experts. His main finding was that IS suppliers are willing to cooperate in an open platform ecosystem if quality and security are unaffected. Furthermore, he outlines the importance of boundary resources (BR) to achieve a compromise between control and generativity on the platform (Van der Wielen et al., 2022). BRs are loosely-coupled components connecting the platform to complementors (IS suppliers and HCPs). Groeneveld (2021) constructed a list of BRs in three different domains within digital platforms: *application*, *distribution* and *social*, of which the *application* and *distribution* boundary resources have the highest positive effect on IS suppliers' willingness to participate in a PBIS. Examples of motivating BRs are standardised APIS, Database Libraries, software development kits, and Terms and Conditions. Kong (2023) additionally researched broad architecture requirements from a stakeholder perspective.

Looking at their research, it can be stated they included mostly IS experts in their research. The lack of including other stakeholders is noticed, directly outlining the need to include other stakeholders than IS experts. The need for including users directly in the design process is also supported by the IS design principles of Hevner (2007), the need for focus on users in the healthcare context by Aanestad and Jensen (2011), and the successful implementation of the delivery model based on patient (user) input by Jayaratne et al. (2019).

User-Centred Design

Requirements describe the capability a system is to fulfil to achieve its mission. Two types of requirements exist, namely: functional and non-functional requirements. A functional requirement is a function the system needs to fulfil. The non-functional requirements involve the behaviour of the system, the structure of the system, and the experience the system needs to support (Brazier & van Langen, 2020). The desired shift towards a more open innovating first-line healthcare involves the emergence of a more extensive developmental process rather than only designing a functional platform (Kuipers, 2023). Creating a more user-centred architecture as core functionality in first-line healthcare could be an inspiring architecture for the entire healthcare field. To ensure the platform functions in a way that triggers a more extensive process, such as bringing the patient up front, the requirements should be based on the user's needs (Aanestad & Jensen, 2011; Sheikh et al., 2021). As shown in Figure 1.2, the system holds two main types of users: patients and HCPs.

Hoving (n.d.) emphasises the importance of involving HCPs in implementing IT solutions in healthcare. He notes that the acceptance and adoption of these technologies by HCPs is crucial to the success of their implementation. Involving HCPs in the

development and implementation of ICT solutions not only contributes to a successful implementation and improves the quality of care and patient safety.

Regarding patient-centred care, which is positively affected by interaction quality, IT can reinforce the relationship between patient and care (Epstein et al., 2010). ISs should provide data access to HCPs and not burden them with administrative tasks, which decreases available time to focus on the patient. Patient-centred also means giving back control of personal data to the patient (Epstein et al., 2010).

The literature already shows small-scale examples of successful patient-centred design, such as the design of a self-manageable asthma mobile health system (Morita et al., 2019), a patient-centred elderly platform (Wutzkowsky & Böckmann, 2018), or a patient-centred platform used by Chi Mei Medical Centre (Lin et al., 2020). The latter also focuses on the need for collaboration between HCPs and stresses the importance of shared decision-making among HCPs (Lin et al., 2020). An even more closely related example is the patient-centred IS used in the *Canisius Wilhelmina Ziekenhuis* (CWZ) in Nijmegen, the Netherlands. These examples outline the potential of user-centred design.

1.2.2. Conclusion: Knowledge Gap and Main Research Question

Summarising the literature review results, the following can be stated. To research the design of a PBIS as support for the current IS ecosystem in Dutch first-line healthcare, best practices of designing general ISs and architecture design need to be considered. IS design and architecture design have been researched for many years and brought essential insights for this study. The conducted researches based on PBIS in Dutch first-line healthcare also show how the IS experts currently act within this system and their motives in adopting an intervention in 'their' IS ecosystem.

However, one of the most essential lacking insights for the PBIS is the need for local adjustment of the system, focusing on the users of the IS. Other researchers also supported this, of which Jayaratne et al. (2019) provides a real-world example of how sufficient user-based design can be. At this moment, the future healthcare perspectives, the needs and values of patients and HCPs regarding the functionalities of an IS are missing. The requirements of the PBIS ecosystem should meet those needs and values before these requirements are translated to any architecture design (Aanestad & Jensen, 2011; Sheikh et al., 2021). But, to create as complete an understanding as possible about designing a PBIS, the architecture design will be within the research objective. To cope with filling the knowledge gap of missing user-centred requirements in architecture design for a PBIS in Dutch first-line healthcare, the main research question to be answered is the following.

Main Research Question

How should the requirements, meeting patients' and healthcare professionals' needs regarding interoperability, be incorporated in the digital architecture design of a platform-based IS supporting Dutch first-line healthcare?

At first, answering the main research question, as stated above, will solve a rather practical knowledge gap. However, the insights of the start-to-end design process of a PBIS ecosystem supporting the IS ecosystem in a healthcare context can be relevant from a broader perspective, including platform design, other healthcare levels, other domains, requirement design, and more. This study first focuses on filling the practical knowledge gap, followed by an extensive reflection on these broader perspectives.

1.3. Relevance within MSc Programme

Designing the platform as an intervention within the socio-technical context of ICT in healthcare involves multiple technical issues, including digital possibilities and the application of design techniques, which are discussed in CoSEM courses. Specifically important within this research is the technical implementation of the platform components while considering the desire to integrate functionalities within currently used systems. However, the technical implementation is limited due to standardised techniques in healthcare. Applying technical disciplines should go hand in hand with the societal context of the system, which is the common thread within CoSEM's curriculum. The societal context involves the public desire for excellent and efficient health care, as stated by Kuipers (2023), and juridical frameworks while considering the IS suppliers, insurance companies, HCPs, and the patient's perspectives. Different interests within the healthcare domain create complexity in implementing a technical intervention. The combination of technical disciplines and the societal context makes this research highly suitable for a CoSEM Master Thesis.

1.4. Involved External Parties

Even though no party is yet designated for designing or implementing the PBIS, Sanday, specialised in developing future-oriented software solutions to connect care around the patient, and TU Delft have joined forces to research how such a platform can be designed for Dutch first-line healthcare. This research is conducted in the context of a research internship at Sanday. The interference of Sanday in this research will be reflected in Chapter 9.

1.5. Reading Guide Thesis

Figure 1.3 gives an overview of the Chapters in this thesis and their main focus point. The master thesis is divided into four phases, described as follows.

- *Phase 0: Introduction and Method*.
  Chapter 1 provides the introduction of the master thesis, including the knowledge gap and main research question. Chapter 2 elaborates on selecting the research approach and resulting sub-questions. For each sub-question, the methodology is discussed.
- *Phase 1: Requirement Engineering*.
  In Chapter 3 the environment of the researched artefact is elaborated on. An extensive overview of the environment is given; this overview also acts as the starting point for the requirement engineering process. The requirements elicitation is discussed in Chapter 4, while Chapter 5 provides the formalisation and analysis of the requirements.
- *Phase 2: Design and Evaluate*.
  Chapter 6 provides the final design of the platform architecture, based on the design evaluation in Chapter 7.
- *Phase 3: Discussion and Conclusion*.
  Chapter 8 provides insights gathered in this thesis regarding exploring a PBIS in an IS ecosystem. The sections in this report discussing these additional insights start with the following (purple) sentence: *'In this Section, additional insights are discussed.'*. Chapter 8 is followed by the reflection and contribution in Chapter 9. Finally, the master thesis research is concluded in Chapter 10, in which the recommendations are also given.

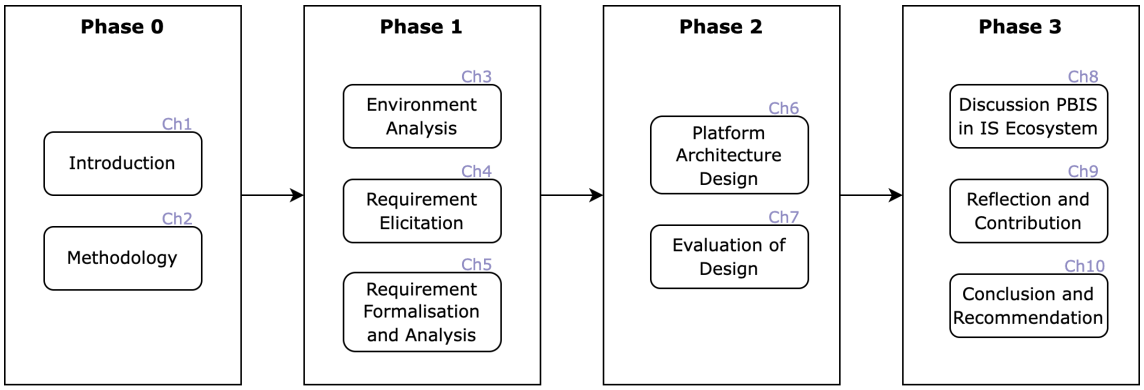


Figure 1.3: Reading Guide Thesis.

2

Methodology

Section 2.1 provides the selection of the research approach for answering the main research question as stated in Chapter 1. The sub-research questions following the applied research method are formulated in Section 2.2. In Section 2.3 the research processes including methods and tools for answering each of the sub-research questions are discussed. An overview of the research processes is visualised in a Research Flow Diagram (RFD). The research processes involved input from people. To show how the input of the individuals is safeguarded, the data management plan is provided in Section 2.4.

2.1. Selection of Research Approach

Answering the main research question *'How should the requirements, meeting patients' and HCPs' needs regarding interoperability, be incorporated in the digital architecture design of a platform-based information system supporting Dutch first-line healthcare?'* needs an approach for the development of a technology-based solution to a practical problem. The technology-based solution in this study is the digital architecture design of a platform-based information system. The practical problem that needs to be addressed is meeting the interoperability needs of patients and HCPs to support them in the Dutch first-line healthcare system.

2.1.1. Design Science Research

Research has been conducted on design science in information system research (Hevner et al., 2004; Peffers et al., 2014). The design of an IS is complex due to the combination of people, structures, technologies and work systems (Hevner et al., 2004). Hevner et al. (2004) introduced design science (DS) research as an opportunity to create a technology-based solution that serves a human purpose. Since the interoperability requirements and architecture design components are intended to support the design of the (technical) PBIS to support patient and HCP processes (practical), the DS approach is applied to this study.

Hevner et al. (2004) created a structured methodology to apply DS on research in IS, the Design Science Research Methodology (DSRM). The DSRM consists of six activities: (1) problem identification and motivation, (2) defining the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. The DSRM is used to define the sub-questions contributing to answering the main research question for this study, while considering the design principles from Hanseth and Lyytinen (2010), as shown in Table 2.1. Design principles are normative principles included in the design of a specific system (Proper & Greefhorst, 2010). Considering this research, it means that the design principles will guide the researcher to a design which will meet the requirements of an IS, as the design principles apply to ISs (Hanseth & Lyytinen, 2010). Design principles support the construction while requirements support the function of a system (Fischer et al., 2010).

Table 2.1: Design Principles of Information Systems by Hanseth and Lyytinen (2010).

Design Problem	Design Principle	Description
Bootstrap Problem	Design initially for direct usefulness	The solution must persuade the initial users through targeting their needs and solving their problems; easy to use and implement; useful without a larger user base
	Build upon existing installed base	Exploit existing infrastructures, platforms or communication formats already in use; no need for new support infrastructures
	Expand installed base by persuasive tactics to gain momentum	Generate positive network effects from extending the user base; before adding new technology, ensure that the user base has grown to sustain the added cost of development and learning
Adaptability Problem	Make the IT capability as simple as possible	Make the information infrastructure as simple as possible (both technically and socially); promote overlapping IT capabilities
	Modularise the information infrastructure	Separate the layers of infrastructures from each other and exploit gateways to connect different layers

2.1.2. Design Cycle Approach

The design science research from Hevner et al. (2004) is embodied by a three-cycle perspective by Hevner (2007). In this research, the cycles, as shown in 2.1 are applied to position the research considering the three cycles: the relevance cycle, the design cycle, and the rigor cycle. This section shortly addresses the content of the cycles.

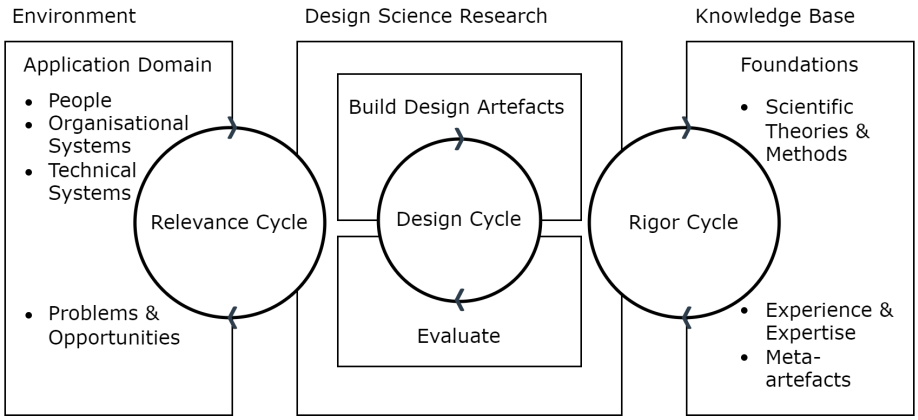


Figure 2.1: Design Cycles of Hevner (2007).

The relevance cycle provides a bridge between environmental factors and design science. The relevance cycle provides the start of a good design process by evaluating the problems and opportunities. Not only the problem and opportunities are being identified, but also the acceptance criteria for the design. The output of the design science is expected to be returned to the environment in terms of evaluation in the domain. Hevner (2007) provides action research as a possible means of a technology transfer method.

The rigor cycle connects with the existing knowledge base for two purposes. The first is the involvement of existing methods and theories, the second is the contribution of the research to the knowledge base. The communication of the artefact and the knowledge gathered by completing the design processes are part of the rigor cycle. This part of the research is important due to its academic contribution. Additionally, the architecture design criteria are derived from the knowledge base, serving as a foundation for defining the criteria that will be used by the researcher during expert interviews to assess the readiness of the architecture design for the application in designing a digital platform infrastructure.

The design cycle ping-pongs between building the artefact and evaluating it. The evaluation is based on the criteria resulting from the knowledge base. The design cycle is a fast-iterating cycle, focusing on constantly designing and assessing the design. This process ends when the researcher sees no further improvements in the design. Iivari (2007) states the following: *"The essence of information systems as design science lies in the scientific evaluation of artefacts."* This implies that the designed artefact should be evaluated during the design multiple times with field experts, to make sure that the design is relevant enough to add it to the knowledge base.

2.2. Sub-Questions Resulting from Research Activities in DSRM

The six research activities as introduced in Section 2.1.1 are now discussed and the resulting sub-questions filling those research activities are defined. First, the formalisation of the sub-question is reported, after which the activities and sub-questions are placed in the design cycles from Hevner (2007).

The *problem identification and motivation* (1) involves the justification of the solution's value by addressing the current situation, and thus the environment. It results in motivation for the researcher and supports the complexity of the problem. In this study, an understanding of the current requirements within the Dutch first-line healthcare IS ecosystem, gave insight into the requirements of the system. What caused the currently existing problems? What requirements should be still considered in the PBIS? Researching the current system contributed to the design of a new ecosystem (Hanseth & Lyytinen, 2004; Hanseth & Monteiro, 1998). The insights on the environment outlining the current system are gained by answering sub-question 1:

Sub-question 1

Which known requirements related to a PBIS in Dutch first-line healthcare should be considered?

During the second activity (2): *defining the objectives for a solution*, it is qualitatively researched how the artefact could be most supportive to the problem and quantitatively determined to what level of performance the criteria should be met (Peffers et al., 2014). In this study, this activity gave insights into the needs of patients, general practitioners (GPs) and pharmacists (PHs). Requirements are developed by applying a value-based requirement engineering approach, consisting of a feasibility study, requirement elicitation, analyses, formalisation, validation and verification (Thew & Sutcliffe, 2018), by answering sub-question 2:

Sub-question 2

What requirements meet pharmacists, general practitioners and patients' interoperability needs in Dutch first-line healthcare?

The third (3) DSRM research activity: *Design and development* involves creating the artefact, in this case including the platform architecture design meeting the requirements listed by answering sub-questions 1 and 2. These requirements are used to support architectural design decisions. The third sub-question is:

Sub-question 3

How can the platform architecture components be designed that meet the requirements?

Sub-question supported the *demonstration*, activity number (4), intended to show how the designed artefact could improve the problem which is being addressed (Peffers et al., 2014), and the *evaluation* (5), intended to state if the designed artefact is ready for practical usage (Johannesson & Perjons, 2014). This also includes an evaluation comparing the design with previously established requirements. By answering sub-question 4 it is tested *if* and *how* the architecture design can guide the design of a PBIS for Dutch first-line healthcare.

Sub-question 4

To what extent is the platform architecture design an effective means to the design of a PBIS supporting Dutch first-line healthcare?

During the various research activities, lessons are learned about designing a digital platform as part of an IS ecosystem. The relevance of the lessons does not remain within the scope of this research, the Dutch first-line healthcare system. In similar situations, as well as in the healthcare domain as in others, where the design of a digital platform is intended to support an IS ecosystem, the lessons learned during this research can be relevant. Therefore, the last sub-question discussed the lessons learned as part of the sixth activity: *communication* (6).

Sub-question 5

Considering the study, what lessons were learned in exploring platform design as part of the Dutch IS ecosystem in first-line healthcare?

The activities and corresponding sub-questions are placed in the design cycles of Hevner (2007). Figure 2.2 shows where the activities and corresponding sub-questions are placed. This provides an overview of the relevance of each activity and sub-question.

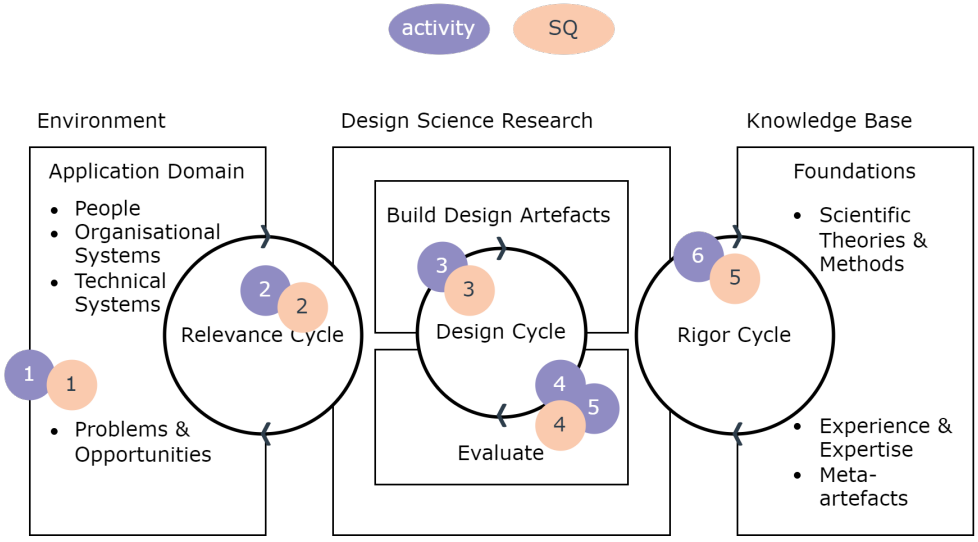


Figure 2.2: Placement of DSRM activities and sub-research questions in the Cycles of Hevner (2007).

2.3. Selection of Research Methods for Each Sub-Question

For each sub-question resulting from the research approach discussed in Section 2.1, the research processes, methods, and tools needed to answer the question are discussed and reflected on in this Section. This study applies a variation of research processes, supporting rich and iterative research. Figure 2.3 provides the RFD as a visualisation of the relation between the research processes as mentioned in Table 2.2. The RFD further appoints the chapters and phases. Following these phases, Sections 2.3.1, 2.3.2, and 2.3.3 provide an elaboration of the methods and tools supporting the research processes in Table 2.2. Furthermore, the Sections discuss the methods used for answering the sub-questions.

Table 2.2: Simplified Overview of the Research Processes.

Phase	Sub-Question	Main Focus	Goal	Research Processes
1	SQ1	Current Situation	Outline Environment	Apply Documents
			Find Earlier Researched Requirements	Apply Documents
	SQ2	Preliminary Research	Research Current Usage and Attitude	Organise Focus Group
			Generate new Ideas	Organise Focus Group
			Validate Findings Focus Group	Organise Semi-Structured Interview
		Survey Application	Validate Findings Preliminary Research	Analyse Statement Assessment
			Generate Additional Ideas	Analyse Survey Clarification
		Requirement Formalisation	Structure the Requirements	Create System Requirement Structure (SRS)
			Validate SRS	Organise Semi-Structured Interviews
2	SQ3	Design	Create Platform Architecture	Compose Platform Modules
				Integrate Platform Modules
	SQ4	Evaluation	Assess Design	Organise Semi-Structured Interviews
			Improve Design	Iterate Suggestion-Based
3	SQ5	Lessons Learned	Outline Effect by Technological Intervention	Discuss Challenges
			Outline Effect on Stakeholder Challenges	Discuss Challenges
			Outline Effect on Feasibility	Discuss Feasibility

2.3.1. Phase 1: Environment and Requirements

The first phase supports a requirement engineering process. The requirement engineering process can be divided into four steps: (1) an environment study, (2) elicitation and analyses, (3) formalisation, and (4) validation and verification, all contributing to the establishment and documentation of requirements (Boulanger, 2016). Each step of the requirement engineering process asks for different data-gathering methods and analyses. The objective of the environment study is to create a framework which clarifies the necessity and restrictions of the PBIS within the healthcare domain. The framework is based on governmental literature and healthcare systems-related documents discussing regulations, initiatives, and standards applicable to Dutch first-line healthcare. The environment study also included existing requirements from earlier conducted research, which are later used in the design evaluation. The environment study supports the first phase and all phases and interpretation of the entire study. All four steps of the requirement engineering process are touched upon by both SQ1 and SQ2. The main difference between SQ1 and SQ2 is the data source, discussed further in the following sections.

SQ1: Which known requirements related to a PBIS in Dutch first-line healthcare should be considered?
The known requirements are elicited by analysing (inter)national laws and healthcare system documents from the government, healthcare initiatives, and healthcare system programmes. Academic literature supported the understanding of the content of the documents and requirements. The literature outlined a list of documents to be considered for designing an intervention in Dutch first-line healthcare. Conducting literature reviews and document analysis provides a way to find information relatively easily and quickly. However, remaining critical of the found literature is essential and is achieved by comparing a variety of resources by the researcher.

Besides the literature and document analysis, the environment is supported by insights from expert interviews from later research processes. Insights of field experts show the relevance of certain aspects of the environment. The downside of including the insights of experts in this environment is the change of a single-perspective insight. Therefore, including insights from later research processes is combined with literature or other documents.

SQ2: What requirements meet patients' and HCPs' interoperability needs in Dutch first-line healthcare?
The elicitation of requirements is primarily supported by answering sub-research question two. In this case, the elicitation involved gathering the relevant requirements from the field directly. Literature provides different techniques, such as interviews, brainstorming, simulations, and analyses of similar systems (Robertson, 2001). In this study, eliciting the requirements meeting the HCPs' needs included four processes: answering sub-research question 1, organising a focus group session, organising semi-structured interviews, and conducting a survey. Discussing the subject with people active in the field of this study during these processes positively affected the *local usefulness* of the artefact, as introduced as a design principle in Table 2.1.

The focus group session is organised wilt multiple participants to enable interaction and discussion. The results of the focus group session are summarised and used to develop statements representing HCPs' perspectives regarding the current system and improvements. These statements are discussed during 1-on-1 semi-structured interviews, to ensure the relevance of the statements. Finally, the statements are validated by conducting a survey, in which the participants are asked to assess the statements. The survey is further applied to generate additional ideas on the statements and gather different perspectives considering the demographic characteristics of the respondents. The analyses resulting in different perspectives between respondent groups supported answering SQ5.

Due to research limitations, the elicitation of the requirements meeting patients' needs did not directly involve patients themselves. The perspective is however considered by analysing HCPs' input and literature on patient values. This directly outlines a limitation of the patient perspective, which is further discussed in Chapter 9.

The formalisation of requirements (step 3 of requirement engineering) implies translating the requirements into a document that can be used as support during the design. The formalisation adheres to standards in requirement documentation. Formalisation includes documenting specifications and graphically structuring the relations by creating a Systems Requirement Structure (SRS) (Brazier & van Langen, 2020). Furthermore, also the *flow* of functionalities can be visualised. In recent years, multiple graphical representations evolved (Long, 2018). From a Functional Flow Diagram (FFD) only focusing on functions and control constructs (Chourey & Sharma, 2016), to a Data Flow Diagram (DFD) only focusing on data triggering events (Long, 2018). A Behaviour Diagram (BD) provides both data triggering and control constructs guiding the functionalities, which makes the BD suitable for representing the functionalities (Long, 2018). Due to time constraints for this study, only the SRS is constructed to formalise the requirements. The SRS is constructed by connecting, aggregating, and aligning the requirements resulting from the elicitation and analysis.

Finally, before translating the requirements into architectural design, the SRS is evaluated. This is done by discussing the SRS during semi-structured expert interviews, focusing on the verification and validation of the requirements and the SRS.

Expert interviews act as a means of obtaining good results (Meuser & Nagel, 2009), but finding experts, who are expected to have insight into aggregated and/or specific knowledge (Van Audenhove, 2007), is not an easy job. The type of experts required to close the knowledge gap is described for this evaluation and for further use of semi-structured interviews. Furthermore, interviews are time-consuming due to the preparation, execution, documentation and analysis, needing time management and realistic planning. The active approach of the researcher and the network of *Sanday* provided a broad range of potential participants for this evaluation process, as well as the evaluation in Phase 2. In both the expert interviews and the focus group session, the diversity of the participants is essential. This is achieved by inviting HCPs from different healthcare organisations, e.g., pharmacists and general practitioners. Additionally, considering the interviews, it is also essential that the participants represent a variety of job positions of the scope presented in Chapter 3. Finally, the participants must have significant years of experience respecting their area (e.g. a GP with only one year of experience is not that much due to the fact GPs generally do not switch job positions, whereas an interoperability layer expert with one year of experience is sufficient, since these layers only exist one year).

Furthermore, the focus group session used to elicit requirements for SQ2 involves the input of HCPs. Healthcare professionals are expected to give valuable insights into the requirements of a PBIS since they experience these functionalities constantly during their work. Applying a survey design to validate the statements does limit the richness of responses due to impersonal participation (Hanseth & Lyytinen, 2010). However, deploying the survey can reach many participants in a sufficient lower amount of time, and the richness of responses is supported by providing open-answer boxes.

2.3.2. Phase 2: Translation to Architecture Design

Phase two consisted of an iterative design process to create the digital platform architecture based on the requirements resulting from Phase 1. Both sub-question 3 and sub-question 4 are part of this iterative design process.

SQ3: How can the platform architecture components be designed that meet the requirements?
To construct the architecture design of the PBIS based on the requirements, literature is assessed to find the best suitable architecture design method. First, the SRS supports creating platform modules enabling the requirements. Integrating the platform modules into an integrated platform architecture is done following a layered approach, showing the platform's business, information, and technology layer. This is further explained in Chapter 6. It must be mentioned the platform architecture is one possible way to meet the requirements, which increases the chance of a biased design. By consulting with several platform architects from various domains to answer sub-question 4, an effort was made to minimise this problem. The drawback does suggest that the design should be viewed as a possibility rather than the sole design that may exist.

SQ4: To what extent is the platform architecture design an effective means to the design of a PBIS supporting Dutch first-line healthcare?
As can be seen in Figure 2.2, the design needs iterations to become a valuable design. These iterations are based on the evaluation interviews for answering sub-question 4. The architecture design is evaluated by conducting expert interviews, within the field of platform architecture, both in the healthcare domain and other domains, to obtain insights from different perspectives. The architecture design is validated using the evaluation criteria for platform architectures and verified by answering the question: *Does the design meet the requirements?* The findings of these interviews are analysed by constructing an overview table, including the suggestions made by the experts and if the suggestion was acknowledged for the iteration. The iterations are extensively reported to support transparency. A final evaluation is based on the comparison with earlier constructed requirements by Groeneveld

(2021), Kong (2023), and van Hattum (2020). The value of the comparison can be questioned because all three studies were master's theses, whose quality is not generally acknowledged. As a result, this comparison is just utilised for evaluation and is not used in iteration rounds.

2.3.3. Phase 3: Contribution and Conclusion

In Phase 3 the researcher answered the final sub-question, reflected on the study and provided the contributions in Chapter 9, and concluded the study and provided recommendations in Chapter 10. In this Section, answering the final sub-question is discussed.

SQ5: Considering the requirement-based platform architecture design, what lessons were learned on exploring platform design as part of the Dutch IS ecosystem in first-line healthcare?
This sub-question is answered by discussing the additional findings during the research process, starting from the requirement engineering process to the architecture design. The lessons learned are discussed based on additional insights gathered during the research processes based on two aspects: the effect of technological intervention and the effect on the stakeholder challenges. Additionally, both are combined to discuss the effect on the feasibility of implementing the intervention. The answer to this question is based on the participants' input but subjected to the researcher's interpretation. This does indicate the interpretation is not supported by any other participants, which can be seen as a limitation. However, the researcher's interpretation provides one critical perspective and might arouse further discussion with other researchers.

2.4. Data Management

This research involved multiple data-gathering methods that included other humans: a focus group and survey to gather insights and interviews to discuss the statements, requirements, and design. In the case of all human-involving data-gathering methods, the risks are assessed and mitigated. For each of the data-gathering methods, this section elaborates on the mitigation. Table 2.3 shows the data gathered during the activities used as results, personally identifiable data and what data management is applied. All research activities are only conducted if and only if the participant agreed with the consent form in the case of the focus group and semi-structured interviews or agreed with the consent message as the starting point for the survey. The consent forms and message are shown in Appendix C.

Table 2.3: Data Management for each Human-Involved Research Activity.

Research Activity	Data used as Results	Personal Identifiable Data	Data Management
Focus Group	Recording and summary of the focus group, anonymous quotes of the focus group	Name and email address	The name, email address and recording will be stored safely on a TU drive, only accessible by the researcher and first supervisor. Summary provided in the thesis report.
Survey	Full answer document of Qualtrics	Email address in case the respondent did want to enter in the win action.	Respondents will be asked to leave personal data behind while answering the open questions in the surveys. The question to gather the email addresses for the win action was provided with an additional consent text.
Semi-Structured Interviews (Phase 1 and Phase 2)	Recording, a summary of the interview, anonymous quotes of the conversation	Name and email address	Personally identifiable data will only be stored safely on a TU drive. Summaries will be provided in the thesis report.

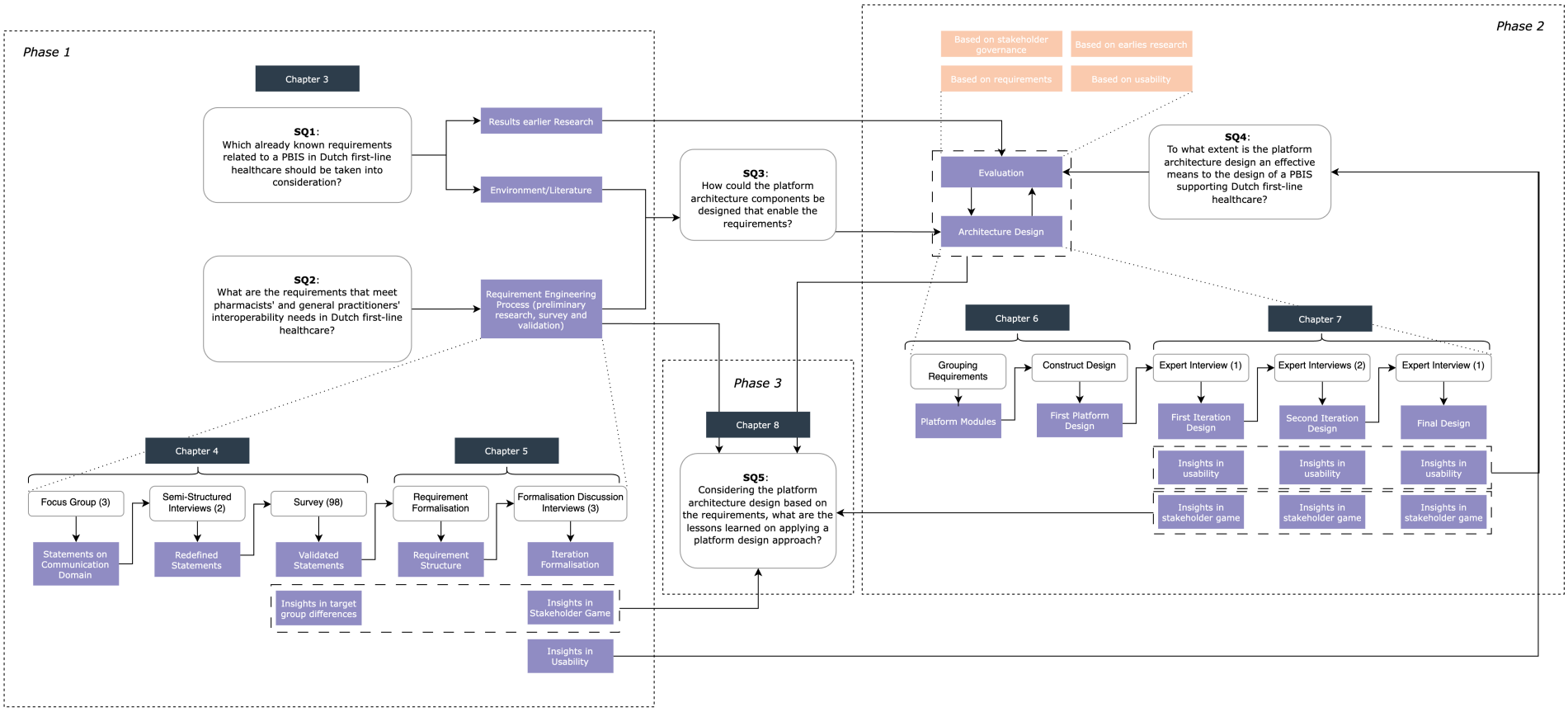


Figure 2.3: Research Flow Diagram Thesis.

3

Environment Analysis: Dutch First-Line Healthcare

This Chapter introduces the current situation further than already introduced in Chapter 1. The information in this Chapter contributes to the feasibility study supporting the requirement engineering process in Chapter 4, by outlining the framework which delineates the requirements and, later on, the platform design. The Chapter follows the environment of the design cycles as shown in Figure 2.2. The cycle outlines the environment based on four pillars: people, organisational and technical systems, and problems and opportunities. First, the people aspect will be covered in Section 3.1, showing the interaction between patients, HCPs and insurance companies.

The organisational and technical systems, including legal institutes, initiatives, programmes, documents, and standards, were found during a literature search on the thesis topic. As described in Chapter 2, the organisations and provided documents are found by conducting a literature and document analysis of parties in the scope of the thesis. The research process was experienced as a broad search process. This study provides an original approach to combining the provided documents and organisations with the interoperability layers from Nictiz (2022a). This was done to provide insights into the documents' usability and the organisations' relevance in this design study. First, these interoperability layers are discussed in Section 3.2. The organisational and technical systems are introduced in Section 3.3, following the overview of the systems and how they are related to the interoperability layers, as provided in Section 3.2.

Considering the problems and opportunities, problems within the environment are described in Chapter 1. The problems arising in the health IT market lacking innovation, poor interoperability, lack of resources, etc. The opportunities for providing solutions to these problems are limited by the framework of people, organisational systems, and technical systems discussed in this Chapter. But the limitations also open opportunities in following these limitations and finding gaps for improving the system. This pillar is not discussed in this Chapter since this entire study will focus on the opportunities for improving the environment. This will be reflected in Chapter 9.

The following must be mentioned before discussing the people, organisational and technical system. The relevance of considering the aspects discussed in this Chapter is partly based on the finding from the preliminary research in Chapter 4 that *communication regarding care around the medication process* needs to be improved.

3.1. People

Figure 3.1 provides a simplified representation of the stakeholder interaction within first-line healthcare, relevant for understanding the scoped interaction within this thesis. The first-line healthcare system goes beyond the representation that is shown. District nurses, dentists, physiotherapists and social workers are furthermore part of the first-line (Rijksoverheid, n.d.) but are excluded in the scope of this master thesis. The stakeholders directly involved in the research are the pharmacy and GP practice employees (bold). The stakeholders indirectly involved in this research are the patient and the insurance companies. Due to time constraints, their perspective is not gathered through empirical research but through literature.

3.1.1. Healthcare Organisations

As mentioned in Chapter 1, this thesis research is applied within the Dutch first-line healthcare system and its healthcare organisations (healthcare organisation). The first-line healthcare not only includes professionals in pharmacies and GP practices (as represented in Figure 3.1), likewise on district nurses, dentists, physiotherapists, and social workers are furthermore part of the first-line (Rijksoverheid, n.d.). Because Sanday is involved in this study, focusing on GP practices and pharmacies for its business, GPs and PHs were expected to be more easily included. Not speaking to other healthcare organisations limits the complete picture but provides particular insight into the relationship between pharmacies and GP practices.

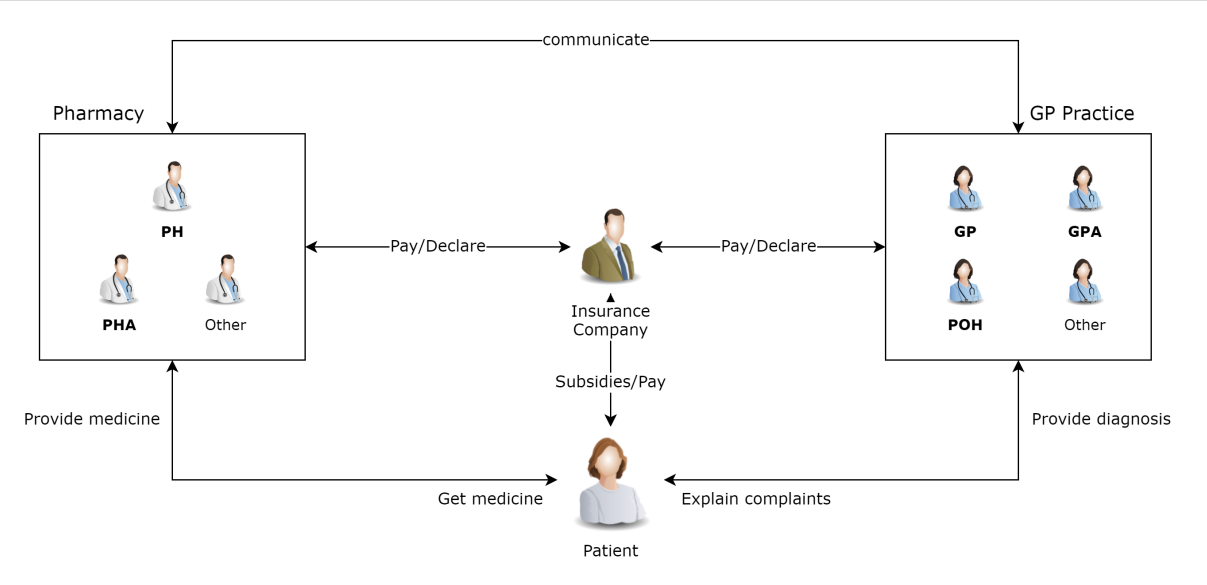


Figure 3.1: Simplified Representation of the Stakeholders within Thesis Scope.

As shown in Figure 3.1 within these organisations, the HCPs directly involved in this study are indicated. This is based on the most commonly held positions within the two organisations: the GPs, PHs, and their assistants (A). The POH on the GP side was added later based on interviews discussed in Chapter 4.

3.1.2. Health Insurance Companies

Health insurance companies are included in the scope visualisation since the relationship between patients and HCPs is affected by health insurance companies. healthcare organisations are paid by health insurance companies. Every citizen in The Netherlands is obliged to close basic health insurance. The state government decides the content of the primary health insurance. Every health insurance company can offer additional insurance and choose what is covered by those additional insurances (VWS, n.d.). This study does not include the perspectives of the health insurance companies, but they do fill a significant role in the financial system of the healthcare context. Although the power of health insurance companies is often seen as unfavourable, also confirmed by participants in Chapter 4, bringing this financial system along is necessary to get through the first implementation phase. The importance of financial means is also outlined during the preliminary research phase as discussed in Chapter 4. Changing the entire financial system is beyond the scope of this study. However, Chapter 6 presents an out-of-the-box idea regarding finances around the platform.

3.1.3. Patients

The term *patient* is used primarily when it's about persons involved in a healthcare-related process. However, the term patient does indicate that the person is also suffering from illness. Some state that an alternative term should be used for the term patient (Neuberger & Tallis, 1999; NEXUS, 2021). Also, during the preliminary research discussed in Chapter 4, it became clear that employees in pharmacies want to shift from the term patient to *citizen in need for medication*, *client* or *individual*. Within this thesis, the term patients is, however, still applied.

Due to research limitations, patients have not been contacted to participate directly in research activities. Despite that, an estimation of their values is formulated into requirements. The discussion with PH3 resulted in three patient perspectives regarding the medication process, namely: (1) patients chronically needing medicines, (2) patients urgently needing medicines, and (3) complex patients. Different values would be applicable for all patients considering the communication in the medication process. However, there are more perspectives on the types of patients. Types of patients have also been categorised in more general communication-focused areas. For example, Flearning (2022) describe four behaviour types of patients considering communication: the self-diagnose, the sceptic, the passive-independent, and the open-minded. Rowland (2013) describe the open-minded patient as flexible and adds the passive, dependent patient type to the spectrum. Patients' perspectives regarding technology are relevant, considering the desire for a digital intervention.

Also, in scientific literature, communication for different types of patients is researched. Brown et al. (2002) researched the effect of strategies regarding shared decision-making, including nurses and active and passive patients in oncology. These strategies included agenda-setting, active listening, checking to understand, enabling question-asking, offering decisions delay, and non-verbal behaviours conveying empathy and warmth. This research does indicate the positive effect of strategy adjustment considering patient types. Viktorsson et al. (2022) researched the primary desires from a young adult perspective on needs when seeking first-line healthcare in southeast Sweden. They found young adults were mainly concerned about being taken seriously considering their illness.

More generally, considering patients' values in a healthcare context, Sulmasy et al. (2017) defines three types of patient values: prudential, moral, and epistemic. They suggest that these types reflect the needs of patients to pursue their well-being and interests, to respect their rights and obligations, and to evaluate the quality and relevance of evidence when receiving care. Literature gives further insights into the embodiment of the values that should be respected. Greenhalgh et al. (2010) identifies seven key elements within patient values reflecting a patient's needs to be individually recognised: uniqueness, autonomy, compassion, professionalism, responsiveness, partnership and empowerment. Following these key elements would result in the patient having control over their health, receiving high-quality and evidence-based care, being treated with respect and empathy, and being enabled to participate in shared decision-making (Entzeridou et al., 2018; Greenhalgh et al., 2010). The personal context is further outlined as an essential addition by Entzeridou et al. (2018), considering the personal condition or private situation in which the patient is. Norman et al. (2011) uses cognitive-affective, normative-ethical, relational-social and situational-contextual terms to consider their beliefs and emotions, moral principles and values, relationships and social networks, and circumstances and constraints when making health care decisions.

It should be concluded that patient values differ per individual. Some patients may prefer more involvement in their care decisions, while others prefer delegating the decision-making to their HCPs. Some patients may have concerns about the risks and benefits of different treatments, while others may have concerns about the costs and accessibility of care. Some patients expect high-quality, respectful, timely care, while others expect long-term relationships and trust with their HCPs. Also, religious or cultural beliefs can be considered when fully picturing patient perspectives.

3.1.4. Outside the Thesis Scope: IS experts

Outside of the thesis scope, requirements have been constructed by three researchers from IS experts' perspectives. The studies of van Hattum (2020), Groeneveld (2021), and Kong (2023) show insights into architecture requirements from an IS expert perspective. First, the design decisions for the three architecture aspects, *core, interface openness*, and *interface stability*, are explored in the master thesis research from van Hattum (2020). Multiple platform experts discussed the many design options for each architecture dimension. The design configurations were made while keeping the platform's modularity in mind. A platform's modularity can range from strictly monolithic to highly modular (Tiwana, 2014). The work of van Hattum (2020) is based on expert interviews with professionals in Dutch healthcare systems. This qualifies his work for evaluating architectural designs based on the criteria for interoperability. The requirements are referred to as Platform Configuration Requirements (PCR).

To improve the participation of IS suppliers on a digital platform in Dutch first-line healthcare, Groeneveld (2021) researched the most positively affecting boundary resources that should support the platform. Since IS suppliers' participation is needed to implement a platform-based design, these boundary resources are essential to the platform design. The *application-based boundary resources* and *development-based boundary resources* affect the participation of IS suppliers most positively. The requirements are referred to as Boundary Resource Requirements (BRR). Finally, Kong (2023) researched the stakeholder (SR) and architectural requirements (AR), following an interview-based approach. The stakeholder requirements arose from interviewing IS and software suppliers in Dutch first-line healthcare. The stakeholder requirements were translated into architectural requirements. These requirements stem from the interviews with IS suppliers and software suppliers.

Despite the requirements being from another perspective than researched in this study, they are still relevant for evaluating the designed platform architecture. Comparing the designed architecture with the architecture requirements as formalised by these researchers provides insights into the potential success of implementation since the IS suppliers should be motivated to enable implementation. The design does not include the requirements directly since this study focuses on the HCP and patients' perspectives, not the IS experts' perspectives.

In addition to examining the involved users, the organisational and technical systems have also been explored. One initial system that emerges after the search process is the interoperability layers model provided by Nictiz (2022a). The following Section describes the interoperability layers, offering a more general understanding of their significance and stressing the importance of considering these layers specifically.

3.2. Interoperability Layers

Aliprandi (2011) emphasises the importance of open standards to improve interoperability. Researchers have defined interoperability in various ways, and multiple models provide insights into interoperability layers. However, the interoperability layers provided by Nictiz (2022a) are directly related to and assess the interoperability of healthcare systems. Nictiz is dedicated to creating a vision for healthcare information systems and their supporting architecture. They develop and uphold standards for digital information management, ensuring clear recording and exchange of healthcare information. Furthermore, Nictiz provides advisory services and shares knowledge on digital information management in healthcare nationally and internationally. Due to their position within the Dutch healthcare context, these layers are chosen to be relevant for this study.

The Nictiz layer model consists of seven layers that must be related to each other to ensure interoperability between parties. As one of the factors for determining a healthcare system's openness, research on interoperability must consider the seven layers of Nictiz. The openness and interoperability of a healthcare system are closely related and will also be examined in this study. Sprenger (2020) states that standards are involved at each layer of the Nictiz interoperability layer model. The layered approach provides a workable and stable information-supporting organisation. Finally, it can determine when a layer is considered sufficient, how it is assessed, and how the quality of the layer is perceived.

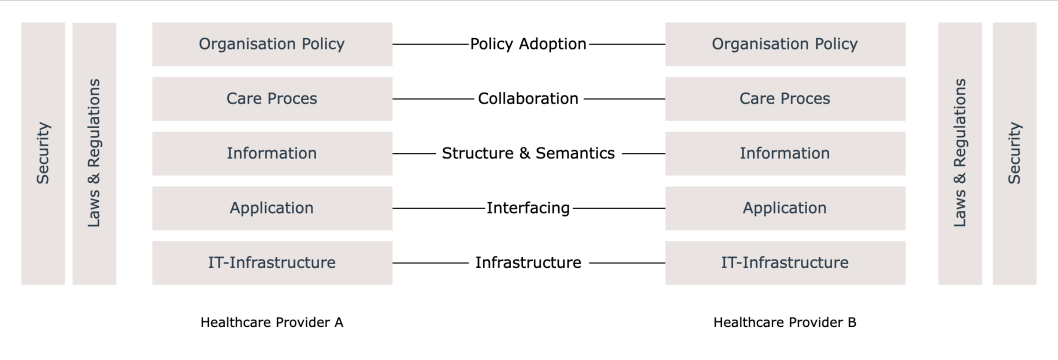


Figure 3.2: Interoperability Layers (Nictiz, 2022a).

3.2.1. Description of the Interoperability Layers

The layers, as visualised in Figure 3.2, are described in this Section. These descriptions are relatively general, while Section 3.2.2 focuses on applying these layers in this study more specifically.

Organisation Policy Layer
The organisation policy layer is about decisions in exceptional situations. When faced with exceptional situations, organisations must carefully consider their decisions and responsibilities at the highest levels of management. Such decisions require a thorough understanding of the agreements and relationships between the patient or other involved institutions and the organisation. Additionally, organisations must ensure that legal and ethical obligations, such as privacy rights, are sufficiently addressed. To this end, many umbrella organisations seek to create cohesive plans for multiple healthcare institutions. These organisations are often involved in the development of top-level decision-making processes. One critical standard in this context is the agreement on the procedures for referring a patient who has completed their treatment. Organisations can ensure patients receive the best care and support during and after treatment by establishing clear and consistent referral procedures. Organisations must carefully consider their responsibilities and obligations when making decisions in exceptional situations.

Care Process Layer
The current focus of the healthcare industry is to provide comprehensive and coordinated care to patients. This requires seamless coordination and communication between various healthcare organisations involved in the patient's care. To achieve this goal, it is essential to have a clear understanding of the processes that overlap and the transfer moments between the involved organisations. In this regard, the healthcare model has a specific layer solely dedicated to the patient care process. One of the crucial questions in this layer is whether the professionals within the healthcare organisation and the patient clearly understand how to work together. This includes establishing agreements on responsibilities related to communication tools between the pharmacist and the general practitioner to streamline the patient's medication process. Furthermore, it is essential to ascertain if the involved parties are willing to share information about the patient's care process. To ensure that the coordination and communication within the healthcare system are effective and efficient, it is essential to adhere to the standards set in the healthcare industry. For example, the *Zorgstandaard COPD* provides guidelines for the care of patients with chronic obstructive pulmonary disease. In contrast, the *Richtlijn Overdracht van Medicatiegegevens in de keten* provides a framework for transferring medication data between healthcare organisations. Adherence to these standards ensures that the care process is streamlined and patients receive high-quality and coordinated care. Insights into current care processes resulting from exploration with field experts (Chapter 4) are shown in Appendix B.

Application Layer
Regarding the systems necessary for sharing and exchanging information, as described in the information layer. It shows which software/systems are being used to support the healthcare process. It is clear that they are not willing to switch systems, but are they willing to adopt an additional system for exchanging information related to the medication process? Furthermore, how much additional software are they willing to take on? In accordance with the data domain models and syntactic exchange structures, such as LSP and Vecozo, these standards should be considered when evaluating the appropriateness of the software for exchanging information between HCPs and patients. Proper adherence to these standards can help ensure that the necessary information is exchanged accurately and efficiently, improving the overall quality of care.

IT-infrastructure Layer
The IT infrastructure layer concerns how the parties would be connected securely and reliably, specifically in relation to the network, server, and database engine. This layer is an integral part of the design process. The PBIS is approached as a technology from this underlying layer, and different perspectives must be considered on how it can be developed in the other layers. Standards that should be considered in this layer include databases and VPN connections, which are crucial for establishing secure connections between the various parties involved in the system. It is essential to carefully consider the design of the network, server, and database engine to ensure optimal performance, security, and reliability of the system. Therefore, it is essential to implement established standards to ensure that the system operates effectively and efficiently.

Law-and-Regulation Layer
The five-layer model is applied to organisations in the Netherlands, such as a change in primary healthcare. The reorganisation/-support of primary healthcare is limited by Dutch laws and regulations. Compliance with these regulations is non-negotiable, leaving little room for discussion. However, a six-layer model can be used at the European level and from the ministry's perspective, where laws and regulations are seen as a means rather than an obligation. From a European/national standpoint, laws and regulations can be used to improve interoperability. Recommendations may be given to the ministry to adjust specific guidelines to improve interoperability. Laws and regulations are introduced as a means for long-term solutions and broadly applicable solutions.

Security Layer
Security is of utmost importance when dealing with sensitive patient information. This is not only a practical consideration but also a legal requirement. To ensure the safety of patient data, security must be implemented in three key ways: availability, integrity, and confidentiality, commonly referred to as the Confidentiality, Integrity en Availability (CIA) classification. Confidentiality concerns some HCPs, who may view it as an extra burden. However, it is crucial to communicate to patients the importance of confidentiality in protecting their personal information. To this end, it may be worthwhile to dedicate extra attention within the pharmacy to communicate the importance of confidentiality to patients. At the same time, it is understandable that providers may not want to spend extra time conveying this message to patients. It is essential to consider the purpose for which patient information is being used and ensure that only relevant information is shared. Defining the purpose of information use can be challenging, especially given how patients approach their HCPs. Nevertheless, developing clear guidelines and formulations for communicating with patients in different contexts is crucial.

3.2.2. Application of the Interoperability Layers

The aforementioned layers illustrate how two organisations can be connected. It is equally important that the collaboration between the two information-supporting processes is also information-supportive. This study includes not only HCPs in the interoperability exploration. The patients discussed in Section 3.1.3, are also seen as a component in the interoperability layers, as visualised in Figure 3.3. The patient system provider can be a PGO, patient portal, or any other system supporting patients in healthcare processes. This study focuses on exploring the interoperability between many system providers, as well as for HCPs and patients.

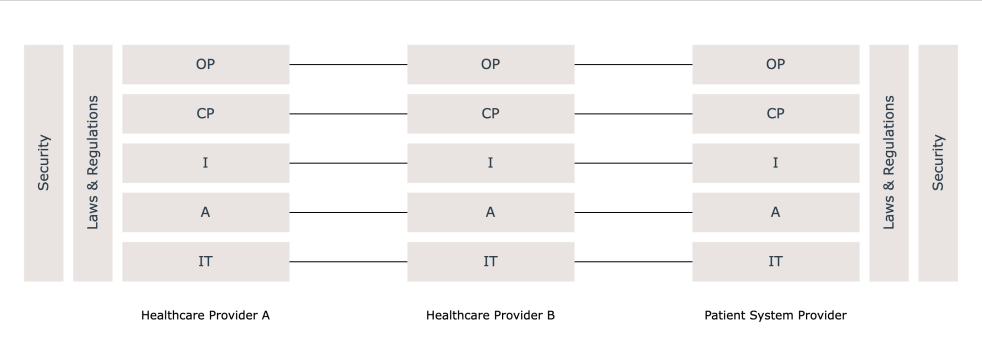


Figure 3.3: Representation of the Interoperability Layers, including the Patient System Provider.

Additionally, applying the organisational and technical systems described in the following Sections affects these interoperability layers. Figure 3.4 shows the organisations involved, the document and/or initiatives they provided, and the affected layers by those documents/initiatives. Section 3.3 describes the systems and their effect on the layers more precisely. It should be noted that the effects visualised are the direct effects. However, the indirect effects on other layers are not necessarily neglected. These indirect effects are hard to identify firmly and, therefore, not visualised in the diagram. The numbers next to the interoperability layers (on the right side) show how often the layer is directly affected by the considered systems in the environment.

3.3. Relevant Systems in the Environment

This Section describes the content and relevance of the systems in the environment plotted in Figure 3.4. A system in this context is also a collective term for a document, law or organisational institution. The organisational and technical systems overlap in this environment by organisations offering standards for technical systems. This study does not go very deep into the highly technical aspects since that would be out of the scope.

3.3.1. Legal Institutions

As visualised as the first organisations in Figure 3.4, the European Commission and the Dutch government play an essential role in the security and laws and regulation layers. Considering the Dutch government, the Ministry of Health, Welfare and Sports is mainly engaged in this study. However, the laws applicable in the context are accepted by the Dutch government, not the Ministry. This Section outlines the most relevant aspects of these organisations and the laws and regulations they provided, mainly to protect the safety of citizens, in this study, the HCPs and patients.

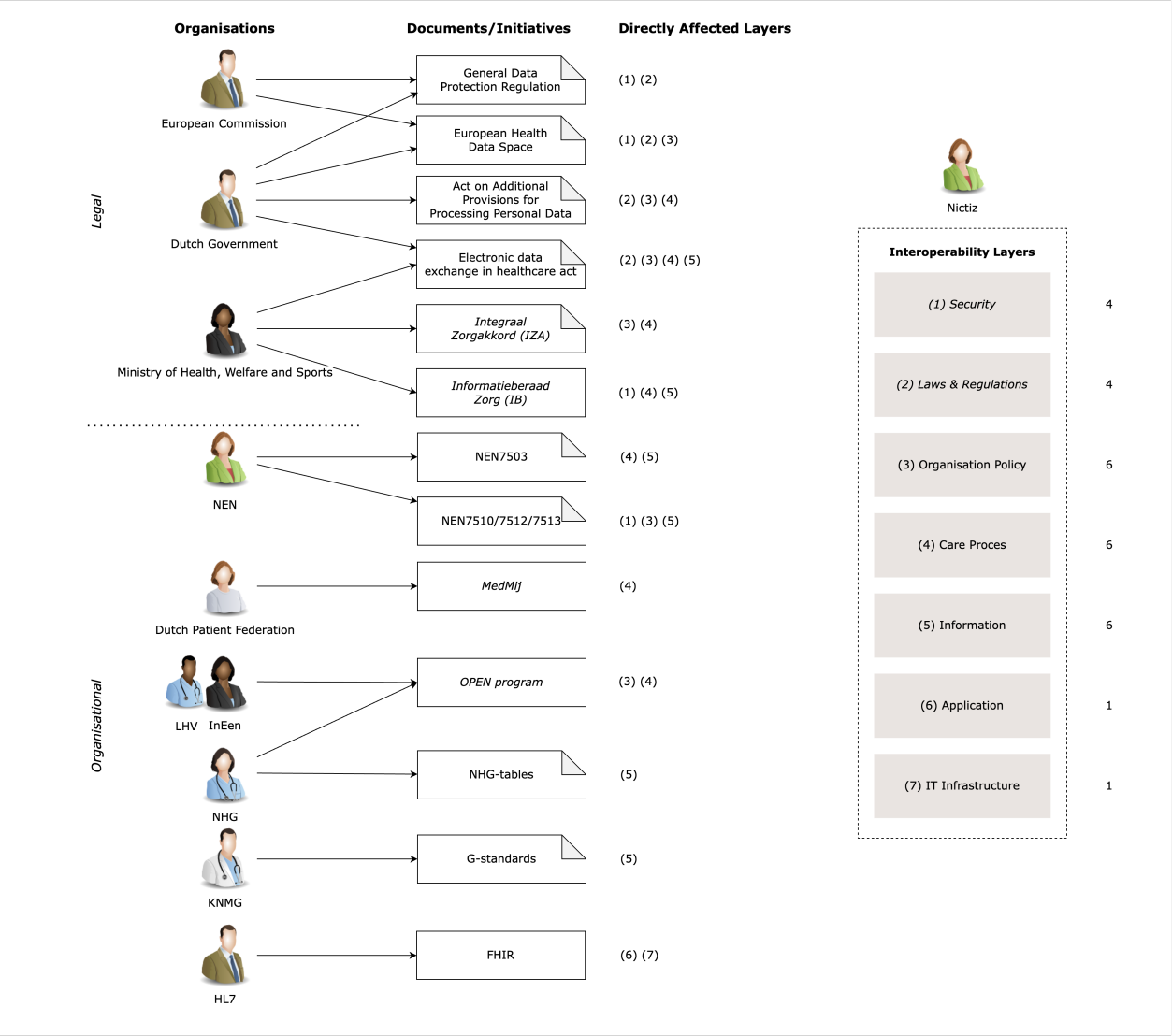


Figure 3.4: Plotted Environment including Organisations, Documents and Initiatives, and directly Affected Layers.

European Commission

The European Commission provided the General Data Protection Regulation (GDPR) to support seven main principles in data protection (1) lawfulness, fairness, and transparency, (2) purpose limitation; (3) data minimisation; (4) accuracy; (5) storage limitations; (6) integrity and confidentiality, and (7) accountability (European Union (2016), Article 5.1-2). The GDPR mainly affects the security layer (1) through laws and regulations (2). Furthermore, the European Health Data Space (EHDS) is a goal of the European Commission to make it quick and simple to extract medical information and give citizens access to their health information. The focus is divided into three subtopics: primary data use, secondary data use, and regulation of the health-ICT market.

The guidelines for the primary use of patient data put the patient in the centre and give patients the right to have more choice over how their electronic health records are accessed and used to deliver care. The secondary use of health data covers electronic health records for other administrative purposes. Useful for, for instance, scientific innovation and policy formation. The third component focuses on developing an internal market for digital health products and services, such as electronic medical dossier systems. The Commission wants to standardise the EU's (product) security, protection, and interoperability rules to promote the effectiveness and efficiency of the healthcare system. In this study, the EHDS affects the security (1), laws and regulations (2), and organisation policy layer (3).

Ministry of Health, Welfare and Sports

The Ministry of Health, Welfare and Sport (VWS, Dutch: *Ministerie van Volksgezondheid, Welzijn en Sport*) is a Dutch government department responsible for public health, healthcare, and social welfare. Its mission is to ensure that every person in the Netherlands has the opportunity to live a healthy and fulfilling life with access to high-quality and affordable healthcare and social support. The ministry develops policies, coordinates activities, and provides funding for various health and social welfare programs and services, collaborating closely with other government agencies, HCPs, and community organisations. Its main goals include improving public health outcomes, reducing healthcare costs, and promoting social inclusion and equality (Ministerie van Volksgezondheid Welzijn en Sport, n.d.). The Ministry of Health, Welfare and Sports's role in this study can be embodied by providing laws,

supporting implementation, funding implementations, regulating monitoring and control, etc. Deciding on the ministry's role is not within the scope of this research but will be discussed in Chapter 8.

The Dutch Act on Additional Provisions for Processing Personal Data
(Wet aanvullende bepalingen verwerking persoonsgegevens in de zorg, 2020) The Dutch Act on Additional Provisions for Processing Personal Data in Healthcare (Wvpz, Dutch: *Wet aanvullende bepaling verwerken persoonsgegevens in de zorg*) regulates the processing of personal data in the healthcare sector, as an addition to the GDPR. The act aims to protect patient's privacy and ensure their medical information's confidentiality. Under the Wvpz, HCPs, including hospitals, doctors, dentists, and pharmacies, must obtain explicit patient consent before sharing their data through electronic exchange systems. The act also requires HCPs to provide patients with information about their rights with regard to electronic data exchange and the operation of the electronic exchange system used for data exchange.

The act establishes rules for creating and managing registers of HCPs and health insurance companies. The register administrator may charge a fee for access to the register, and the act requires the administrator to establish procedures for adding, modifying, and removing data from the registers. The act ensures that patients have control over their medical information and that HCPs are held accountable for its responsible use and management. This register supports organisation policy (3) of multiple healthcare organisations since responsibilities for HCPs and insurance companies are defined. The provisions and content of the Wvpz include several crucial and relevant points. Overall, the Wvpz is designed to balance the need for medical information to be shared between HCPs for effective treatment with the need to protect patient privacy and confidentiality. Relevant articles for this study, mainly affecting the care process (4) and information (5) layer, are listed below.

- *Article 4* BSN is used solely to process personal data about the client.
- *Article 8.2* If the data is made available through an electronic exchange system, the legal entity responsible for managing and maintaining this system is authorised to process the BSN, to the extent that it is necessary to fulfil their obligations as the administrator.
- *Article 9.2* The HCP must report the BSN in relation to the provision of, indication for, or insurance of healthcare to a HCP, indication agency, or health insurance company.
- *Article 3.2.3* The Centre for Indication of Care Needs (CIZ, Duch: *Centrum Indicatiestelling zorg*) evaluates requests for long-term care provisions under the Long-Term Care Act (Wlz, Dutch: *Wet langdurige zorg*) (Wet langdurige zorg, 2022) and provides indications for them. The right to care is determined through an indication decision made by the CIZ upon the insured's request. The right to care established in the indication decision corresponds to the insured's needs.
- *Article 15.1* There must be guidelines for managing the registers, securing personal data, and monitoring their functioning.
- *Article 15.3* The registered administrator may grant access to provisions upon request to a HCP, indication agency, or health insurance company registered in the register. The administrator may charge a fee for this service.
- *Article 15.1* Rules must be established regarding including, modifying, and removing data in the registers of HCPs, indication organisations, and health insurance companies. Additionally, rules must be established regarding the management of the registers, the protection of personal data, and the supervision of the functioning of the registers.
- *Article 15.3* The administrator of the register can grant access to the facilities to a HCP, indication organisation, or health insurance company registered in the register upon their request. The administrator may demand payment for the use of the facilities.
- *Article 15a.1* Under the electronic data exchange system HCPs use, the client must have explicitly given consent for their data to be available.
- *Article 15d.1* Data is electronically transmitted at reasonable intervals.
- *Article 15d.2* Concerning dispensing medication, the pharmacist must provide the client with direct electronic access to their medication data upon dispensing. The client can request the pharmacist to make certain self-medication information available in the electronic exchange system.
- *Article 15e* Regarding information storage, it is necessary to keep a record of who made certain information available and on what date, as well as who accessed or requested specific information and on what date.

Electronic Data Exchange in Healthcare Act
Electronic Data Exchange in Healthcare Act (Wegiz, Dutch: *Wet elektronische gegevensuitwisseling in de zorg*) is a law for electronic data exchange in healthcare in the Netherlands. Formally known as EGiZ (formally a code of conduct), of which the purpose was to guide healthcare organisations on how to securely and responsibly exchange patient information electronically Nouwt (2019). The EGiZ was officially respected as law in 2023. The Wegiz includes principles and guidelines for data protection, information security, and privacy and emphasises the importance of obtaining patient consent to exchange their information. The Wegiz is intended to ensure that healthcare organisations meet legal and ethical data protection and privacy obligations when exchanging electronic patient data. The Wegiz relies on cooperation between healthcare organisations. Two critical aspects within the Wegiz informing the organisation policy (3) and care process (4) layer through laws and regulations (2) are listed below.

- The *source record holder* is the HCP, where the patient presents their complaint. The source record holder records the patient's data. The data in the source record may be necessary for other HCPs with an existing healthcare relationship with the patient. This can affect the policy agreements between healthcare organisations since it defines the care process.
- According to Wegiz, there are two types of data exchange traffic: push and pull. Push traffic means that a HCP (the source record holder) sends data to another HCP where the treatment relationship is known, for example, sending medical record information from a GP practice to a pharmacy. Pull traffic means that a HCP requests information and the source record holder provides this information based on the request.

The above legal institutions mainly show that they can achieve specific results within the context through laws and regulations. So this goes through the laws and regulations (2) layer to carry through. But from the government initiative, two other systems have been set up that are not directly linked to laws and regulations but are intended to influence future-proof cooperation between different healthcare parties. The IZA and IB are explained below.

Integrated Care Agreement
The Integrated Care Agreement (IZA, Dutch: *Integraal Zorgakkoord* aspires to maintain high-quality, affordable healthcare in the future. The Ministry of Health, Welfare and Sport and numerous healthcare-related parties have agreed to do this. Hospitals, mental health organisations, and senior care industries are among the IZA's signatories. Since multiple organisations have committed themselves to the IZA, it is expected to affect the organisation policy (3) and care process (4) layers. The IZA centralises the following objectives in an agreement constructed by Ministerie van Volksgezondheid Welzijn en Sport (2022).

- Ensure equal access to quality care for all population groups, considering diversity and freedom of choice;
- Focus on prevention and support for a healthy lifestyle and self-reliance, with the involvement of municipalities;
- Limiting medicalisation through early problem clarification and providing appropriate support in care and welfare domains;
- Optimal use of available capacity without wasting resources;
- Reduce administrative burden for care professionals;
- Retaining care professionals by promoting job satisfaction, control, trust, safety and health, and paying attention to inflow and outflow.

Informatieberaad Zorg
The *Informatieberaad Zorg* (IB) is a Dutch organisation established in 2014. It is a platform for collaboration between healthcare organisations, HCPs, patient organisations, and the Dutch government. The organisation's goal is to promote developing and using digital information systems in healthcare in the Netherlands. The Informatieberaad Zorg provides a platform for discussing and developing standards for exchanging healthcare information between different HCPs and promoting adopting new digital technologies and innovations in healthcare. By working together, the organisation hopes to improve (1) medication safety, (2) patient-centred care, (3) standardised information exchange, and (4) single storage of information (IB, n.d.). The IB can hereby affect the security (1), care process (4) and information (5) layers.

3.3.2. Organisational Initiatives

Not only legal institutions involve with the healthcare context and provide rules for improving it. Among others, the organisations: NEN, Dutch Patient Federation, LHV, InEen, NHG, KNMG, and HL7 provide more guidance and support to the context (in the form of guidelines and standards) and are therefore discussed in this Section. The guidelines and standards of these organisations are selected based on relevance for interoperability between healthcare organisations and patients. More organisations are active in this field, but the most relevant were selected to include in this study.

NEN-guidelines
NEN (Dutch: *Stichting Koninklijk Nederlands Normalisatie Instituut*) supports the connection of parties and stakeholders to ensure they reach agreements in standards and guidelines. They do this in national and international standards committees. Organisations are not required to adhere to NEN guidelines but may receive certifications for some. This allows an organisation to show that the guidelines have been adequately observed. This confers a certain status.

NEN7503 focuses on the prescribing and dispensing of medication. It is part of the broader implementation of information standards for medication transfer in the Dutch healthcare system. The guideline covers several aspects of the medication process, including medication prescribing, lab values for medication, and contra-indications and allergies. Its purpose is to contribute to implementing the quality standard 'Guideline for transfer of medication information in the chain' in the Netherlands (NEN, 2022b).

The following NEN standards focus on ensuring medical data's confidentiality, integrity, and availability: NEN7510, NEN7512, and NEN1713. To start with NEN7510, focusing on information security (NEN, 2020), and thus affect the security (1) layer. Guidelines are provided to protect the sensitive personal data of patients. The standard aims to ensure healthcare data's confidentiality, integrity and availability. NEN7510 covers risk management, access control, incident management, physical and environmental security, and employee awareness to establish and maintain information security management to identify and address security risks effectively. Practically, NEN7510 outlines the following activities: conducting risk assessments, establishing access controls for sensitive data, encrypting communication channels, implementing security incident response procedures, and ensuring staff members are adequately trained in information security practices. These activities also show NEN7510 affects the organisation policy (3) layer since agreements must be made on an organisational level. NEN7510 has two extensions: NEN7512 and NEN7513. Organisations can receive a certification for NEN7503 and NEN7510, but not specifically for NEN7512 and NEN7513 (QSN, n.d.). However, the guidelines are still relevant for supporting the security layer even more.

- NEN7512 specifically addresses the secure exchange of medical data *between HCPs*. The standard sets guidelines and requirements for protecting personal health information during transmission and storage. NEN7512 emphasises the importance of confidentiality, integrity, and availability of health data, especially when shared electronically. The standard also covers authentication, audit logging, and data retention. By complying with NEN7512, healthcare organisations can ensure that patient information is securely exchanged between HCPs, reducing the risk of unauthorised access or data breaches and enabling efficient and effective healthcare coordination and collaboration (NEN, 2022a).

- NEN7513 is an extension of NEN7512, focusing on the secure messaging of medical data *within healthcare organisations*. It provides guidelines for the secure exchange of information within a single organisation, covering aspects such as electronic patient records, electronic prescribing, and digital referrals. It sets access controls, encryption, user authentication, and audit logging requirements. The standard also addresses patient consent, data retention, and incident management (NEN, 2018).

MedMij
Foundation MedMij is a Dutch non-profit organisation that aims to facilitate secure and standardised health data exchange between patients and HCPs. MedMij (n.d.) provides a technical framework and standards that securely enable HCPs to share health information with patients through PGOs. Foundation MedMij aims to empower patients to have more control over their health data and to support them in making informed decisions about their health. By allowing patients to access and share their health data with their HCPs, MedMij aims to improve the quality of care and make it more patient-centred. MedMij also works closely with HCPs, software developers, and other stakeholders to ensure that its technical framework and standards are up-to-date and meet the needs of all parties involved in the health data exchange. Through its efforts, Foundation MedMij is contributing to the ongoing digital transformation of the healthcare industry in the Netherlands. When providers of PGOs adhere to these agreements, they are authorised to display a MedMij label. MedMij sets high standards for these PGOs. The goal is that patients who want to can collect, manage, and share health data using a self-chosen personal health environment that meets the requirements. Since MedMij focuses mainly on improving the care process from the patient perspective, it directly affects the care process (4) layer. The solutions proposed for adjusting the care process might indirectly affect other layers.

OPEN program
The OPEN (2023) program is a collaborative effort by important organisations within first-line healthcare, including *Landelijke Huisartsen Vereniging* (LHV), *Nederlands Huisartsen Genootschap* (NHG), and InEen (an association of organisations for first-line healthcare). The program was developed in response to the legal requirements outlined in the first part of Dutch privacy legislation and the Mental Health Act (Wvggz, Dutch: *Wet verplichte geestelijke gezondheidszorg*), which aim to promote the secure and efficient exchange of patient information between HCPs (Rulkens et al., 2014). The OPEN program has established system baseline requirements in response to the *Online access to the H-EPD by the patient* guideline. Specifically, the program aims to make patient data from the H-EPD available online in a user-friendly manner for both HCPs and patients. It enables patients to use their data for consultation preparation, online requests for repeat prescriptions, and e-consults. Additionally, the program seeks to enable HCPs to receive, review, and store patient-generated data, such as self-monitoring results and responses to consultation preparation questions, in a user-friendly and structured manner within the H-EPD. The OPEN program's development principles emphasise the importance of adapting to the needs of HCPs, quick implementation of digital information exchange solutions, promoting patient autonomy, and creating regionally tailored solutions that comply with relevant privacy legislation. Overall, the OPEN program represents a significant step forward in promoting the secure and efficient exchange of patient information in Dutch first-line healthcare, and its development principles ensure that it remains adaptable to the changing needs of HCPs and patients alike. The ideas of OPEN are equal to this study. Focusing on the care process (4) for HCPs and patients as the most essential layer, including agreements that should be made on the organisational policy (3) level.

G-Standards
G-standards (Dutch: *Geneesmiddelen-Standaarden*) are introduced by KNMG (2022). The G-standards, introduced by KNMG, are guidelines and standards for electronic communication in healthcare. These standards cover various aspects of digital information exchange, including medical records, prescriptions, referrals, and lab results. The G-standards aim to ensure the secure and standardised exchange of medical information among HCPs, institutions, and systems. They recommend data formats, communication protocols, security, and privacy protection. The G-standards also address patient consent, identity management, and interoperability between healthcare systems. The G-standards affect the information (5) layer by providing standards to apply; the indirect layer would be the security layer. But since, in this study, the G-standards are considered as information support, the information layer is seen as the directly affected layer.

NHG Terminology
Nederlands Huisartsen Genootschap (2023) provided terminology content for healthcare systems, documented in a specific register. Referred to as the NHG tables, these tables specify which terminology should be utilised within GP practices. The tables vary from, for example, *ICPC codes* for symptoms and diagnoses to *Diagnostic Determinations*, including laboratory determinations and physical examination. These tables support the information (5) layer by creating more generic information storage. The NHG tables can be incorporated into the design to promote clarity for users and complementors of the platform considering the communication.

HL7
HL7 (Health Level Seven International) is a global organisation that develops and publishes a range of standards for exchanging, integrating, sharing, and retrieving electronic health information. The HL7 terminology standards provide a common language for communicating clinical and administrative data across various healthcare systems and platforms, ensuring interoperability and consistency in health information exchange. These standards cover various areas, such as clinical document architecture, laboratory results, medications, and allergies. Fast Healthcare Interoperability Resources (FHIR) is critical in facilitating the efficient and accurate exchange of health information, ultimately improving patient care and outcomes (Nictiz, 2023). Why FHIR? It is suitable for mobile technology and linking different applications and devices. It has building blocks that align well with the Dutch healthcare information building blocks (Zibs, Dutch: *Zorginformatie bouwstenen*), it provides robust support for existing terminology,

there is excellent documentation available and a large international community, open-source tooling is available, e.g. application development, developers have a short learning curve. They can therefore start building quickly (MedMij, 2021).

Considering the Zibs, Nictiz (2022b) provided the latest version of the Zib publication. This document comprehensively describes all information standards per Zib and data cluster. These standards must indeed be implemented within the architecture, but this pertains to detailed work. Providing notifications within the architecture regarding the relevant Zibs applicable to the components may be worthwhile.

3.4. Conclusion Chapter 3

Chapter 3 contributes to answering the first sub-question: *Which known requirements related to a PBIS in Dutch first-line healthcare should be considered?*. The environmental analysis has provided insights into multiple aspects of this study.

Firstly, the result identifies the key players within the scope of this thesis, namely HCPs, patients, and insurance companies. While the patients and HCPs serve as the primary users, including health insurance companies, is also essential due to their relevance in financially supporting the patient-HCP relationships. However, the search results indicate that no specific requirements are found in the existing literature regarding the perspectives of HCPs and patients concerning a PBIS ecosystem. The perspectives of HCPs will be researched in Chapter 4, since it is expected they can participate more easily directly in this study. Despite the direct participation of the patients is not within the research limitations, the found patients' perspectives based on values as discussed in Section 3.1.3 will be included in elicitating requirements.

Contrarily, general architectural requirements have been established for IS experts. They will not be directly incorporated into the design since this study focuses on addressing the unique needs of the patients and HCPs, emphasising their perspectives and experiences. The requirements will, however, be used for evaluating the design resulting from a comparison between the designed architecture and the IS experts' requirements.

Secondly, the relevance of interoperability layers is highlighted. As discussed in Section 3.2, these layers serve as a means to categorise statements that support IT infrastructure design. The horizontal layers can be customised differently to accommodate new technologies. This research will engage GP practice and pharmacy employees to gather valuable input for these layers. Their input will inform the configuration of these layers. By aligning the goals of these layers as proposed by Nictiz (2022a), a system can be designed that seamlessly fits within the interoperability layers for healthcare IT systems, which is the primary focus of this research.

Each layer of the model is subject to different requirements. These requirements are derived from documents and systems provided by legal institutions and organisations, showing both public and private sectors are concerned with the healthcare sector and its IT systems' implementation. The results indicate that the initiatives least focus on the application (6) and IT infrastructure (7) layers. The focus from the stakeholders is primarily placed on security (1), laws and regulations (2), organisation policy (3), care process (4) and information (5) layer. The focus on these layers encompasses aspects of safety and care processes. The attention given to the layers related to information, collaboration, and other areas is confirmed by various initiatives. It shows many involved parties in improving and assessing these layers, limiting the flexibility of decision-making considering those layers. The fewer documents for the application (6) and IT infrastructure (7) layers can suggest that these layers have more flexibility in decision-making or less complexity than the others.

Concluding the environment analysis for answering sub-question 1, the following can be stated.

- There are no specific requirements considering a PBIS from the perspective of HCPs and patients yet; those are researched in this study;
- The requirements following IS experts' perspectives will be considered to evaluate the design resulting from this study;
- Deciding on the relevance of documents is done by connecting them to the interoperability layers from Nictiz (2022a);
- Legal institutions provide laws affecting the security, organisation policy, care process and information layer;
- Organisations provide further standards, guidelines and initiatives for all layers;
- The application and IT infrastructure layer are least mentioned in the assessed documents, indicating more flexibility for the design;
- The organisation policy, care process, and information layer are most mentioned in the assessed documents, indicating more limitations/less flexibility but also more relevance;
- The security layer is only legally supported, indicating the least flexibility and the most restrictions.

4

Requirements Engineering Process: Elicitation and Analysis

This Chapter elaborates on the processes intended to contribute to valuable requirement engineering. First, preliminary research was conducted, including expert talks, a focus group, and two semi-structured interviews. Section 4.1 provides the approach and results of the preliminary research. The preliminary research led to a set of statements assessed on a bigger scale by launching a survey. Section 4.2 discusses the survey design and Section 4.3 the quantitative and qualitative results of the survey. The result of this Chapter is a list of requirements gathered by field research.

4.1. Preliminary Research

The requirement engineering process started with preliminary research. By discussing the subject of interoperability between pharmacies, GPs and patients with field experts, the core of the relevant needs became clearer, presented in this Section. Three preliminary research activities have been conducted to familiarise with the system and gather information and a direction for opinions. Since the requirement engineering process is positioned in the relevance cycle in the design cycles from Hevner (2007), applying preliminary research contributes to a more suitable design.

4.1.1. Respondent Recruitment

This section discusses the relevant outcomes of the *field expert talks*, the *focus group*, and the *semi-structured interviews*. Table 4.1 shows all participants involved in the preliminary research. As seen in Table 4.1, most of the participants had a lot of years of experience in their current job position. Considering IE1 and IE2, the category years of experience was neglected since they are consultant health and ICT specialised in interoperability following the layer model of Nictiz (2022a), which was introduced in 2022. No GPs, PHAs, and POHs were involved in the preliminary research, even though they are included in the scope.

Table 4.1: Overview Participants Preliminary Research.

Interviewee	Job Position	Years of Experience	Research Activity
IE1	Consultant Health and ICT	1 year	Unstructured Expert Talk
IE2	Consultant Health and ICT	1 year	Unstructured Expert Talk
PH1	PH	22 years	Focus Group Session
PH2	PH	18 years	Focus Group Session
GPA1	GPs' Assistant	17 years	Focus Group Session
GPA2	GPs' Assistant	20 years	Semi-Structured Interview
PH3	PH	24 years	Semi-Structured Interview
PH4	PH	19 years	Unstructured Expert Talk

The recruitment of participants involved a series of steps to ensure an adequate sample. During the recruitment process, the healthcare domain's workload, outlined in Chapter 1, became a reality. Many potential participants cited personnel shortages and busy periods as reasons for their limited availability. Consequently, additional, unplanned recruitment measures were implemented. Initially, the plan involved recruiting participants through LinkedIn, utilising both the researchers' personal network and the Sanday channel. The focus group was introduced by the researcher based on a scheduled moment, three weeks in advance. However, the response to the LinkedIn invitation was modest, with only four participants indicating their interest, of which one of those participants subsequently cancelled a few days before the session. Two additional recruitment steps were undertaken to ensure a sufficient number of participants for the focus group session. A recruiting call session was organised, and the researcher contacted the Sanday newsletter email list, requesting interested individuals to contact the researcher if they were

willing to contribute to the research. This provided some response for further research, but the focus group was still held with only three participants.

After the focus group was held while keeping the limitations in mind, the researcher attended a pharmacy fair: the Mosadex Experience in Utrecht, The Netherlands. During this day, hundreds of PHs and PHAs attended the Mosadex Experience to gather and inspire each other with the current developments in pharmacy. The researcher spoke to many visitors and prepared a QR code-accessible survey, including a graphic explaining the research (Appendix E) and the option to leave an email address behind. These participants were invited to fill in the survey.

4.1.2. Unstructured Expert Talk: Interoperability Expert

First, to get a proper idea of the field of interoperability, the term *interoperability* is discussed with two experts in the interoperability field, of which one focused on interoperability in first-line healthcare specifically, while the other expert focused on interoperability more generally in healthcare systems. The most important findings of the talk with field experts on the term interoperability for this study are listed below.

- The term interoperability should be defined clearly since people use it differently and don't exactly know what they're talking about;
- The interoperability layer model of Nictiz (2022a) is mainly being used by lots of organisations in first-line healthcare to assess and improve their digital infrastructures, rather than create them;
- To HCPs, interoperability is mainly understood as the information exchange supporting a care process;
- They outlined the importance of medication transfer (Dutch: *medicatieoverdracht*) and eTransfer (Dutch: *eOverdracht*), respectively referring to medication files and patient files;

This meeting was enlightening in the sense of using interoperability in a more practical way, considering the context of Dutch first-line healthcare and especially the perspective of HCPs.

4.1.3. Focus Group: Setup and Results

By engaging participants in an interactive discussion, a focus group facilitates the exploration of various viewpoints and allows for the extraction of insights from each others' responses (Greenbaum, 1998). The collaborative approach helps to overcome the limitations of individual perspectives and enables a deeper understanding of the complexities involved in the setting. The comprehensive setup and outcomes of the focus group applied in this study are shown in Appendix D. Whereas 1-on-1 interviews are more in-depth, a focus group evoked participant interaction. That makes the results interesting because this interaction can also be compared to the population. The goals of qualitative research, described by Moser and Korstjens (2018): (1) exploration and discovery, (2) context and depth, and (3) interpretation, are taken into account in formulating the focus group goals. The following three goals for the focus group are based on several directions described by Greenbaum (1998).

1. Use of the system → What do the interaction and use of systems look like now?;
2. Attitude towards the system → What do they think of how this is going now?;
3. Idea generation → How do they envision the future?

Where goals 1 and 2 mainly focused on what the current situation is, supporting the answer of sub-question 1, goal 3 focused on the future needs considering the collaboration, supporting answering sub-question 2. The focus group results in Appendix D are used to draw conclusions following the three goals formulated above. The findings of the focus group that are relevant for conducting the survey, to assess the insights on a bigger scale, are referred to as FF[number] (Focus group Finding).

Conclusions Current Usage
At first, the results show that pharmacies and GP practices are still at different levels of innovation, technology and cooperation with other HCPs. The opportunities to share prescriptions, lab values, and validation requests strongly depend on the organisations' systems. The prescription, lab values and validation requests (Dutch: *fiatteringsverzoek*) can be seen as *hard* medical information, which is straight to the point and highly structured. The insight that this is depending on the organisation's system provider, is found interesting for this study. Researching these information-sharing aspects would not be of great value for the entire healthcare system, since it depends on the system provider and IT specialists utilising the opportunities. The finding does outline the challenges in implementing new technologies in the current system, which will be reflected on later in Chapter 8.

Secondly, regarding PHs taking on more responsibilities, an interesting insight emerged regarding efficiency. Many PHs believe handling additional requests requires more time (Interviewee PH1). However, PH2 has a different perspective, suggesting that assuming more responsibilities can actually improve efficiency within the practice, which PH1 did acknowledge afterwards. On the other hand, the interviewees think that GPs should open up on passing on responsibilities to pharmacies. Since the focus group participants mentioned different opinions on this aspect, this is considered valuable for the survey statements (FF1).

Furthermore, the results show that the role of an assistant in a healthcare organisation differs within participants' GP practices or pharmacies. To get a greater insight into the level of responsibilities and involvement of assistants, this is considered for the survey as well (FF13).

Conclusions Attitude
The attitude towards digitisation in first-line healthcare brought up a discussion about the effect of digitisation on the concurrent position of the organisation, mostly considering the effect on the number of patients that will get lost when organisations can

connect to the system more easily due to digitalisation (FF2). Although PH2 did stress the importance of a business-minded perspective, stating that the position of the pharmacy will then be based on speed, patient relationships, and good connections, the critical reaction to the digitisation by PH1 and GPA1 did indicate that this is included as an interesting topic for a statement.

The discussion about local and/or national perspectives did not expand greatly during the focus group session, but the interoperability policy layer would positively be supplemented by insights into the perspectives on agreements locally/nationally (FF3) and is therefore still included as a relevant area for the survey.

Conclusions Idea Generation
Efficiently gathering the lab values, meaning that they will only be gathered when the lab values change and automatically be updated in the system, is the first desire that came up during the idea generation phase. However, it became clear this development is already considered in the programme of Medication Process 9.0, and reinventing the wheel is not seen as valuable insight by PH1 (FF4). Therefore, this is not considered for developing further perspectives.

PH2 introduced communication regarding care around the medication process. This led to an interesting discussion. Both PH1 and GPA1 agreed on the importance of improving communication around the medication process since this is not regulated and it results in many hurdles for HCPs. They highlighted the importance of documenting it for the short- and long-term. The need for this perspective should however still be validated on a bigger scale, and thus it should be considered for the statements (FF5). Some ideas were mentioned about creating this digital communication tool. It can enable pharmacies to have more contact with the GP and patient about the medication process, to support a network-based healthcare system (FF6), the communication should be in the current system (FF7), the communication tool can replace email and phone calls (FF8), and the communication about the care can be documented code-based (FF13). Since these ideas resulted from the brainstorming session during the focus group by only three experts, it is found important to assess them on a bigger scale in the survey.

The idea also brought some discussion points to the surface. First is the fear of a continuous, chaotic stream of messages (FF9). Also, the trustworthiness of the input of the patient was clearly questioned by PH1 (FF10). Following the discussion on patient involvement, further insights were gathered regarding patient involvement. A discussion arose on the personal decisions of patients, and whether these should be directly communicated with HCPs (FF11). Additionally, the patient's memory is questioned, resulting from insignificant medical knowledge (FF12).

Finally, the involvement of medical specialists as other HCPs in a treatment relationship with the patient was mentioned. The question does arise whether the communication should be accessible to all of the HCPs with a treatment relationship. What if the communication is always accessible to the patient (FF14)?

Focus Group Reflection
The setup of this focus group was different than the focus group was supposed to be following the literature. Since usually 6-10 people are invited and expected to result in the desired effect of a focus group (Greenbaum, 1998), the unavailability of two other GPs and another PHA can be considered a limitation of the results. However, due to the following three interpretations, the results are still considered valuable insights for statement development. (1) The respondents clearly delved into each other's perspectives and insights, which then sparked further comments from another participant. (2) The outcomes from the focus group will be subjected to additional examination via a survey, which positions the focus group as a preliminary step for the survey. (3) The focus group participants' enthusiastic participation and active engagement during the session highlighted their ability to connect with the discussed topics.

4.1.4. Statement Development

Based on the insights gathered during the focus group, the first version of the statements was created and can be found in Appendix F in Table F.1. The requirements are categorised based on the interoperability layers from Nictiz (2022a). Figure 4.1 shows the layers, adjusted specifically for this study, showing where the opportunities are regarding input from respondents. The coloured layers are the layers for which the respondents could be able to provide input. The black layers are not directly dependent on the perspectives of the respondent groups (GP, GPA, POH, PH, or PHA). The IT infrastructure layer is not considered in the statements for the survey. The IT infrastructure is actually the new technology that is being developed or researched. When two organisation units are involved in an IT infrastructure enabling interoperability, the top four layers are the layers that matter to the end-users (Nictiz, 2022a). On the law-and-regulation and security layer, no input is necessary either, since it is already committed.

Statement Discussion by Semi-Structured Interviews
To improve the survey setup regarding accuracy and comprehensibility, the statements are initially discussed with two experts. Appendix F shows the setup and results of the semi-structured interviews with PH3 and GPA2, of which the conclusions are discussed following. The findings of the semi-structured discussion interviews relevant for adjusting the statements for the survey are formulated as DF[number] (Discussion Finding).

To improve comprehensibility, both respondents indicated the importance of providing an example situation regarding the *soft* information about the medication process and the care around the medication process since they valued the explanation of the researcher (DF1). Furthermore, the discussion led to the change of statement CP1, namely: the change from *more* to *easier* communication, since both outlined communication is already happening through phone or email. This takes a lot of time and is insufficient, therefore *easier* communication would be more suitable. Moreover, HCPs are not always able to pick up the phone for a quick discussion due to consults and other planned activities, and the conversation is never documented properly (DF2).

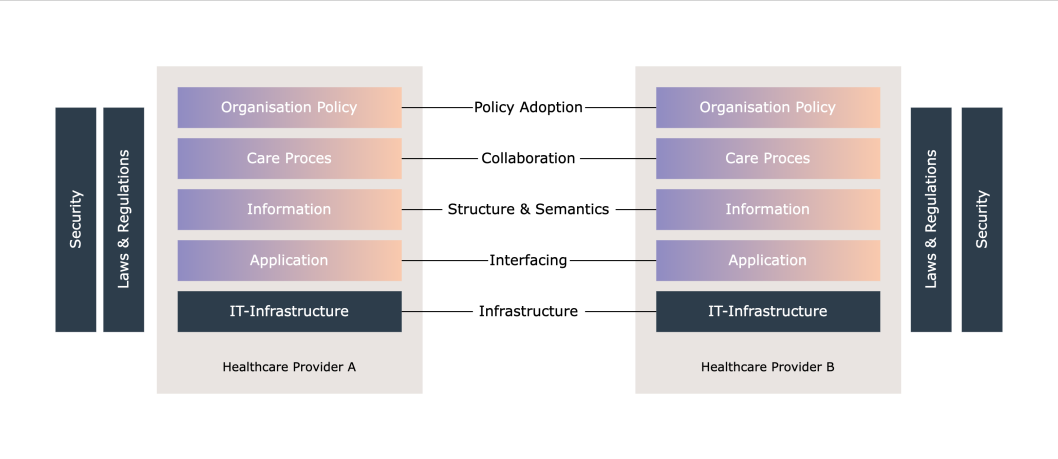


Figure 4.1: Interoperability Layers Showing the Input Possibilities per Layer (Nictiz, 2022a).

Furthermore, the discussion of statement P1 with PH3 resulted in neglecting P1 for the survey. A more digital solid system for first-line healthcare will make it easy for other PHs to plug in. This might result in more Internet pharmacies that are easily accessible to patients as a substitute for offline pharmacies. However, the respondents in the focus group and PH3 outlined the importance of personal care, the entrepreneurship of the PH, and the business mindset they have and are able to express. PH1 showed concerns about this digitalisation during the focus group. PH2 refuted it by discussing the importance of the business and going along with the time, which PH3 also mentioned. Former statement P1 is thus rejected (DF3).

Also, statement CP2 has been found too generic. The research should focus more on the real-time input of the patient in the communication. The patient should be able to communicate their decisions. The current possibilities for a patient to provide information about changes in their medication process are (1) call or send an email, (2) communicate when visiting the GP practice or pharmacy, (3) notify during the repeat recipe process (see quote below) or (4) do nothing. Considering these possibilities, the statement should therefore focus on of whether the GP and PH want constant availability for patients to leave their message (DF4).

> *The patient calls for a repeat recipe and the assistant notifies that the patient should have needed the prescription already a couple of months ago. Then the assistant rings a bell and notifies the GP.* (Interviewee GPA2)

The open input in the semi-structured interviews for each statement has been received as very valuable. Therefore, the survey should also provide an option to provide feedback on the statement (DF5). Furthermore, the discussion highlighted the differences between assistants' involvement. It depends on the pharmacy or GP practice the assistant is working with and how they set up their practices (DF6). Finally, the discussions around statements CP4 and CP5 did not show any consent about who wants to process requests from whom, which is, interesting to dive into deeper (DF7).

Expert Talk with PH4
After discussing the statements, an additional unstructured expert talk with PH4 was conducted to validate the findings and bring-ing new insights. The talk, of which the summary is provided in Appendix G, brought the following insights. First of all, neglecting statement P1 was validated by PH4. PH4 also shares the perspective of PH3, indicating that digitising the healthcare domain needs courage and should not be held back by HCPs with resistance to digitalisation. Considering the socio-technical context of this research, PH4 proposed to focus on the positive thoughts for developing a digital intervention rather than listening to the con-cerns on digitisation. This will be reflected in Chapter 9, but is neglected for now. Furthermore, patient involvement was namely discussed resulting in the validation of the following. (1) Patients need to be better informed (about medication). (2) Improving the understanding of the patient's condition needs more up-to-date communication.

4.2. Survey Design and Methodology

The validation of the statements constructed in preliminary research is done by conducting a survey. As already discussed in Chapter 3, the target groups are GPs, GPAs, POHs, PHs, and PHAs. The two main goals of the survey are as follows.

1. Validate the statements that have aroused during the preliminary research;
2. Generate new opinions and ideas.

Generating new opinions and ideas will be difficult since the survey will be filled in digitally without interaction. To enable this goal, an answer box is included for each requirement or set of requirements. The assessment is validated by a Likert scale assessment, enabling analysis based on the mean and standard deviation.

Literature shows a number of possible analysis procedures for Likert scale surveys. Two directions of interpreting the results of Likert data or introduced by Boone and Boone (2012), namely Likert-type data and Likert-scale data. The difference between

Likert-type and Likert-scale is the following. Likert-type items are assigned values that indicate a ”greater than” relationship, although the specific degree of magnitude is not implied. As a result, Likert-type items are categorised within the ordinal measurement scale due. Likert-scale on the other hand, is analysed at the interval measurement scale, where the order of the variables, as well as the differences between these variables, is known (Boone & Boone, 2012). Their suggestions on analysing the data are shown in Table 4.2.

Table 4.2: Suggestions for analysing Likert-type data and Likert-scale data. (Boone & Boone, 2012).

	Likert-type	**Likert-scale**
Tendency	Median or Mode	Mean
Variability	Frequencies	Standard Deviation
Associations	Kendall tau B or C	Pearson's *r*
Other	Chi-square	ANOVA, T-test, Regression

The statements are being assessed based on a 6-point Likert scale and the option not to assess the statement (due to lack of knowledge/incentive), shown in Figure 4.2. Considering the scale, it is assumed the respondent could interpret the scale as a numbered scale (1 to 6), and the results in this study will therefore be assessed as an interval scale (Likert-scale data). The scale enabled participants to show how strongly they felt toward a statement.

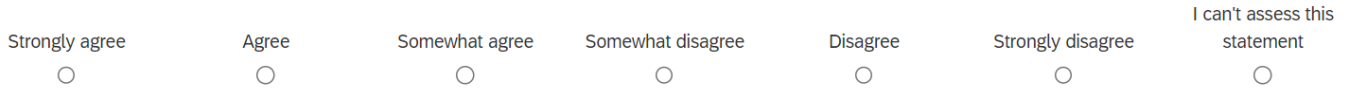


Figure 4.2: Answer Options for Statement Assessment in the Survey.

To provide additional insights relevant to evidence-based policy development or implementation strategy, demographic information is added to the survey. In this way the results can inform decision-making on the most valuable strategy, answering questions like: Who do we need for further discussion? What target groups have a more positive perspective? Based on what demographic variables do opinions depend on? Section 4.2.2 provides the selection of additional demographic variables.

4.2.1. Formulating Survey Statements

Table 4.3 shows the final version of the statements for GPs specifically, resulting from the findings in the preliminary research (column: Findings). For the development of the final statements to be assessed in the survey, it is important the statements are unilateral, meaning only one interpretation and one goal is related to one statement. Some statements are divided into two (or more) statements to achieve this.

Variety within Statements

The statements related to the *policy*, *information*, and *application* layers in the survey are indifferent toward the participants. However, when it comes to the *care process* layer, slight differences are created in how the statements are presented, based on the respondents' discipline. The responses to statements CP1, CP3, and CP4 in the *care process* layer vary depending on the job position or job type. For instance, CP1 depends on the job position: respondents responding from a POH discipline see four options (GP, GPA, PH, and PHA), while other groups only see three options. To maintain consistency and coherence in the survey responses, the option related to POH is excluded for respondents who did not hold that specific role. This decision is based on the functional interpretation of a POH, whose tasks encompass a combination of tasks performed by GPs and/or GPAs. Therefore, PHs and PHAs had the option to choose from the available alternatives instead of selecting POH. The same principle applies to CP4, where internal communication is not relevant within the scope of this statement. CP4 primarily focused on communication with the patient and other healthcare organisations, such as GP, GPA, and POH for PHs/PHAs, and vice versa. Another statement that varied depending on the organisation type is CP3. GPs, GPAs, and POHs received this statement from the perspective of GPs, which implies transferring responsibilities in the care process. While, for PHs or PHAs, the statement reflected the perspective of *taking over* responsibilities. In summary, the care process layer statements are adjusted to show variations in presentation and interpretation based on the respondents' discipline. CP1 and CP4 offered different options depending on the job position, excluding the POH option for respondents who do not hold that role. CP3 differed for job type, with GPs, GPAs, and POHs viewing it as transferring responsibilities, while PHs and PHAs perceived it as taking over responsibilities.

Enhancing Comprehensibility

The statements are formulated from the I-perspective to improve the statements' comprehensibility. Insights on the tone-of-voice of the target group have been retrieved by participating during the Mosadex Experience and by organising meetings with the marketing team of Sanday. To improve a general understanding of the subject, also resulting from finding DF1, the text in the following box was provided to the respondent before moving on to the statements.

"Before you continue, I want to explain the following. Please read this carefully so you know what the statements are about!

The statements will often include the following: *communication regarding care around the medication process.* This is about the communication between the pharmacy, GP practice, and patient regarding personal developments, preferences, and agreements regarding the care around the medication process (taper process, personal patient preferences, brief consultations about a patient, etc.). This does not involve prescriptions. A situation as an example:

A patient takes medication three times daily but does not like it. The patient takes the medication only twice daily and informs the pharmacy when he picks up his medication. The PH/assistant chatted with the patient about the reason and the situation. The PH/assistant gives the adjusted medication and adjusts it in the system. The results of the brief chat are actually relevant to the attending physician as well. So the PH calls the physician to discuss it. Neither of them documents the outcomes of the conversation, but they are aware of the situation because they called each other.

You will soon be shown statements that deal with communication regarding care around the medication process. You will be asked to rate these by choosing within the range *strongly agree* to *strongly disagree* If you cannot rate the statement, choose *I can't assess this statement*. Below the statement is an input field where you can leave comments. This is not obligatory, but your explanation is very valuable for the research!"

Balanced Statements
Furthermore, a subset of the statements in the survey is phrased negatively. This choice was intended to encourage respondents to remain attentive and not simply provide automatic responses. By incorporating a balance of negatively formulated statements, specifically statements I2a, I2b, and A1, it is anticipated that respondents will generally answer these questions with higher levels of agreement. If respondents assessed these statements in the opposite direction, it indicated a potential lack of reliability. Such instances were acknowledged in relation to the provided clarification following the assessment. The decision to include only a few statements for validating trustworthiness is based on the understanding that positively formulated statements are generally more comprehensible, which is a crucial factor in survey research. The + and - symbols in the column indicate whether the statement is formulated positively or negatively.

Statement Sequence
The sequence of the statements in the survey is different than in Table 4.3, which follows the Nictiz layer sequence. The sequence of the questions in the survey can influence the answers of the respondents. It is chosen to start the survey with the statements regarding the care process, since it was expected to ensure a recognition point for the participants, resulting in a warming-up effect towards the respondents.

4.2.2. Selection of Demographic Variables

To obtain insights into the effects of demographic variables on the assessment of the statements, these were also included in the survey. This section shows which demographic variables were included, which scales were used to answer those demographic variables, and why they were chosen to be relevant. The demographic characteristics provided categorical values for the data analysis. Table 4.4 presents the questions asked to each respondent. Q1 and Q2 served to classify respondents into the appropriate groups. Additionally, including the PH-holding GP category is important, as numerous conversations with PH-holding GPs took place during the Mosadex Experience. Excluding them would have resulted in missed opportunities for potential respondents.

Table 4.4: Demographic Questions: All Respondents.

Q1: At which organisation type do you work?	**Q2: From the perspective of which discipline are you completing this questionnaire?**
() GP	() GP
() Pharmacy	() GPs' Assistant
() Pharmacy Holding GP	() PH
	() PHs' Assistant
	() Practice Supporting GP (POH)
Q3: How many years of experience do you have in Dutch first-line healthcare?	**Q4: In which municipality is your practice located?**
() 0 to 1 year	Drop down menu with all Dutch municipalities.
() 1 to 2 years	
() 2 to 5 years	
() 5 to 10 years	
() 10 or more years	

Table 4.3: Statements Survey (GP).

Nr	+/-	Findings	Statement
Organisation Policy Layer			
P1	+	FF3	I want to make national agreements on the communication regarding care around the medication process.
P2	+	FF3	I want to make local agreements on the communication regarding care around the medication process.
Care Process Layer			
CP1		FF5, FF6, DF2	In terms of care around the medication process, I would like to consult in an easier way with ...
CP1a	+		... PHs
CP1b	+		... PHs Assistants
CP1c	+		... GPs' Assistants
CP2	+	FF10, FF11, FF12, DF4	I want patients to be able to contact the GP practice and/or pharmacy directly about their own choices around the medication process.
CP3	+	FF1	I am quite willing to transfer more responsibilities to the PH/assistant regarding care around the medication process as a result of digitisation.
CP4		FF13, DF7	I am adequately involved in the care around the medication process, ...
CP4a	+		... so I want to process requests from the patient.
CP4b	+		... so I want to process requests from the PH.
CP4c	+		... so I want to process requests from the PHs' assistant.
Information Layer			
I1	+	FF13	I want the information exchanged about care around the medication process to be linked to certain codes.
I2		FF10, FF11, FF12	I want patient input on developments within his/her medication process ...
I2a	-		... not always to be adopted.
I2b	-		... not always to be adopted, because the patient is not always trustworthy.
I3	+	FF9	I would like to be able to decide whether communication notifications come in real-time in the system or not.
I4	+	FF5, FF6	I would like to receive information from the patient about his/her personal developments regarding the medication process easier (medication change due to side effects/no result/other reason).
I5	+	FF14	I want communication regarding care around the medication process to be available to the patient and those who have a treatment relationship with the patient.
I6	+	FF14	I want some communication regarding care around the medication process to be available *only* to HCPs.
Application Layer			
A1	-	FF7	If a communication tool is going to be added for communication regarding care around the medication process, I don't want it in the same system we already work in.
A2	+	FF7	I prefer using as least as possible systems during my working day.
A3	+	FF7, FF8	I am quite willing to use an additional system for communication regarding care around the medication process if it would replace phone calls and mail contact.

Discussing the respondents with a marketing manager at Sanday resulted in adding the GP supporter (POH, Dutch: *Praktijkondersteuner huisarts*). A POH is an employee within GP practices, able to provide valuable information. Questioning the job position provided options for targeting and insights based on the target group.

The insights in terms of the number of years of experience were expected to be valuable in terms of perspectives regarding for example healthcare digitisation. Understanding the effect of years of experience within the industry can support strategy. Long-term employees may have a greater need for change because they have been dealing with the same issues for a long time, or they may not need change because they feel a connection to existing procedures and are averse to change. To map the years of experience, the categories proposed by Centraal Bureau voor de Statistiek (2018) are used.

Vermeij et al. (2021) researched four different types of municipalities for policy purposes. The differences between municipalities are considered using these four types of municipalities. Since the respondents were not expected to know the municipality *types*, they were asked to fill in their municipality, which was later coupled with the right municipality type during the data preparation phase. Insights in differences between municipality types were expected to be interesting for designing implementation strategies.

Table 4.5 and 4.6 show the specific demographic question asked to GPs, GPAs and POHs, and PHs and PHAs. Langelaan et al. (2018) uses the categories in Q6 as a characteristic of GP practices. The type of practice was expected to affect their perspective on collaboration needs. Employees in solo practices were expected to have a less collaborative character because their practice does not express that character either. The selection and construction of Q5a/Q5b and Q7 resulted from brainstorming with a marketing manager at Sanday. The Standard Practice, equal to 2095 patients, is the standard measurement for the size of a GP practice (Kleijne, 2017). Furthermore, the collaborative character of a GP practice was expected to be expressed by the care

group they are affiliated with. Most GP practices are affiliated with a care group, which supports collaboration among other HCPs. Pharmacies are not connected to any care groups. To maintain consistent data between both parties (size and level of current collaboration with others), consideration was given to posing a similar question to PHs and assistants. However, it was decided to omit the question due to the lack of an objectively comparable aspect for pharmacies. As a result, an unequal number of demographic characteristics was included in validating the responses. This is not seen as problematic, as insights are still gained solely from the GP questions. The categories for the size of the pharmacies (Q5b) were discussed earlier with PHs involved in the preliminary research.

Table 4.5: Demographic Questions: GPs, GPAs, and POHs.

Q5a: What is the size of the practice you're working on?	**Q6: What type does the general practice you work at belong to?**
() 1 Standard Practice	() Solo Practice
() More than 1 Standard Practice	() Duo Practice
	() Group Practice
	() Other, namely: ...
Q7: Does your healthcare group support collaboration with other HCPs?	
() Yes, namely: ...	
() No	
() I don't know	
() We're not affiliated with a healthcare group	

Table 4.6: Demographic Questions: PHs and PHAs

Q5b: How many people use your pharmacy for medications? (hereafter referred to as patients)
() 0 to 8000
() 8000 to 10000
() 10000 or more

4.2.3. Survey Testing

The survey was reviewed through a discussion of content and questions with the first supervisor and a marketing manager at Sanday. During the Mosadex Experience. over a hundred PHAs were contacted, which gave an approximation of the language they would prefer, and also gained insight into their knowledge regarding the systems. The tone-of-voice of respondents was also outlined during the preliminary research since some of the target group participated. The statements are formulated in easy language and focused on one idea. The survey was created using the software Qualtrics, as proposed by TU Delft. The look and feel of the survey can be found in Appendix H.

4.3. Interpreting Quantitative Results

The survey was accessible for ten days. After this, the survey was closed to gather and analyse all results. The results, of which extensive data is provided in Appendix I, will be discussed in this Section.

4.3.1. Data Preparation

At first instance, the Qualtrics data automatically indicated finished surveys. One metadata column, 'Finished', had the possible values: 'False' or 'True'. This could be used as a criterion for adopting the respondent's answers. Some respondents, however, had a 99% progress rate in the metadata column 'Progress'. This was the case when participants did not press the last button. However, the last question was only intended to gather email addresses for the win action and is not used in any analysis. It could be seen that every respondent having 99% progress has filled in every requested question used in the analysis. Therefore, the data rows were included for the analysis if the progress percentage was 99% or above. There were ninety-six respondents with 'Finished' equal to 'True' and ninety-eight with 99% or above. The refined strategy thus led to two more considered respondents. Forty-three responses were designated as unusable for the quantitative analysis. The qualitative analysis, including analysing the clarifications given to the assessment of the statements, does include incomplete surveys. For this study, it could have been interesting to see their clarification. However, the number of completed surveys (ninety-eight) did lead to the conclusion to leave the unfinished surveys totally out of reach due to an expected lack of incentives among these participants.

One participant provided negative clarifications, as evidenced by statements like "Sigh...", creating confusion. Upon closer examination, it became apparent that in another clarification, the respondent mentioned that he/she only proceeded with the survey because it was necessary to access another survey. This clearly indicates that the respondent was not genuinely engaged or invested in this research. Consequently, this respondent was excluded from the analysis and removed from the data set.

Furthermore, as a prerequisite, the respondents were obliged to assess each statement. In cases where a respondent could not assess a statement, they had the option to choose "I can't assess this statement". This approach aimed to minimise the occurrence of respondents answering questions they genuinely did not know the answer to. In that case, the analysis did not consider the assessment for that specific statement. Additionally, it should be noted that there were instances where respondents expressed uncertainty about a statement in the clarification but still provided an assessment, discussed in Section 4.3.3. In such cases, despite their uncertainty, these respondents chose to provide an answer. This assessment was included as this research seeks to gather the opinions of as many HCPs as possible.

Finally, a new categorical variable was created based on the categories included in the survey to find more valuable insights. Respondents answering the survey from the disciplines GP, GPA and POH, were added to the job type group A (GP/GPA/POH), working at a GP practice or PH holding GP practice. Respondents answering the survey from the perspective of disciplines PH and PHA were added to the job type group B (PH/PHA), working at a pharmaceutical organisation.

4.3.2. Quantitative Analysis

Results

The numerical values allow for the application of various statistical tests to measure the central tendency (mean), variability (standard deviation), associations (Pearson's r), and other relevant statistics such as ANOVA, t-test, or regression analysis (Boone & Boone, 2012). The numerical results in this study are shown in Table 4.7. The table shows the mean of every statement, displayed in descending order, already indicating the ranking of the statements by the respondents and the standard deviation. Since not all statements were assessed by all respondents, the number of assessments for each statement is also shown. At first, the results show that all statements are assessed relatively positively, except for I2a and I2b.

Table 4.7: Mean-Based Ranking Statements.

Statement	Mean	n	s
A2	5.26	97	0.82
GPA_CP1a	5.50	18	0.71
GP_CP1c	5.46	28	0.84
PH_CP1c	5.27	26	1.19
CP4b_B	5.27	45	1.12
A1	5.22	93	1.29
POH_CP1d	5.20	5	1.79
POH_CP1a	5.20	5	1.30
CP4c_B	5.11	46	1.02
P2	5.10	92	1.20
GPA_CP1b	5.06	18	0.87
PH_CP1b	5.04	26	1.43
GP_CP1a	5.00	28	1.15
I5	4.96	94	1.05
GPA_CP1c	4.94	16	1.24
I1	4.91	75	1.10
CP2	4.88	95	1.12
CP4a	4.83	96	1.05
GP_CP1b	4.78	23	1.35
P1	4.76	92	1.20
CP4b_a	4.76	49	1.16
PHA_CP1c	4.70	20	1.56
CP4c_A	4.69	51	1.12
I4	4.68	95	1.17
I3	4.66	85	1.21
I6	4.62	89	1.41
CP3_A	4.60	47	1.17
PHA_CP1b	4.55	20	1.54
PHA_CP1a	4.53	19	1.61
CP3_B	4.46	46	1.53
PH_CP1a	4.32	25	1.80
POH_CP1b	4.00	4	2.16
POH_CP1c	4.00	4	2.16
A3	3.61	95	1.69
I2a	3.38	89	1.49
I2b	3.01	92	1.47

Interpretation of the Means

The ranking of the statements based on the means provided insights into the importance of implementing each statement. The numerical scale was based on the categorical scale from *totally agree (6)* to *totally disagree (1)*. Each statement with a mean within 4 (*somewhat agree*) and 6 (*totally agree*) can be considered in the design. The prioritisation of the requirements can be based on the mean, for example: from 3.5 to 4.5 is interpreted as *somewhat agree*, 4.5 to 5.5 is interpreted as *agree*, and means above 5.5 as *totally agree*. Then, a prioritisation method can be applied to provide insights into the level of prioritisation. Prioritising requirements improves the development process of an IT intervention since development teams are supported in decision-making considering adopting or rejecting particular requirements (Ahmad et al., 2022). Ahmad et al. (2022) introduces multiple prioritisation methods. The MoSCoW method can, for example, be used as follows. *Somewhat agree* statements belong to *could*, *agree* to *should*, and *totally agree* to *must*. However, no methods or theories are researched on the translation from a Likert scale to a prioritisation, thus, the prioritisation is not considered further.

The results show that I2a and I2b are rated on average as 3 (rounding down), equal to *somewhat disagree*, which is negative. I2a and I2b assess the trustworthiness of the patient. As discussed in Section 4.2, these statements were formulated negatively in the survey. The assessment of the participants was turned around during the data preparation. Considering the interpretation of the mean of the statements, it indicates that the respondents do not assess the trustworthiness of the patient positively, resulting in the need for considering this in the design.

Assuming the translation of numerical to interpretation within the Likert scale, the assessment of A3 is within *somewhat disagree* and *somewhat agree*, reaching for the latter. A3 assesses the perspectives considering using another system for communication regarding care around the medication process if it would replace phone calls and emails. The results of A3 are further researched and concluded in Section 4.3.3.

Interpretation of the Standard Deviation

The standard deviation (σ) provides insight into the data's dispersion level. A high standard deviation indicates more spread-out data, while a low standard deviation indicates that data is clustered around the mean. In this case, the *sample standard deviation* is calculated since the data represents a population sample. To calculate the standard deviation, the mean of each statement is calculated. For each data point, the mean is subtracted from the assessment of that data point, resulting in a deviation. Then the squared sum of all deviations is divided by n-1. Using n-1 (degrees of freedom of 1) in the denominator when calculating the sample standard deviation is based on statistical principles and is known as Bessel's correction (Taylor, 2019). The reason for this correction is to provide a less biased estimate of the standard deviation. When calculating the sample standard deviation, the variability of

the population is estimated using a subset of the data. Using n-1 instead of n in the denominator adjusts for the fact that I am estimating the population standard deviation based on a sample. Dividing by n-1 instead of n slightly inflates the standard deviation value, which provides a more accurate estimation of the population standard deviation (So, 2008).

Looking at Table 4.7, the standard deviation ranges from 0.71 to 2.16 on a 6-point scale. A standard deviation of 0.71 means that the data points are more clustered around the average mean for that statement. In this case, it indicates that the respondents assess the statement more similarly than in the case of the statements with a standard deviation of 2.16. However, the statements for which the standard deviation is 2.16 only include four respondents, indicating that drawing conclusions about this statement and its statistics is irrelevant.

Following the interpretation of the means as discussed in the previous Section, a difference could indicate that the statement was assessed as *agree* generally, while a data point with a standard deviation greater than 1 can result in an assessment interpretive as *somewhat disagree*. This shows that a high standard deviation can affect the prioritisation of the statements. For these statements, going from the agree side of the scale to the disagree side, it can be concluded the differences indicate that the requirement suffers from disagreement within the population sample. Further research on a bigger scale is needed to improve the insights into these disagreements.

4.3.3. Validation of the Results

The statements' assessment results are validated based on a sample comparison and dependency tests. First, the demographic characteristics in the sample are compared to the values in the population. Then, the relation between the demographic variables and the assessment of the statements is decided by applying statistical tests to the results. To determine the differences for categories with two groups a T-test is performed. For the categories with 3 groups or more, an ANOVA test and an additional Tukey-HSD test.

Sample Analysis
Figure I.1 in Appendix I shows the respondents' demographic characteristics distribution. To obtain insights into the differences and similarities between the sample (results of this study) and the population (real-world figures) , the distributions gathered by the survey are compared with the population. The findings for each of the characteristics are listed below.

- The number of people executing the job positions GP, GPA, POH, PH, and PHA, are respectively (around) 11757 (Batenburg et al., 2022), 35000 (Geit et al., 2022), 4300 (Van Hassel et al., 2016), 6226 (Hogenbirk et al., 2022), and 16500 (Bos, 2022). This results in the following distribution: GP: 15.9%, GPA: 47.4%, POH: 5.8%, PH: 8.4%, and PHA: 22.4%. Looking at the sample distribution, the results show that the number of PH and GP is relatively high, but the number of GPAs is relatively low. The sample does not have a similar distribution for job positions compared to the population.
- Considering the populations' job position distribution: 30.8% PH/PHA, and 69.2% GPA/GP/POH, the results show that the sample distribution (47.4% v.s. 52.6%) does have a weaker difference, but the distribution does fall in the similar direction as the population.
- The number of GP practices, pharmacies and PH holding GPs in the population is distributed as follows: GP: 4874 (Batenburg et al., 2022), PH: 2005 (Hogenbirk et al., 2022), PH holding GP: 400 (LHV, 2021). Resulting in respectively 67%, 27.5%, and 5.5%. The results show comparatively fewer GPs for the sample.
- Assuming that each municipality has comparable numbers of GP practices and pharmacies, the populations' distributions of municipality types are as follows: small-scale: 58.4%, small urban: 24%, affluent residential: 12.9%, and university cities: 4.7% (Vermeij et al., 2021). Respectively 41.2%, 28,9%, 6.2%, and 23.7% in this study do show a higher percentage for university cities. This difference could be declared by the fact that the number of practices and pharmacies in university cities is significantly higher than in other municipalities since one of the characteristics is the high density of people in the municipalities. This is instead speculation. The sample differs from the population.
- Looking at the years of experience, 74.2% for 10 or more years directly stands out. No information about the populations' years of experience per category has been found. This varies too much within each job position. The results can show that people tend to work for a long time in this sector.
- The distribution of types of practices in the Netherlands is as follows: 17.5% solo, 43.8% duo, and 38.7% group (Geit et al., 2022). In the sample of this study, this is 21.6% solo, 35.3% duo and 27.5% group practice, and 15.7% other. *Other* includes 5 HOED practices (Dutch: *Huisartsen onder één dak*), and one null-practice (Dutch: *Vrije praktijk*). HOED practices do have a similar idea as group practices. It could be the case that Geit et al. (2022) did interpret HOED practices as group practices as well, which could declare a relatively higher percentage for group practices.
- The size of a pharmacy in terms of the number of people retrieving their medicines at a specific pharmacy has an average of 8100 in 2022 (Stichting Farmaceutische Kengetallen, 2022). The average of the sample in this study cannot be specifically determined based on the answers. However, the distribution of 0 to 8000: 28.3%, 8000 to 10000: 26.1% and 10000 or more: 37%, does indicate the median being in the category 8000 to 10000. No firm conclusions can be drawn from this, but it does give an indication.
- This also applies to the size of GP practices. The number of practices with having the size of 1 Norm Practice, or more than one, could not be specified precisely.

Concluding, it can be said the sample is not a representative presentation of the population. The findings can, therefore, not be generalised to the population. However, the findings will still provide valuable insights into the respondents' perspectives.

Examining Influential Respondents' Characteristics Applying Statistical Tests

The impact of the demographic variables on the assessment is determined using the significance tests T-test and ANOVA, of which the results are shown in Appendix I. These analyses provide the opportunity to find the effect of a categorical value on the numerical assessments. An example of the hypothesis used to validate the assessed statements based on statistical tests is shown below. The hypothesis is rejected/adopted based on the p-value resulting from the statistical tests. Furthermore, it is important that the sample size is considered an indication of the validity of the differences in the data. The *power* of a statistical test provides an indication of this validity. The conclusion on the validation of the results provides insights into this *power*.

- Null hypothesis (H0): Size GP practice and the assessment of I2b are not related in the sample of the population; The proportions of Size GP practice are the same for different values of the assessment of I2b.
- Alternative hypothesis (H1): Size GP practice and the assessment of I2b are related in the sample of the population; The proportions of Size GP practice are not the same for different values of the assessment of I2b.

Following the hypothesis example for Size GP practice and the assessment of I2b, the T-test is applied since the variable Size GP practice consists of two categories. In this example, if the p-value of the T-test is below the threshold of 0.05, the assessment of I2b depends on the size of GP practice, and the difference between the two groups of Size GP practice is acknowledged in the sample.

A one-way ANOVA test is conducted for the demographic characteristics with more than two categories. A one-way ANOVA test is selected for this study since the relationship between a categorical demographic variable and the assessment of a statement is researched. A *two-way* ANOVA test would include *two* categorical variables and a dependent variable, which is not in line with the goal of the survey analysis. In this case, a p-value below the threshold of 0.05 indicates the unlikeliness of the differences being occurred by chance alone, thus the independent variable (the demographic characteristic) is likely to have a significant effect on the means for a particular statement. However, the ANOVA test does not yet tell which categories do have a significant difference from each other. For each of the Demographic Variable:Assessment pair that has a p-value < 0.05 for the ANOVA test, also a Tukey-HSD test is performed. The Tukey-HSD test runs pairwise comparisons among each of the categories within the demographic variable. It uses an error estimate to find the categories that are statistically different from one another (Bevans, 2022).

Conclusions Analysing the Validation Results

In this Section, additional insights are discussed.

Firstly, since the sample of the population does not have similar distribution as the populations for all demographic variables, the results cannot be generalised to the population. However, the results would still provide interesting insights into the sample of the population. The results of both the T-test and the ANOVA test in combination with the Tukey-HSD test, of which the results are shown in Appendix I, led to significant insights on influential demographic characteristics for some statements, as shown in Table 4.8.

The table shows the statement:demographic Characteristic *pair*, Category 1, Category 2, the means, the numbers of included data points, and the conclusion. Some significant statement:demographic characteristic pairs have been excluded from this table, either since the number of included data points for a category was too low, or due to an undefinable category, documented in Section I.2.1 in Appendix I. Based on the conclusions presented in Table 4.8, the following decisions can be derived, having an effect, considering a mean below 3.5 as *disagree* and above 3.5 as *agree*.

To start with statement A3, testing the acceptance towards an additional system for communication if that system would decrease phone calls and emails. From the results listed below it is concluded that despite the fact PHs are willing to accept an additional system for communication, GPs will not accept it, and thus the design should enable integration within their own ISs.

- The negative evaluation of statement A3 (mean = 2.89) by Organisation Type GP indicates that the additional communication system is not perceived as a viable option for GP practices;
- Significant differences are observed within the Job Position category, specifically between the assessment of GPs and PHs, as well as between GPs and PHAs, further supporting the notion that GPs do not favour an additional system as a substitute for communication. The mean score of 2.37 signifies a clear disagreement among GPs regarding this matter;
- Furthermore, the Job Type analysis for A3 confirms these findings, taking into account GPA and POH as well. Although the mean score of 2.86 is slightly higher, it still falls within the disagree spectrum, suggesting that GPs, GPA, and POH are not in favour of the additional system as a communication substitute.

Conclusions are also drawn considering the trustworthiness of a patient, including statements I2a and I2b. Researching the perspectives on the statement (divided into two parts): *(a) I always want to accept the input of patients on developments within their medication process ... (b) because the input of the patient is always trustworthy.* The results listed below show that trustworthiness is not directly guaranteed, and therefore some control mechanism is needed.

- GPs are more willing to trust the patients' input (mean = 3.85) than GPAs (mean = 2.56) and PHAs (mean = 2.30);
- Job Type group GP/GPA/POH is more willing to trust the patients' input (mean = 3.72) than Job Type group PH/PHA (mean = 3.00).

The other significant pairs do have differences within the categories mentioned in Table 4.8, but these differences only indicate a stronger or weaker feeling of *agree or disagree*, and thus the decision whether to include/exclude a statement for the requirements does not change. Concluding, the validation resulted in additional insights for the discussion in Chapter 8, but still, all of the statements will be included in the formalisation in Chapter 5.

Table 4.8: Conclusions Significant Effect of Demographic Characteristics on an Assessment.

Pair	Category 1 [mean, n]	Category 2 [mean, n]	Conclusion
A3:Organisation Type	GP [2.89, 47]	PH [4.45, 42]	Employees in pharmacies are more likely to accept an extra system for communication regarding the care process than employees in GP practices.
P2:Organisation Type	GP [5.19, 45]	PH [4.71, 41]	Employees in pharmacies do agree less on making local agreements then GP practice employees.
I6:Size of Practice	1 SP [3.40, 10]	> 1 SP [4.86, 37]	GP practices larger than 1 Standard Practice do agree more on the need for some communication regarding care around the medication process should only be available to HCPs
A3:Job Position	GP [2.37, 27]	PH [4.38, 26]	PHs are more willing to use an additional system for communication regarding care around the medication process if it would replace phone calls and emails than GPs.
A3:Job Position	GP [2.37, 27]	PHA [4.53, 19]	PHAs are more willing to use an additional system for communication regarding care around the medication process if it would replace phone calls and emails than GPs.
CP4a:Job Position	PH [5.35, 26]	PHA [4.25, 20]	PHs do agree more on being adequately involved in the care around the medication process and thus wanting to process requests from the patient than PHAs.
CP3_B:Job Position	PH [4.96, 26]	PHA [3.80, 20]	PH are more willing to take over some of the responsibilities regarding care around the medication process as a result of digitisation than PHAs.
I2b:Job Position	GP [3.85, 27]	GPA [2.56, 16]	GPs are more willing to adopt patients' input considering the trustworthiness of the patient than GPAs.
I2b:Job Position	GP [3.85, 27]	PHA [2.30, 20]	GPs are more willing to adopt patients' input considering the trustworthiness of the patient than PHAs.
I4:Job Position	GP [4.21, 28]	GPA [5.18, 17]	GPAs are more willing to receive information more easily from the patient about his/her personal developments regarding the medication process than GPs.
I2a:Job Type	GP/GPA/POH [3.72, 47]	PH/PHA [3.00, 42]	GP/GPA/POHs are more willing to adopt patients' input than PH/PHAs.
I2b:Job Type	GP/GPA/POH [3.33, 48]	PH/PHA [2.66, 44]	GP/GPA/POHs are more willing to adopt patients' input considering the trustworthiness of the patient than PH/PHAs.
A3:Job Type	GP/GPA/POH [2.86, 50]	PH/PHA [4.44, 45]	PH/PHAs are more willing to use an additional system for communication regarding care around the medication process if it would replace phone calls and emails than GP/GPA/POHs.
P2:Job Type	GP/GPA/POH [4.74, 47]	PH/PHA [5.47, 45]	PH/PHAs are more willing to make local agreements on the communication regarding care around the medication process than GP/GPA/POHs.
CP2:Job Type	GP/GPA/POH [5.10, 50]	PH/PHA [4.64, 45]	GP/GPA/POHs are more willing to enable patients to contact the GP practice and/or pharmacy directly about their own choices around the medication process than PH/PHAs.

4.4. Interpreting Qualitative Results

Not only the statistics are considered relevant for analysing the survey results. The clarifications given by the respondents are also analysed from multiple perspectives. First, in Section 4.4.1 the clarifications are used to determine whether the respondents' assessments corresponded to their clarifications. Then, in Section 4.4.2, clarifications are analysed using an open coding approach to find interesting and overarching opinions for each statement.

4.4.1. Evaluating Alignment: Assessing the Trustworthiness

At first, the results show that respondents raised inquiries regarding certain statements, with subsequent clarifications highlighting varying levels of confusion or ambiguity. Regarding statement I1, nine respondents expressed uncertainty, three respondents reported a lack of understanding of statement I3, and two respondents found statement I5 to be vague.

Furthermore, during the analysis, certain participants expressed either positive or negative evaluations of a statement. However, upon examining the clarifications provided alongside their assessments, it became apparent that the formulation of these clarifications was contradictory to some of the assessments (for example a clarification on A1: *"In the same system, for sure, decrease double actions"*, with a contrary assessment of *totally agree*). To identify these contrary evaluations, a document containing only the clarifications and assessments was created. With straightforward interpretations, clarifications were re-typed by the researcher. As a result, the assessments were changed in polarity (from positive to negative, and vice versa), while maintaining the same level of strength (e.g., *strongly agree* to *strongly disagree*, and vice versa).

4.4.2. Clarification Analysis

Selecting Method for Clarification Analysis
All clarifications of each statement were gathered and it was indicated what point the respondent was adding to its clarification. Then, it became clear how many respondents agreed on specific areas, and what different areas were indicated as important. Section I.3 in Appendix I provides an extensive overview of the clarifications for each statement. The clarifications were summarised followed by an open coding approach. All clarifications are analysed, and the cores of the clarification are documented. This was done for each clarification within one statement, or set of statements (For example: Only one clarification box was provided for CP4, including CP4a, CP4b, CP4c). Examples of these processes are described in Table 4.9. If a clarification outpointed the same core as a previous clarification, this was seen as the same core. When all clarification had been analysed, the cores were compared, sharpened, and merged if possible in the axial coding phase, of which some examples are given in Table 4.10. Although

the number of clarifications for each (set of) statement(s) was not that high, this approach did lead to the cores of the clarifications relevant for consideration.

Table 4.9: Examples in the Open Coding Phase.

Clarification	Assigned Codes
"I only want to process requests from the patient if I am 100% sure it is approved. Otherwise, I ask the patient to discuss it with a doctor first." (Statement CP4B)	• subject to consultation with the GP
"The care system benefits from knowing what the situation is. Privacy only gets trickier that way" (Statement I6)	• transparency • privacy of HCP at stake
"Some information is hardly interoperable for a layman; patients may, through misinterpretation of e.g. certain lab results, make choices that are unfortunate for the intended treatment outcome, when there would have been no need to do so." (Statement I6)	• correct interpretation by the patient not guaranteed
"Patient remains their own boss on what they take and don't take and how. Better that they report it that we know and can anticipate it than that they do it and say nothing. The barrier to report/consult should be as low as possible." (Statement CP2)	• positive effect for therapy adherence • open-attitude: should always be possible

Table 4.10: Examples of Code Merging in the Axial Coding Phase.

Statement	Original Codes	New Code
I2	• It depends on the knowledge of the patient • Patient misses substantive knowledge • Patient does not remember all information	• The knowledge of the patient is questionable
I3	• There is a lot of redundant information • Would work against system contamination	• Positively affects system contamination
A2	• Leaves more time for the patient • Lots of systems are time-consuming	• Time-related desires

Identifying Additional Requirements

Additional requirements were constructed following the clarification analysis. The supplementary requirements arouse from clarifications prefaced with phrases like "Yes, provided that...," indicating that the respondent has appended an additional condition to the original statement. The inclusion of these clarifications is justified by their potential to provide valuable insights for system improvement. Consequently, the requirements resulting from these clarifications hold significant value in the context of design. Table J.1 in Appendix J shows the additional requirements for each statement based on the clarifications.

Identifying Further Insights relevant to Design

Looking closer at the content of the clarifications in the results, the following findings are formulated, following a one-statement approach, indicating that the insights were gained looking at the clarifications within one statement. The number of respondents supporting the result is denoted with [number]. Each of the findings is considered in the formalisation of the requirements in Chapter 5.

- *Trustworthiness of the Patient (I2):* The findings suggest that there is a level of scepticism regarding the knowledge of the patient. Some respondents question the extent of patient knowledge [12]. This highlights the need for effective communication and information-sharing practices to ensure patients have a clear understanding of their healthcare processes.
- *Range of Communication (I4):* Patients have multiple channels available for contacting healthcare providers, including PGO, App, Portal, Desk, Mail, Tel, and Website [10]. This emphasises the importance of including a diverse range of communication options to accommodate different preferences and ensure accessibility for patients.
- *Patients' Control (I5):* Respondents strongly emphasise the importance of giving patients control over their healthcare [6]. They also stress the need for transparency in providing information to patients [5]. These findings underscore the significance of empowering patients and involving them in decision-making processes to enhance their healthcare experience.
- *Communication in Current System (A1):* A high number of respondents stated the importance for implementing the communication in their currently used system in the clarification [21]. Although it is expected the respondents do strongly prefer this, it can also be explained by the negatively formulated statement. It is expected respondents felt a higher urge to respond in the clarification.
- *Fragmentation of Communication (A3):* There is a clear desire among respondents to reduce reliance on the phone [9] and email communication [5]. This highlights the need for more efficient and streamlined communication methods, potentially through the utilisation of digital platforms and technologies.
- *Local Agreements (P1/P2):* The findings indicate a strong preference for locally fine-tuning agreements regarding communication around the care process [8]. This suggests that healthcare organisations should prioritise tailoring communication practices to local contexts and requirements to optimise efficiency and effectiveness.

- *Repeat Processes (CP3A/CP3B):* Standardising repeat processes [5], especially for chronic medication [1], is seen as highly desirable. This highlights the need for clear and specific guidelines in standardising repetitive healthcare processes, particularly in managing chronic conditions.
- *HCP Responsibilities (CP4A/CP4B):* There is a call for ensuring that the organisational overview corresponds with reality and clarifying responsibilities regarding prescribing [4]. Additionally, 2 respondents mention the specific context of minor illness, in case it is expected that the patient is more flexible in choosing a HCP. This emphasises the importance of clear roles and responsibilities within healthcare teams to ensure effective coordination and accurate information sharing.
- *HCP Communication (CP1A/CP1B):* Internal communication is generally perceived as good [12]. Respondents suggest implementing chat functions instead of phone calls [5] for easier communication with HCPs, particularly with GPs [5] and PHs [4]. This highlights the need for efficient and accessible communication channels to facilitate collaboration between different healthcare stakeholders.

Identifying Tensions

In this Section, additional insights are discussed.

Finally, the results show tensions among the respondents (rejecting the demographic variables), The tensions are discussed in Table 4.11. The quantity of supporting clarifications [n] serves as an indicator of the level of support for that particular aspect of the tension.

Table 4.11: An overview from Tensions Arising from Statement Clarifications.

Statement	Tension
I1	There is a divergence of opinions regarding the efficiency of codes, with some proponents [6] and others expressing concerns about the time-consuming nature of documentation [4].
	The importance of uniformity is emphasised by some [6], while others highlight the limitations in communication due to uniformity [2].
I2	The value of patient information is acknowledged by some [5], whereas others raise doubts about the patient's knowledge [12].
I3	Some argue for direct notifications for everyone [3], while others advocate for giving individuals control [2].
I4	While some recognise the value of up-to-date information for timely action [9], others express concerns about decreased organisational oversight due to an excess of information [3].
I5	There are differing opinions on patient involvement, with some considering patients being too rapidly involved [1], while others stress the importance of transparency as desired by the patient [12].
I6	Similarly to the previous point, some believe that patients may misinterpret information [5], whereas others emphasise the patient's desire for transparency [11].
A2	There is a clear need to reduce phone/mail communication and allocate more time [14], although there are concerns about the administrative aspects [7].
A3	While some argue against reinventing the wheel locally [3], others support local adaptation for fine-tuning [8] and quick implementation [3].
P1/P2	Some exhibit an open attitude [5], while others discourage frequent patient contact and encourage self-initiated communication [5].
CP2	Some individuals express willingness to participate [7], while others believe they won't have enough time [2].
CP3	GPs perceive a PH is missing context [2], whereas the PH believes the AIS is comprehensive [2].
	PH are willing and capable of taking over responsibilities due to their medication specialist character [7], while GPs want to stay end-responsible [6], which is however also mentioned by PHs [2]
CP4	Some suggest that the PH sector should be authorised to prescribe medication [4], whereas others argue that GPs bear the responsibility and that PH professionals should refrain from doing so [3].
CP1	There are differing views on internal communication, with some stating it is satisfactory [8], while others emphasise the need for improvement [6].

Overall, the results illustrate the importance of effective communication, patient empowerment, standardisation of processes, and clear responsibilities in enhancing healthcare delivery and optimising the patient experience. These insights can inform the development and implementation of communication strategies and protocols that address the needs and preferences of both patients and HCPs. The tensions aroused will be discussed further in Chapter 8.

For this study, the requirements are being formulated on a relatively high level. The lower level, including more details on how the requirement should be met and thus provide insights on the performance level of the requirement, is not within the scope of this research. This should be mentioned since literature requirements are mostly formulated on a low level. The requirements formulated in this research are high-level requirements. For ease of reporting, they are referred to generally. as *requirements*.

4.5. Additional Requirement Elicitation: Patient Values

The importance of patient-centred design is not only denoted by literature in Chapter 3, but also by respondents in the clarifications, for example, two additional requirements resulting from clarifications: CP2.2 (*The design should enable patients to choose their way of communication.*) and CP2.3 (*The design should ensure questions of the patient end up with corresponding prescriber.*). Furthermore, the findings in *Patients' Control (I5)*. The clarifications for I5 supported the empowerment of the patients [6] and the need for transparency towards patients [5]. These findings were not directly included as additional requirements since the clarification did not directly mention: *"Yes, provided that ..."*, but do outline the importance of patient-centred requirements.

The environment analysis in Chapter 3 provided insights into the patient values in healthcare systems. The values mentioned by Greenhalgh et al. (2010) are translated into a norm, as proposed by van de Poel (2013). van de Poel (2013) introduced value-based requirement design following the values hierarchy as shown in Figure 4.3. The requirements added to the SRS follow this hierarchy, as shown in Table 4.12. The values of Greenhalgh et al. (2010) are first translated to a more specific norm, which is then further dis-aggregated into lower-level requirements; this formalisation method is further explained in Chapter 5.

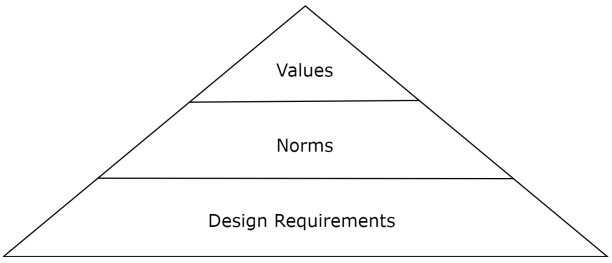


Figure 4.3: The three Basic Layers of Value Hierarchy (van de Poel, 2013).

Three requirements were added following this approach. (5.1) Improving the self-management of the patient supports the values of autonomy, partnership, and empowerment. Self-management means involving the patient during care processes, considering information provision, decision-making, etc. Providing sufficient information to increase the knowledge of the patient also touches upon the findings on the Trustworthiness of the Patient (I2), as described in Section 4.4.2. (5.2) Providing patients with personal care supports uniqueness and compassion, by adjusting for example the tone of voice towards a patient, based on the patient's preferences. Finally, (5.3) supporting patients' trust in the system supports the values of professionalism and responsiveness. The trust of the patient includes the perspective towards the way HCP respond to their requests, also including professionalism. Trust, of course, can, even more, be supported by guaranteeing the privacy of the platform and availability of the platform.

Table 4.12 shows which requirements were added to the list following the importance of a patient-centred design based on the values concluded from the environment analysis.

Table 4.12: Additional Requirement Elicitation from Patient Values.

Req	Requirement Description	Values (Greenhalgh et al., 2010)
5.1	Support self-management of the patient.	autonomy, partnership, empowerment
5.2	Provide patients with personal care.	uniqueness, compassion
5.4	Support patients' trust in the system.	professionalism, responsiveness

4.6. Conclusion Chapter 4

Chapter 4 supported answering sub-question 2: *What requirements meet pharmacists', general practitioners' and patients' interoperability needs in Dutch first-line healthcare?* The preliminary research started by providing insights into the relevance of interoperability from a HCP perspective. The talks with interoperability experts, familiar with the layers of Nictiz (2022a), started with outlining that HCPs do not generally know the term *interoperability*, resulting in a different direction for extracting the needs by using other terminologies in the elicitation process.

The process of developing statements for the survey involved several vital steps. First, a focus group was organised, although it is essential to note that due to its limitations, it formed part of the broader preliminary research process. Including both perspectives (GPA and PH) in the focus group was beneficial, as it facilitated interaction and discussion among the participants. This active participation resulted in valuable insights into the current situation (which was added to Chapter 3, attitudes, and generating new ideas. The focus group served as a crucial starting point for enhancing *communication regarding care around the medication process* and identified various points of consideration. These considerations were formulated into statements, categorised based on interoperability layers. Categorising the statements based on the layers made it easier to place them into context and provided a framework for further discussions. The statements were discussed in two semi-structured interviews to ensure relevance and assess usability for the survey. Additionally, based on these interviews, some final remarks were incorporated into the statements, and insights were gained to improve comprehensibility. This iterative statement development and refinement process generated valuable insights for the research.

Executing the survey resulted in a positive response, enabling valuable insights into the perspectives of HCPs. The survey successfully validated the statements, admitting varying levels of strength. Despite the tensions arising from the clarifications provided by respondents, all statements were assessed as valid for inclusion in the requirements. However, it is essential to note that the results cannot be generalised to the broader population due to two reasons: (1) the demographic characteristics of the sample differ significantly from the population, (2) the power of the significant results is relatively low, preventing firm conclusions for the overall population. Nonetheless, the demographic variables offered insights into differences among job types, positions, and organisation types. As well as a significant difference regarding the practice's size, smaller practices are less inclined to believe that communication should solely be accessible to HCP employees. As the survey's primary objective was to validate the statements, the importance placed on low power or the number of respondents was lower. Instead, any significant insights gained, even with low power, were interpreted as valuable contributions towards answering sub-question 5 in Chapter 8.

Not only were the validated requirements and additional requirements resulting from the clarifications included, but the clarifi-

cations and literature also shed light on the patients' perspectives. Although patients were not directly involved in eliciting the requirements, the explicit citing of their perspective in the clarifications by HCPs highlights the significance of considering the patient's perspective differently.

Finally, it should be mentioned the diverse range of elicitation methods raises concerns regarding the consistency of including requirements. Initially, the requirements were derived from an extensive statement validation process that utilised the survey approach. However, the additional requirements resulting from the clarifications, and the patient-related requirements formulated based on interpretations of the clarifications and literature, were not extensively validated through research. Unfortunately, due to time limitations, engaging in discussions with other HCPs regarding these requirements was not feasible, and thus it is acceptable for the further process.

5

Requirements Engineering Process: Formalisation and Evaluation

In this Chapter, the results following from the requirements elicitation described in Chapter 4, are evaluated. The creation of the SRS is described in Section 5.1, starting with the formalisation method in Section 5.1.1. To support requirement structuring, the requirements are aggregated and rephrased to avoid overlapping and ensure precise requirements, discussed in Section 5.1.2. Then, the requirements were grouped following the SRS provided by (Brazier & van Langen, 2020). The SRS is described in Section 5.1.3. The evaluation based on this SRS is discussed in Section 5.2. Finally, the improvements made based on the evaluation are reported in 5.2.2

5.1. SRS Design

The requirements resulting directly from the survey results, from qualitative and quantitative analysis, are merged into the final requirements enabling participants' interoperability needs. The formalisation of the requirements is discussed in this Section.

5.1.1. Formalisation Method

The formalisation of the requirements follows an approach of Brazier and van Langen (2020). Their approach enables the designer to structure the requirements based on the following questions. Top-down: *what is needed to realise this requirement?* and bottom-up: *what is the purpose of this requirement?* By structuring the requirements, they are coupled goal-based. Figure 5.1 visualises the idea behind a composition in the SRS. These questions can be asked for every composition within the SRS.

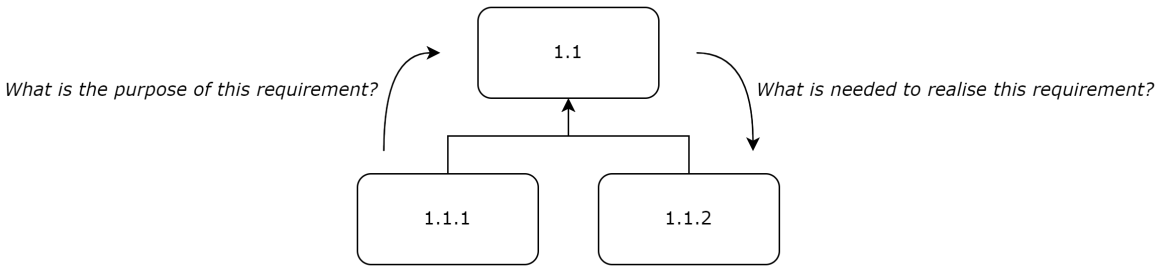


Figure 5.1: SRS Semantics.

5.1.2. Requirement Aggregation

To avoid overlapping requirements, aggregation of the requirements was conducted. The aggregation steps are described in this section. The aggregation was based on (1) merging, (2) revising, and (3) aligning.

Table 5.1 shows the merging steps taken to minimise the requirements included in the final SRS. Requirements were merged because multiple requirements formed the same goal within the design. During this process, it was essential to pay attention to the primary purpose of the requirements. The requirements had to be rephrased and merged without changing the primary purpose of the requirements. This did not only count for the requirement merging processes but also during alignment and revision. Statement CP3A.2 (*The design should include a feedback mechanism enabling PH/PHA to get feedback on choices regarding the care around the medication process.*) was revised to CP3.2 (*The design should include a feedback mechanism enabling HCPs to get feedback on choices regarding the care around the medication process.*) based on the fact both acknowledge the willingness of HCPs to receive feedback. I5.3 (*The design should ensure the communication regarding care around the medication process won't be a gush of information.)* was revised based on language use. The revised requirement emphasised the need for the design to

Table 5.1: Overview of Aggregation Process: showing the New Requirement, Original Requirements and the Reasoning.

New Req.	Original Requirements	Reasoning
3.2.1	• I2a • I2b	Unified interpretation and addresses the common objective effectively.
CP3.1	• CP3A.1 • CP3B.1	Both emphasise the need for enabling the shift of GP practice responsibilities to pharmacy employees concerning the care surrounding the medication process.
1.1	• *JobPosition_CP1(a/b/c)*	The requirements related to easy consultation were merged to enhance the ease of communication between relevant parties.
1.1.2	• *CP3.1* • CP3B.2	Both requirements focus on handling the responsibility shift from GP practices to pharmacies.
1.2	• A1.1 • I1.2 • A2.1	These requirements emphasise the importance of seamlessly incorporating the communication tool within the currently existing systems.
5.1.2	• I4.1 • CP2.1	Seeks to enhance easy and fast communication from patients to HCPs regarding personal developments in the medication process: optimise the flow of information, ensuring efficient and timely communication between patients and their caregivers.
1.1.3	• CP4b_B.1 • CP4c_B.1 • CP4b_A.1 • CP4c_A.1	All requirements' purpose is a seamless and efficient system for the exchange and management of requests between different stakeholders, such as PH/PHA and GP/GPA.
2.2	• I6.1 • I5.1 • A1.4	The new requirement states that access to communication regarding care around the medication process should be based on disciplines, which was initially included by the merged requirements.

facilitate clear and concise communication regarding care around the medication process. It served as a high-level goal for other requirements. Finally, to create a comprehensive SRS, some high-level requirements were added to bridge the branches, and the requirements were re-numbered to fit logically within the branch number.

5.1.3. Description of SRS

The final SRS is shown in Appendix L, including 5 branches of which the top-level requirements are shown in Figure 5.2. The structure is shortly described to provide a general understanding of the effect of structuring the requirements. It provides a complete overview of what the system is expected to achieve, following the quantitative, qualitative and literature results. The SRS as provided in Appendix L is the final SRS, adjusted based on the evaluation as discussed in Section 5.2, following the improvements as discussed in Section 5.2.2. The branches for agreement support and access regulations provide requirements relevant to both HCPs and patients.

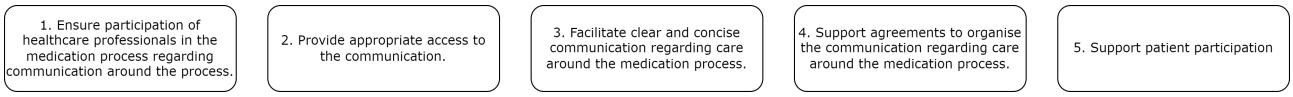


Figure 5.2: Top-Level Requirements SRS: Outlining the Goals of the 5 Branches.

1. HCP-Participation
Supporting participation from a HCP perspective is the most discussed interaction in this study since only GP practice and pharmacy employees were directly involved in the research process, described in Chapter 4. Considering communication, three crucial areas are *cooperation improvement*, *integration*, and *control*. Improving the cooperation between HCPs can be realised by making communication *easier*, by supporting the *shift* of responsibilities, and by enabling HCPs to handle *requests* of other HCPs. These opportunities for realising an improvement of the cooperation are an essential basal incentive for HCPs to join the platform. The integration also needs to be realised in three areas: *incoming notifications*, *existing databases*, and *other medical specialists*. HCPs think the communication should be integrated with existing and other medical specialists' systems. The final incentive for participating is control. HCPs are reluctant to hush messages and notifications and, therefore, willing to manage this based on their preferences and schedule.

2. Access Regulation
Furthermore, areas for regulation of access were defined based on *organisation*, *discipline*, and *medication*. The access to communication will be decided by the patients since they need to have the ability for self-management. Organisation- and discipline-based access would enable the message to be answered by the right HCP. The medication-based access would not be needed for enabling communication but rather for research or insights on the medication. Access to a list of questions or remarks labelled

medication-based would increase the knowledge of how patients perceive the medication, and what questions are frequently asked.

3. Clear and Concise Content
Essential, is clear and concise communication. The resistance among HCPs considering communication regarding care around the medication process is present in reluctance to a gush of information. Clear and conciseness are proposed to be realised at the source and post-source. They are starting from the source (which can be a patient or a HCP, but worries on input were only expressed considering patients, so patients are the focus point). Managing the patients' input will ensure the input will be limited within a specific framework, realised by managing the expectations and increasing the trustworthiness by providing patients with sufficient information regarding the care around the medication process and building a verification mechanism. A post-source approach can be realised by connecting the communication to a code list and labelling parts of the communication and situation. This list will include existing codes and a specific code base based on frequently communicated areas. Regarding the usability of codes, HCPs argued for a sufficient amount of included communication areas, well-documented codes, and easy-to-find codes.

4. Agreement Support
Supporting agreements between HCP is merely focused on the HCP side, but following these local or national agreements does support the trustworthiness of the system and therefore also touches upon the patients' perspective. The trust of the patients will increase if transparency is intended and HCP abide by the agreements. Supporting local and national agreements was already found to be important in the preliminary research, while inter-HCP agreements were additionally found during the survey analysis.

5. Patient-Participation
The participation of patients is an additional branch in the SRS. This shows that the patient perspective is an add-on to the perspective of HCPs as outlined earlier. The patient-centred requirements do mostly result from the usability and attractiveness to participate in the communication. A new communication tool will not be preferred by all types of patients, for example, the elderly who experience difficulties in using new technologies and prefer to call. Therefore, choosing their way of communication is a requirement that should be met to enhance patient participation. The communication platform should not replace all other communication tools in the first place but rather support the shift towards a new communication tool. As discussed in Chapter 4, supporting self-management, personal care, and trust in the system are necessary means to realise patient participation.

5.2. Evaluating the SRS

The SRS is evaluated based on well-written requirements and usability with field experts. However, the quality of requirements is assessed more widely in the literature. Dzung and Ohnishi (2012) discusses the requirements elicitation using an ontology, which goes a little deeper into the functionalities for each requirement elicited using the survey results. The main point of Dzung and Ohnishi (2012) is the inclusion of *where*, *who*, *why*, *when*, and *how* in a requirement. In this research, the *who* is covered in terms of *who is involved in the functionality?*, the *why* is covered by positioning the requirement as a result of the survey, the *how* will be further researched assessing the possibilities in platform components for each statement in Chapter 5.1. The *when* and *where* are not covered in the requirements as formulated in this research.

In this research, the requirements will be validated based on four criteria provided by Brazier and van Langen (2020). These four criteria are (1) verifiable, (2) justifiable, (3) independent of implementation, and (4) express a single capability. According to the system requirement specification, each requirement should have a unique identifier, capability, related values/need/desires, source, type, qualification and fulfilment criterion (Brazier & van Langen, 2020). These requirement specifications are not included in this research, due to project time restrictions and the purpose of use considering the requirements. Corresponding values, needs or desires and the source are not explicitly included, since the requirements directly result from user needs and desires addressed in the survey, which indicates the source as well. The discussion during the three interviews led to the following findings.

5.2.1. Results of the Semi-Structured Evaluation Interviews

This Section shows the results of the three semi-structured interviews with the participants as shown in Table 5.2. All respondents are product owners within the healthcare context, working at a company providing IS software to healthcare organisations. PO1 has many years of experience, while PO2 and PO3 are relatively new in their position as product owners in healthcare IT. The fact that they all serve the same job position may restrict the range of perspectives. However, since each is a product owner of a different product, the scope does not get too narrow.

Table 5.2: Overview Participants Requirement Formalisation Evaluation.

Interviewee	Job Position	Years of Experience
PO1	Product Owner AIS	23 year
PO2	Product Owner HIS	7 years
PO3	Product Owner Platform Based Information System in healthcare	6 years

Conclusions Clarity of the Requirements
The phrasing of the requirements was assessed positively by the interviewees, only indicating the importance of obtaining a shared understanding of abbreviations used in the requirements.

"Upon reviewing the scanned information, it was noticed that the term "HCP" (HCP) was unclear. It is important to ensure that everyone is speaking the same language and using consistent terminology." (Interviewee PO2)

However, considering the justness of the requirements (justifiable), the following can be stated as the result: not all requirements in the SRS are justifiable. Since the duality of sources within the SRS (literature, quantitative- and qualitative survey results), the justness differs. The justness depends on the source of the requirement. On the one hand, some requirements result from validated statements that arose during the preliminary research. Since those requirements were discussed in person, the reason behind the requirements is more apparent. Other requirements result from clarifications from the survey. The respondents did not further clarify those clarifications, there were not asked to do that. Due to the goal of the survey: idea generation, those clarifications were, however, interpreted as applicable. But, assessing the requirements based on justness outlined this decision's cons. Including the clarifications as a requirement leads to less/nearly justifiable requirements.

"The first question that pops up in my mind: What is the reason behind all the requirements?" (Interviewee PO3)

PO3 aroused the question of *why* the requirements should be met. This was something PO3 could not see from a layman's perspective. The researcher could not answer this question since the requirement resulted from a clarification in the survey. Therefore, the why question cannot be answered for each requirement in the SRS. If this more in-depth information is deemed necessary in the design, the requirements should be further discussed based on its reason and how it should be specifically designed.

Conclusion Usability of the SRS

All product owners did mention similar ideas about the usability of the SRS. The conclusion on usability is the following. None of the requirements could be communicated directly to a development team to realise the right design. The development team invited to develop the requirement should have more specific requirements. More details of the requirement should be discussed and evaluated with an information analyst and a developer. This process is far from being realised with this SRS. Before requirements are handed over towards a development team, the requirements are divided into multiple user stories using different formats (for example, UML Use Case Modelling or Epics). Each interaction, each setting, and each decision is based on an analysis, including business aspects, best practices, experiences from earlier realised requirements, etc. The fact that all interviewees stated this did not arouse unexpectedly.

"For example, when it comes to communication, there are various methods like integrating an app, such as WhatsApp. Eventually, we reached a point where we considered WhatsApp a viable idea. How is that determined?" ... Then, we delve into the specifics, considering factors such as who wants this, whether it's intended for a specific customer group, how it will be monitored, what integration is required, and what criteria it must meet. Do we need to be available at all times? Are developers involved in the process? (Interviewee PO3)

The quote above shows one example given by PO3 to indicate the possible detailing process. The way PO3 keeps itemising questions indicates that there are still many questions to ask, looking at the SRS. The following two quotes show examples of usability within development teams. The fact that handing over high-level requirements to development teams takes a lot of time and increases complexity for development teams outlines the importance of a more efficient way: including the developers in creating storylines for each requirement.

"Handling requirements as these large blocks take much longer and become highly complex for the development teams. They don't know where to start without a clear start and endpoint. They struggle to determine the starting point when they receive a large block. To reduce complexity and increase predictability, you must provide more detailed specifications to guide them through the development process and clarify the scope." (Interviewee PO2)

"Once I start creating user stories, I consult with the developers to understand what is feasible and what we already have in place. They help refine the criteria for the stories. We then discuss the stories together, ensuring everyone is aligned in their understanding." (Interviewee PO2)

Despite the requirements being interpreted as not ready for direct development, they do show a good view of the goals resulting from desires in the target group. This could help the product team to decide on which part will be developed and which part will be excluded since it was not significant enough or the requirement was not supported by enough users of the system (in this case, for example, the requirements resulting from clarifications by only 1 or 2 respondents).

"It's valuable to have a detailed breakdown of the requirements through a needs analysis, considering what customers or target audience would want in terms of communication." (Interviewee PO3)

Conclusion Incentives in Design

The discussion furthermore contained a clear perspective on the incentives for deciding on the realisation of the requirements. First, the most easily expressed incentive was formulated as a business case. Positioning the requirement in a business case, including incentives from a company perspective, mainly focusing on obtaining targets: profit, quality of the system, good reviews of the company, etc., outlined new discussion points.

The development process involves creating a business case, determining the impact, and conducting a cost-benefit analysis. Once we receive the green light, we move on to detailed elaboration. ... We identify the needs, spot trends, evaluate the potential for usage, and assess its potential benefits for the company, such as attracting more customers. (Interviewee PO3)

Conclusion Trade-Offs in Design
Furthermore, it became clear that the incentive to meet all clients' desires is not present. This is due to their experience that this will never be possible with their client base. Only PO3 mentioned that PO3 works on a system that is respectively new, enabling PO3 to listen more carefully to clients' needs.

> *"It's just not possible to please everyone. ... It's not possible to do everything, so decisions are made to meet as many interests as possible."* (Interviewee PO1)

> *"Breaking things down into smaller components, even at a lower level (including this level), is necessary. You cannot do everything. The development team cannot handle everything either, so choices have to be made"* (Interviewee PO3)

This trade-off was discussed even more specifically with PO3, diving into the managing needs of HCPs in terms of system settings.

> *"It's an interesting challenge because customers want everything adjustable, but from a development perspective, making everything adjustable is not feasible. It's detrimental to the maintainability of the product. There must be a lot of communication, and testing becomes challenging because you must test all scenarios. The goal is to make it as generic as possible and minimise settings per HCP"* (Interviewee PO3)

Thus, the desire for HCP control resulting from the survey results is hard to obtain in practice. This is a very time-consuming coding process, which increases the costs of enabling such a manageable functionality. The finding that the interviewees cannot consider everything in practice outlines a limitation of the practical implementation of this research.

5.2.2. Improvements SRS

Following the clarity and usability evaluation results, the SRS was adjusted by specifying some requirements more precisely. Table 5.3 shows the requirements for which additional requirements were necessary. Statements 1.2.1 and 1.3.1.1 are rephrased since they were assessed as unclear. Moreover, the following criteria resulted in an adjustment of the statements: rephrase vague statements (1.2.1, 1.3.1.1), specify too high-level statements further (1.1.1, 1.1.3, 3.2.1, 3.2.2, 5.2.1, 5.4), ensure consistency among branches of statements (2, 1.3.1), ensure there is only one goal within the statement (Brazier & van Langen, 2020) (1.3.2, 1.3.2.1), do not yet provide solutions (3.2.1). The final SRS can be seen in Appendix L.

Table 5.3: Additional Requirements Resulting from Specification.

Req.	Additional Level	Reasoning/Source
1.1.1 Enable HCPs to consult easier with other HCPs.		
	1.1.1.1 Provide a technology-mediated communication tool	Siitonen and Aira (2019), Avrahami and Hudson (2007)
	1.1.1.2 Provide easy access to the communication	Elicitation Finding
	1.1.1.3 Provide an asynchronous communication tool	Elicitation Finding
1.1.3 Support HCPs to process requests from HCPs in other healthcare organisations		
	1.1.3.1 Enable HCPs to get feedback from other HCPs on patients' input.	Splitting of Requirement
	1.1.3.2 Enable HCPs to get feedback from other HCPs on HCPs' input.	Splitting of Requirement
3.2.1 Ensure trustworthiness of patients' input.		
	3.2.1.1 Provide patient with sufficient information regarding the care around the medication process	Patiëntenfederatie Nederland (2016)
	3.2.1.2 Ensure patient's input is checked	Elicitation Finding
3.2.2 Manage patient expectations regarding the communication.		
	3.2.2.1 Provide an indication of response time of HCP	Avrahami and Hudson (2007)
	3.2.2.2 Provide an indication of response content of HCP	Avrahami and Hudson (2007)
5.2.1 Ensure communication has a personal feeling		
	5.2.1.1 Connect patients to familiar HCPs	Patiëntenfederatie Nederland (2016)
	5.2.1.2 Enable use of spoken language	Patiëntenfederatie Nederland (2016)
5.4 Support patients' trust in the system		
	5.4.1 Provide a feedback mechanism	Berger et al. (2020)
	5.4.2 Provide user guidance	Cahour and Forzy (2009)

5.3. Insights on Conflicting Requirements

In this Section, additional insights are discussed.

Looking at the SRS as shown in Appendix L, several requirement pairs experiencing tension are defined. The conflicts are found between requirements enabling patients' and HCPs' needs. Some of the proposed approaches to somewhat solve the tension bring additional design requirements. These requirements are reported.

Patient Desire for Choice vs HCPs' Resistance to Change in Communication Tools
Enable patients to choose their own way of communication (5.1.1) and *Provide a technology-mediated communication tool (1.1.1.1).*

Tension: The results show while the diversity of choice is desirable from a patient perspective, HCPs prefer the contrary. It would not be realistic to expect communication to be directly totally switched to a new communication tool. Solutions in between would support the process of implementing a new communication tool.

Approach: Convince patients to use the communication tool by making it *easy to use*. It is expected that this incentive is not easy to obtain. Patients prefer calling to healthcare organisations, especially the elderly. The communication tool should be nearly as easy as calling and provide as clear communication as calling to convince patients to choose the communication tool over already known communication mechanisms. Enabling HCPs to document the email or call in the same communication object as where the messages are would be helpful for the complete documentation of the communication regarding care around the medication process.

Patient Desire for Direct Communication vs HCPs' Resistance to Over-Communication
Support asynchronous communication (1.1.1.3) and *Ensure direct communication from patient to HCP (5.1.2.2).*

Tension: The results indicate that while HCPs prefer asynchronous communication because it allows for more convenient consultation because neither party needs to wait for the other, patients prefer to hear directly from the HCP they are requesting.

Approach: The directness of the communication should be enabled by ensuring patients can directly send something to the HCP. The system will provide the patient with information about response content and response time to satisfy the patient. Requirements 3.2.2.1 and 3.2.2.2 will support this tension. On the other hand, the patient is sure that the message arrived at the HCPs' communication system. Asynchronous communication is thus not entirely negative for them.

Enable HCPs to manage receiving messages (1.3.1) and *Ensure direct communication from patient to HCP (5.1.2.2).*

Tension: The SRS further demonstrate that while HCPs desire to maintain control over patients' incoming messages due to the frequently mentioned concern that a system would get clogged with all these notifications, communications should actually be proactively notified to facilitate direct patient communication.

Approach: This includes the same story as the previous tension. It is expected that it would help the patient if they got some information about the expected response time. Some additional information on the message they send to the HCP. Has it arrived? Did they read it? How much time do they need for a response? Therefore the information on receiving a response to a message is essential to tackle these tensions between patients and HCPs.

The results show tensions already arise between the small number of requirements enabling patients' and the HCPs' needs. This was already expected since the HCPs' needs are already discussed in the survey results, and the requirements with the most tension are handled. It is interesting to see tensions between HCPs' and patients' needs without even researching them in detail. This indicates that tensions will arise when researching more perspectives on digitising communication.

5.4. Conclusion Chapter 5

The requirement for the formalisation of interviews shows that the SRS design is not yet ready to pass on to a development team. The requirements need more in-depth detail to be concrete enough for practical development. It needs information on how the requirements should be achieved. This includes multiple details: use cases, detailed information description, security features, and many unanswered questions. Based on this conclusion, some of the requirements are expanded with one level, based on literature discussing the next level of that requirement.

Furthermore, the discussion concluded that not every component could be adopted in practice immediately, indicating an important practical limitation. However, since the platform design is intended to research possibilities outside of practical implementation, no requirements will be rejected for consideration in the platform architecture.

6

Design: Platform Architecture Enabling Interoperability Requirements

This Chapter presents the design of the platform architecture, enabling the interoperability requirements as formalised in Chapter 5. First, Section 6.1 outlines the platform architecture perspective. Section 6.2 describes the platform modules realising the low-level requirements. The design includes a high-level abstraction platform architecture, with the main focus on the business and information layer, as introduced by The Open Group Architecture Framework (TOGAF). The technology layer is partly addressed, including the technologies enabling the core functionalities rather than discussing the details of the technology layer. The overarching platform setup is discussed in Section 6.3.

6.1. Perspectives on Platform Architecture

The platform architecture is described differently by multiple researchers. Where some plead for a simple representation of the platform architecture, other researchers have a more zoomed-out perspective on platform architecture, focusing on the understanding of the ecosystem (Op 't Land et al., 2009).

Additionally, platform architecture is described as the organisation logic of the platform at different layers (Silva et al., 2019; Yoo et al., 2010). The layers describe the setup of dependency within an architecture. The top layer depends on the layer below, which in turn depends on the layer below, etc. The bottom layer is therefore the most stable layer in the architecture. The layered approach is also adopted by Janssen (2010), discussing a 5-layer meta-framework to design an enterprise architecture (EA). The layered approach is supported by the ArchiMate language. TOGAF also implies these layers, including the main focus points of modularity and standardisation. Regarding standardisation it is already known this is highly relevant for first-line healthcare, since the standardisation agenda is up and running. The modularity of the first-line healthcare IT system would be something new. The modularity can provide easy connections to other systems, which is proven to be desirable resulting from the focus group findings.

6.1.1. A Layered Approach

Figure 6.1 shows how the interoperability layers are connected to the Architecture Development Method (ADM) cycle. The ADM cycle visualises the iterative character of the design process. After each process step, the design should be reflected. The ADM cycles are categorised as follows.

- The *preliminary (0)* and *architecture vision (A)* are seen as the architectures context;
- The *business architecture (B)*, *information systems architectures (C)*, and *technology architecture (D)* belong to the architecture definition;
- *Opportunities and solutions (E)* and *migration planning (F)* are considered transition planning;
- And *implementation governance (G)* and *architecture change management (H)* as architecture governance.
- In the middle, *requirement management* is added to enhance a perfect fit of the architecture.

Chapter 4 and 5 are directly coupled to the ADM cycle in terms of *requirement management* and the relation to the other layers. *Architecture vision (A)* is supported by gathering the needs of the target group during the focus group session, while *business architecture (B)* and *information system architecture (C)* are supported by the results of the survey and the formalisation of the requirements in Chapter 5. The *technology architecture (D)* is defined based on the environment analysis in Chapter 3, and following best-fitting technologies enabling the functionalities in the design. How this is integrated into the design is shown in Section 6.2.

Lankhorst et al. (2009) see modelling the architecture framework as support to the modularity as a means for going along with the time, new organisation strategies, ideas, and collaborations since the consequences and changes have an effect on all domains within the architecture design. It also enables informed governance. The ArchiMate language was designed and partly funded by a Dutch initiative. The ArchiMate language has been transferred to the Open Group's TOGAF architecture framework and is now seen as the standard description of enterprise languages to gain a less detailed and more course-grained perspective. More detailed enterprise languages are BPMN and UML, providing a detailed perspective on reflectively the process, data, and user interaction from an enterprise system.

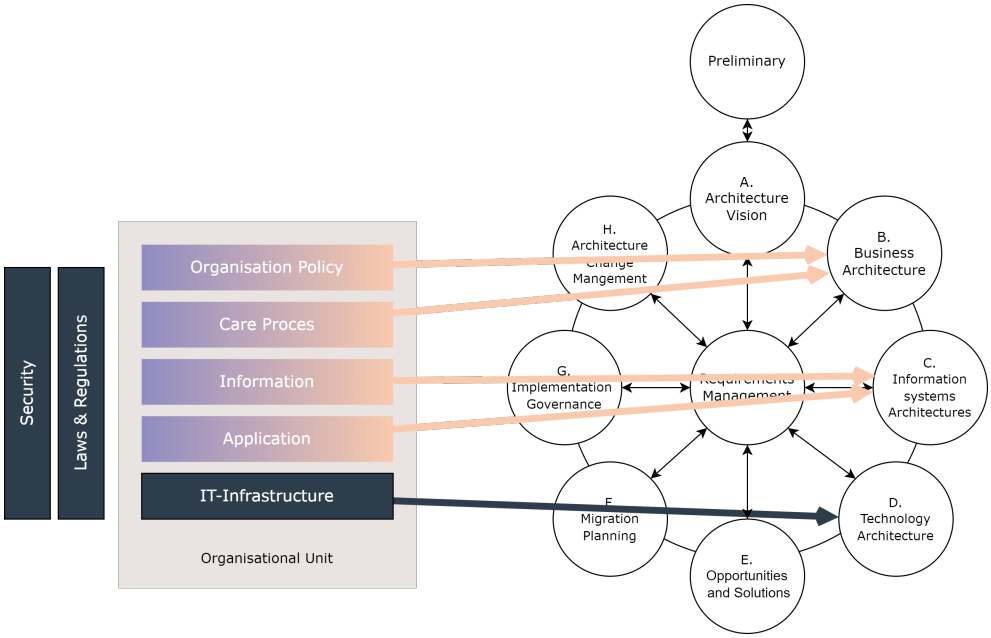


Figure 6.1: Interoperability Layers and TOGAF (Nictiz, 2022a).

6.1.2. Thesis Perspective on Platform Architecture

The diversity of perspectives on platform architecture design points out the relevance for formulating a perspective that is adopted in this thesis, and thus in the platform architecture design. The layered approach is adopted partly. The *technology architecture (D)* is not fully employed due to a lack of relevance for this research perspective but is considered partly. Only the technologies that are proposed to enable main areas like *supporting exchange between users*, *supporting innovation*, and *supporting security* are already added to the design. Furthermore, it is assumed that there will be a platform owner responsible for the design of the platform. The platform owner is able to choose the design options and is not committed to any collaboration in this decision yet. Moreover, it is assumed that regulations and new collaborations or contracts can be made to support the implementation of the design. Therefore, the architecture follows out-of-the-box thinking, of which a challenge is the implementation of the design, which will be further discussed in Chapter 7.

6.2. Platform Architecture

The platform architecture designed in this study is shown in Figure 6.2. In this Section, the platform is described as a result of the data gathered in this study specifically, without neglecting the requirements derived from the literature in Chapter 3. To improve the comprehensibility of the core interaction on the platform, the box below outlines the main application of the platform explained using an example.

> *Bob is registered with a PGO. With his PGO, he can send a comment or question through the chat module. Bob is a diabetes patient and has been taking medication for years, but he still wants to ask something or send a message. For the message, Bob prefers to send a message to his own GP and PH, where he has been going for all those years. Bob opens the chat module and types the message he wants to send to his PH and GP with the update.*
>
> *Bob selects the PH and GP with whom he has a treatment relationship and sends the update via the chat module. The message is sent by the PHA to the platform in the accepted structure through the API. The accepted message is communicated from the platform to the connected parties. Since the PHA has added the correct senders to the metadata of the message, the platform can reach the appropriate healthcare organisation systems. The healthcare organisation receives a notification that a message is waiting for them. Once they accept it, they receive the content of the message. A response is not expected, but the system can provide feedback to the patient that the message has been received successfully.*
>
> *For the question about the medication, Bob composes an additional message. He doesn't mind whether his pharmacy or GP responds to the message; even a different pharmacy and/or GP is fine. In his PGO chat module, he indicates that it doesn't matter to him as long as the organisation is in the same region. All recipients receive a notification that a question is ready to be answered, indicating whether they are the only recipient or if there are multiple recipients. The organisation that first indicates its willingness to answer the question receives the content of the message. When the PH responds to the question through their AIS- chat-module, and it is sent to the platform in the correct structure by the AIS, the platform ensures that the message is sent back via the PGO API. In the case of the second example, the HCP and the healthcare organisation they work for are rewarded for answering the question.*

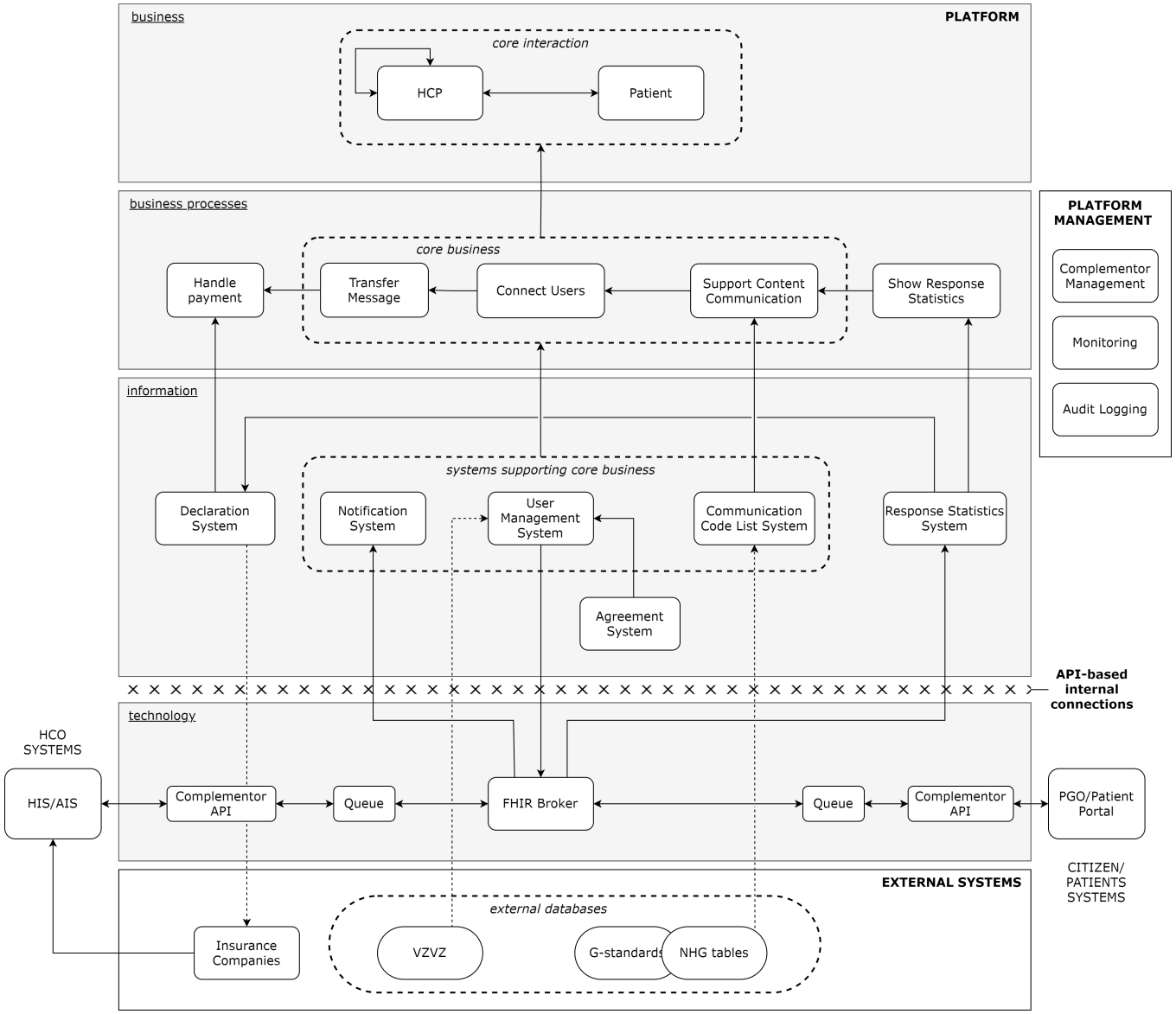


Figure 6.2: Platform Design Enabling Interoperability Needs.

The platform does not include any user interfaces but fills two main functions: partitioning and systems integration. Partitioning means that the ecosystem follows a decomposition approach, where each sub-system is relatively autonomous from the other. Partitioning also supports the governance of the system since the overview increases when the system is divided into more sub-systems. The sub-systems are now handled as so-called black boxes: objects of which the internal workings are neglected (Petch et al., 2022). The black boxes should be designed after the collection of black boxes is envisioned.

Translation to Platform Modules

The translation from the requirements to the platform design is based on constructed platform modules, which will be described first. The basal functionality of the platform module will then be described more in detail, including the requirements that are realised within that module. Based on the following criteria, platform modules had been specified: (1) Dependencies among the requirements, or a shared purpose, (2) Functionality similarities among the requirements (since these can be tackled within the same module), (3) User roles and needs (to enable platform modules to target the right solutions for each user). The platform modules are based on the requirements at the lowest level of the requirement structure, since those requirements are most operational, and requirements above those are merely an amalgamation of two or more requirements on a lower level. The modules are formalised respecting a life cycle approach, meaning the input and output of a module are defined. The life cycle approach also enabled the definition of performance measures (*Note that these performance indicators are not yet discussed with any field experts*). The modules and the main goal of the modules are listed below, followed by the Sections describing the modules.

1. *Communication Module:* enable HCPs and patients to communicate with each other regarding the care around the medication process.
2. *Code Implementation Module:* support the content of the messages to realise clear and concise communication.

3. *Patient Engagement Module:* stimulate patients to join the communication.
4. *Reward Module:* facilitate a reward mechanism to reward users for participating on the platform.
5. *Complementor Integration Module:* enable complementors to join the platform structured and monitored.

Not all requirements will be realised on the platform, but are still mentioned in the modules. This was due to the evaluation of the design, discussed in Chapter 7, resulting in additional insights on stakeholder responsibilities, outlining the requirements that could be the responsibility of platform complementors. The requirements which were originally included in the module, but for which full responsibility lies with the complementor in the final design, are still shown in the list of requirements within the module, to show transparency on how the platform is designed.

6.2.1. Communication Module

The input and output of the communication module is visualised in Figure 6.3. The message received by the FHIR broker through the API (discussed further in Section 6.3), triggered by the sender's system is the starting point for the communication module. The communication module is responsible for making this message available on the queue for the HCPs for which the message is intended. The performance of the communication module can be based on the reliability and the speed of delivery.

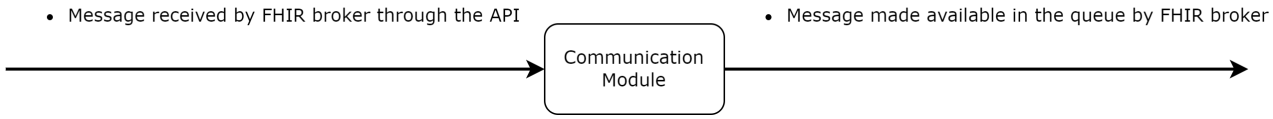


Figure 6.3: Input and Output of Communication Module.

Table 6.1 shows all requirements being realised by the communication module. As stands out, some requirements are fully realised by the complementor. To start with managing the notifications (1.3.1.1 until 1.3.1.3). In the preliminary research and survey results it was found HCPs want to manage incoming notifications, based on level-of-urgency, planning, and storage. Those notifications do not consist of the content of the message yet but only indicate the message is waiting for a response. Managing those notifications needs a lot of additional HCP-dependent information (such as schedule, time zone, urgency-perspective, etc.) on the platform, which is tried to be minimised due to safety. The platform will send the notification from the API to their system, to which the system will then have to respond as desired by its own HCPs.

Table 6.1: Low-Level Requirements Communication Module.

Req	Requirement	Realised By
1.1.1.1	Provide a technology-mediated communication tool	API, FHIR broker
1.1.1.2	Provide easy access to the communication	API, *Complementor*
1.1.1.3	Support asynchronous communication	FHIR broker, Queue, Notification System
1.1.2.2	Ensure questions of the patient end up with the corresponding prescriber.	User Management System, FHIR broker
1.1.3.1	Enable HCPs to send requests to other HCPs.	Agreement System, User Management System, FHIR broker
1.1.3.2	Enable HCPs to receive requests from other HCPs.	Agreement System, User Management System, FHIR broker
1.1.3.3	Enable HCPs to react to requests from other HCPs.	Agreement System, User Management System, FHIR broker
1.2.1	Ensure incoming notifications are coupled to the systems of the organisations.	API, *Complementor*
1.2.3	Ensure other medical specialists can be connected to the communication regarding care around the medication process.	API, Complementor Management
1.3.1.1	Enable HCPs to manage level-of-urgency of incoming notifications.	*Complementor*
1.3.1.2	Enable HCPs to manage the storage of incoming notifications.	*Complementor*
1.3.1.3	Enable HCPs to manage incoming notifications based on planning.	*Complementor*
1.3.2.1	Enable HCPs to get feedback from other HCPs on patients' messages.	*Complementor*, User Management System, Notification System
1.3.2.2	Enable HCPs to get feedback from other HCPs on HCPs' messages.	*Complementor*, User Management System, Notification System
2.1	Enable organisation-based selection for communication transparency.	*Complementor*, API, FHIR broker, User Management System
2.2	Enable discipline-based selection for communication transparency.	*Complementor*, API, FHIR broker, User Management System
3.2.1.1	Provide patients with sufficient information regarding the care around the medication process.	*Complementor*
3.2.1.2	Ensure the patient's input is verified.	*Complementor*
5.1.2.2	Ensure direct communication from patient to HCP.	API, FHIR broker, User Management System
5.2.1.1	Connect patients to familiar HCPs.	*Complementor*, FHIR broker, User Management System

Additionally, it can be seen that requirements 3.2.1.1 and 3.2.1.2 are also realised by the complementor. Both requirements aim to support the trustworthiness of the patient's input. Providing sufficient information to the patient in advance is seen as the

responsibility of the complementor (the HCP). How the HCP will share this information with the patient, can be done by choosing multiple directions. The same applies to the verification of patients' input. Verifying patients' input on the platform would need the platform to open the message, and thus store the message centrally. To increase safety, the number of times the message is opened should be prevented. The complementor will be responsible for the verification of the message. It must be appointed that this will need further research. Will it take a lot of time? Can it be automated? Are non-HCPs capable of verifying this information?

The requirements that are included in the platform do have the main purpose of enabling a user to send a message to another user. The content of the message can be a question from the patient to one or more HCPs, an answer from a HCP to the patient, a request for feedback on a certain case from one HCP to another, or an answer from a HCP to the HCP asking for feedback. The nature of the message being sent on the platform should be indicated in the metadata of the message.

Meta Data Message
The content of the message and the structure that will be accepted on the platform is elaborated on in Section 6.3. As can be seen in Figure 6.3, the communication module receives an already structured message, and thus the structure is not part of this module. Metadata of the message is however used in the communication module and therefore discussed.

By categorising messages using metadata, system performance can be enhanced and future functionalities can be enabled. For instance, the metadata containing a label indicating the medication can facilitate linking anonymous messages to specific medications, opening up possibilities for advanced functionality. The use of metadata goes beyond this functionality, for example by the use of time stamps and logged HCPs opening the message in audit logging. It would support monitoring, compliance, and investigating potential issues/possibilities. Furthermore, the metadata can consist of the ID of the therapy prescriber and the HCP involved from the start of the episode, patient ID, episode ID, therapy ID, etc.

This module should link the number of messages a HCP handles to a certain payment/reward mechanism. Therefore, it is deemed necessary that each message in the communication object is handled as an individual object. The fact that the messages should be linked specifically to a medical specialist would also support the clarity of responsibilities, and enable the right access to the messages. The metadata of the message and the response to that message is important for the reward mechanism connected to the messages, which is further elaborated on in Section 6.2.4.

Feedback Exchange between HCPs
Requirements 1.3.2.1 and 1.3.2.2 indicate the need for HCPs to obtain feedback from other HCPs on requests from HCPs and patients. The requests are seen as independent messages that can be sent by the HCP. Technically, it can be possible to directly forward the message from a patient towards a HCP, asking for feedback, however, privacy issues arise when the message sent by a patient is sent to another HCP, since making messages anonymous is a study on its own. What if the patient sent a picture showing the patient's head? What if the unstructured part of the message consists of a phone number? How will the platform be able to make these messages anonymous? What about safeguarding the objective of the message? These difficulties asked for a different approach considering the desire for asking feedback. The HCPs will be responsible for creating a new message that they are willing to send to the other HCP. The HCP sending the request for feedback has the ability, and responsibility, to make the message anonymous, without rejecting the main goal of the message.

User Management System
The access to and directing of messages will be regulated through the API only accepting the message from the queue, if the HCP asking for the message from the IS is logged in, based on the right authentication. HCPs do already work with user authentications in their own systems. The user management module of these systems, indicating their unique identity, connected to for example BIG-registration (Ministerie van Volksgezondheid Welzijn en Sport, 2023), should be used to identify the user within the communication system. The user management would be a list of these users, kept internally by healthcare organisations. It is not desirable that this information is stored outside of their own system. The list will support authentication, which is done by UZI cards in pharmacies and GP practices.

Currently, there are three types of UZI-cards, creating a variation in access according to healthcare organisations: (1) employee card, (2) employee card connected to name, and (3) care professional card, of which the employee card (1) does have the least access possibilities. The *care professional card* is currently the only card that also includes the job position of the UZI card holder. The *employee card with name* also includes who it is, the *employee card* only registers the organisation in which the employee is working (CIBG, n.d.). For the user management module, this would indicate that care professionals using an *employee card* (with or without a name) should be supported by another authentication mechanism before entering the communication module, since else no address of them is registered.

Labelling
Labelling messages would support the use of messages in a structured way. The way messages would be labelled does need further research. But it can already be seen that HCPs need labels regarding the medication, the discipline allowed to see the message, and the organisation allowed to see the message. The medication-based access (statement 2.3) is however excluded from the requirement list since the storage of a message on the platform will not be part of supporting the core interaction. Insights are gained on how this can be possible as a future possibility. The medication-based access can be regulated by an access control list, stored in the centralised storage of the communication system. Messages should be stored based on the medication labels, but the most important feature would be ensuring the messages are stored anonymously. This will need an additional platform module.

API Design
The communication module depends on the message retrieved from the API. The APIs should include endpoints enabling communication between different healthcare organisations' systems. The endpoints in the API should include a mechanism to read the messages' metadata to ensure the right direction. The use of APIs is discussed more in detail in Section 6.3.

Temporary Storage: Queue
Where could the message be temporarily stored? Literature provides lots of possibilities for storing communication. To start with an old introduction: relational databases, store data in tables, where each row represents a record and the columns the attribute or a property of the record (Baxendale & Codd, 1970). Document-oriented databases save and organise data as documents, this could be arrays, key-value pairs, or more nested structures (Leavitt, 2010). Since every object can have different types of schemes, this will allow for more flexibility and scalability than relational databases. Object storage stores data as objects including data, metadata and a unique identifier, while no hierarchies or fixed structures are used to organise data, enabling users of the data to manage, and access data using HTTP-based protocols or RESTful APIs.

Whereas in 1986 the stack data storage following a last-in-first-out approach was already fully understood, the world of queues opened, introducing the first-in-first-out storage (Li et al., 1986). A message queue is a type of storage that stores and organises data as messages, consisting of data, metadata and a unique identifier. Message queues can ensure reliable message delivery, inter-application connectivity, versatility, resilience, and improved security. Message queue cannot be used for storage, once the message has been read, the message is deleted from the queue (increasing safety on the platform).

Notification System
As described in the example in the text box, the platform sends a notification through the API to the complementors' ISs if the message is waiting in the queue. Sending notifications when the FHIR broker sends a message to the queue, can't be done by the FHIR broker, but needs an additional system, for handling the notifications. The FHIR broker can send a signal when the message is placed on the queue, followed by the notification system translating this signal into a notification for the complementors' system.

The way notifications are sent can be based on multiple approaches. An example of design in a consumer context is pushing notifications. (Iyer & Zhong, 2021) researched two consumer push strategies, a noisy push strategy, and a partial push strategy. They concluded, within the consumer context, that push notifications (including a red button with the number of messages for example) improved customer checking since they create an impulse to check the notifications. Despite this design context is different than consumer behaviour, it does indicate the importance of researching how the notifications need to be sent to the HCPs to obtain the best possible result.

6.2.2. Code Implementation Module

This module's objective is to implement a comprehensive code management system that includes well-documented, easy-to-find codes related to the care around the medication process. This component enables generic communication, ensuring transparency and consistency in information exchange.

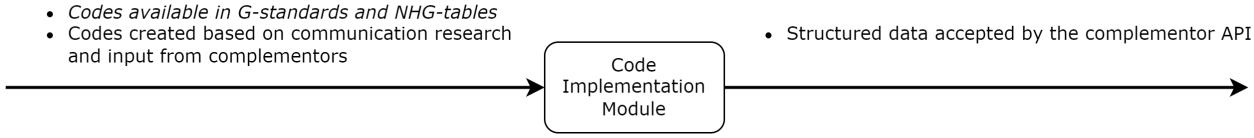


Figure 6.4: Input and Output of Code Implementation Module.

The code implementation module supports the content of the messages sent through the platform. To support users, the platform needs to somehow safeguard the quality and clarity of the communication. The participants in this research indicated resistance towards an overkill of unclear information. Limiting this by adding a labelling process to the communication would improve the generosity of the information. Existing labels, and codes, are found in practical documents as described in Chapter 3. In the PH and GP domain, the standards for applying code-based information exchange can be found in G-standards (KNMG, 2022) and NHG-tables (Nederlands Huisartsen Genootschap, 2023). Additional codes will need to be constructed. The low-level requirements realised by this module are shown in Table 6.2.

Table 6.2: Low-Level Requirements within Code Implementation Module.

Req	Requirement	Realised By
3.1.1	Include a sufficient amount of communication areas.	Communication Code List System
3.1.2	Ensure well-documented codes.	Communication Code List System
3.1.3	Ensure easy-to-find codes.	Communication Code List System, API, *Complementor*
1.2.2	Provide links between communication regarding care around the medication process and ICPC codes.	Communication Code List System, *G-standards, NHG-tables*

A trade-off is found in deciding who will be responsible for the translation of the communication. Will it be the sender itself, by providing answers to structured data forms in which the data should be directly placed (provided by the used system), even by using drop-down menus (for example the patient chooses the healthcare organisation and HCP through drop-down menus). Will it be the complementor, accepting unstructured and unlabelled data, but translating that data before transferring it to the platform? Or will it be the platform?

Following the results of the evaluation it is assumed that the complementor will receive the responsibility for delivering data that is coupled correctly to the codes provided by the platform. The codes already available by KNMG (2022) and Nederlands Huisartsen Genootschap (2023) can directly be used. The information in the *communication code list system* would include additional codes and a fusion of multiple codes. Considering the additional codes, an example of a code can be a frequently asked question. The responsibilities for providing those frequently asked questions or notifications should be defined, but the purpose of this would be that it can be researched how many times a specific question is asked. Question-code could also be used in a fusion of a question code, an already existing medication code, and a code on illness (for example *Patient asks: What is the effect of this medicine? Patient has diabetes. Patient takes metformin.* could be coded by QE1-DIABETES-METFORMIN). From a future vision, the labels of the message can be stored in the platform, providing insights on what questions/comments are made frequently looking at a particular illness or medication.

Furthermore, the effect of using a code base in a couple of areas of communication could support AI tools, which currently develop at full speed, especially in the area of answering all types of questions. healthcare organisations are already experimenting with applying AI in answering healthcare-related questions. For example, the radiology domain, leading in the use of AI for assessing X-rays. They were able to take the lead since they saved X-rays for 20 years already and therefore had a lot of training data (Kalse et al., 2023). This indicates, that if communication is stored for a longer period of time (which does require some additional research on save storage, since now the information is stored within complementors' systems), it can be determined sooner whether the query can be answered by AI.

6.2.3. Patient Engagement Module

The patient engagement module realised by the platform itself is shown in Figure 6.5 and is primarily focused on establishing data considering the HCPs' response statistics. The overarching goal is to support patient participation by enhancing self-management, and choice of communication. Patient engagement is already supported/interwoven by the communication and message module, but this module does dive into more platform features that should engage patients in participating in the digitalisation of communication.

This includes providing patients with different communication channels (e.g., messaging, video consultations), enabling accessible communication from patient to HCP, and supporting patients' input and expectations. However, as seen in Table 6.3, the responsibilities for patient engagement are mostly realised by the complementors. The requirements enabled by the complementors are focused on only the patient side and don't necessarily need to be handled by the platform. As discussed in the previous Section, the complementors are responsible for providing the communication in the correct structure (further discussed in Section 6.3). How they achieve this, is part of their IS, and creates possibilities for innovation among the complementors.

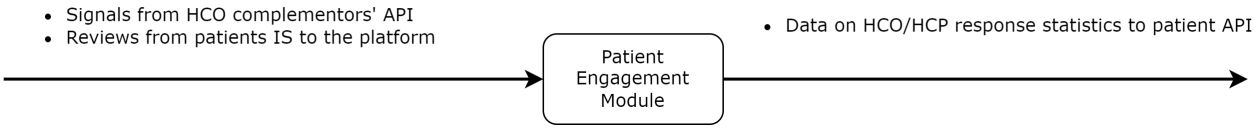


Figure 6.5: Input and Output of Patient Engagement Module.

Table 6.3: Low-Level Requirements Patient Engagement Module.

Req	Requirement	Realised By
5.1.1	Enable patients to choose their way of communication.	*Complementor*
5.1.2.1	Ensure easy communication from patient to HCP.	*Complementor*
5.2.1.2	Enable use of spoken language.	*Complementor*
5.2.2	Ensure communication is adjusted to the patient individual needs.	*Complementor*
5.4.1	Provide a review mechanism.	*Complementor*, Response Statistics System
5.4.2	Provide a user guide for patients.	*Complementor*
3.2.2.1	Provide an indication of response time of HCPs.	Response Statistics Service, FHIR broker, API
3.2.2.2	Provide an indication of response content provided by HCPs.	Response Statistics Service, FHIR broker, API

Self-Management Patient

Enabling patients to choose their way of communication is the responsibility of the complementor. However, not only the complementor on the patient side. It includes two different objectives, (1) patient IS enabling patients to call the patient IS to construct a

message for HCPs, (2) HCP ISs enabling HCPs to fill in the message and the answer in the communication module considering the patient of interest, to document the phone call, email, or face-to-face conversation. The latter can be researched using examples from a customer relationship management (CRM) system like HubSpot, enabling system users to document communication automatically in one overview, including email, phone calls, and meetings (HubSpot, n.d.). Nonetheless, HCPs expressed reluctance against administrative work, so implementing the second objective will be difficult to support.

Response/Review Mechanism
Not only choosing their way of communication improves self-management. A review mechanism serves two values: *self-management* and *trust*. The review mechanism will enable patients to review the answers of the HCPs, based on speed, content, etc. Providing the patient with the opportunity to commit to the system in a way that can influence other users in more argue-based decisions improves the self-management of both patients in this case. If patients contribute adequately to this review mechanism, it improves self-management (since the patient can choose based on more information), as well as trust (due to improved transparency and understanding of how an HCP is reviewed).

The review will be received by the complementors of the user and will be accepted on the platform in a defined structure. The response statistics system will save the structured reviews linked to the HCPs. Note that the complementor is responsible for making the review anonymous since it will be sent to other users. It should be researched how frequently the complementors will be updated on the reviews and who will receive what reviews.

Information Availability Patient
Furthermore, the information available to the patients will improve self-management and personal care. Patients need more information, as also discussed by NHG (2022), for example focusing on translating ICPC codes to patient-friendly titles. The table for translating the ICPC codes to patient-friendly titles (NHG-table-65) is included in the platform to support complementors with clear overviews of standard codes that are advised to be used in translating the communication towards a patient. These tables can be generated additionally. Furthermore, the information can be adjusted to patients' needs to improve personal care. For example, disparities in language use because older people are habituated to speaking a different language than young people or the availability of non-Dutch languages for Dutch citizens who speak another language. These prerequisites are the complementors' obligation to enhance innovation.

6.2.4. Reward Module

The current Dutch healthcare system primarily relies on financial rewards as incentives for HCPs. Funding is used to reward work, time, and effort. This is justified by the need to allocate financial means, particularly given the current pressure on healthcare resources. However, this research additionally explores alternative reward mechanisms while acknowledging the importance of financial incentives. Table 6.4 shows the low-level requirement realised by the reward module, of which the in- and output are shown in Figure 6.6.

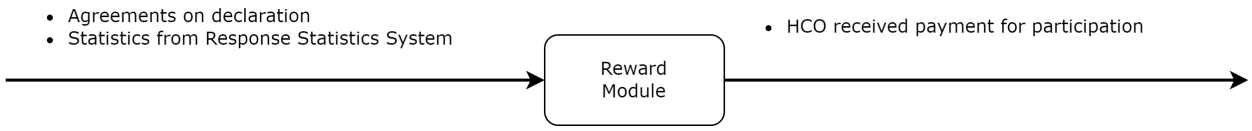


Figure 6.6: Input and Output of Reward Module.

Table 6.4: Low-Level Requirement Reward Module.

Req	Requirement	Realised By
1.1.2.1	Include a reward mechanism for taking over responsibilities.	Agreement System, Declaration System

What will be rewarded?
In the context of communication regarding care around the medication process, HCPs desire rewards to motivate their involvement. Several factors can be considered for rewarding HCPs: (1) time, (2) number of handled requests, and (3) their rating. Firstly, time. HCPs can be rewarded for their time answering patient inquiries or addressing concerns related to the medication process. This acknowledges the value of their time and effort. Secondly, the number of handled requests. Rewarding HCPs based on the number of requests they handle from patients and other HCPs creates incentives to efficiently handle communication and prompt responses. This metric reflects their efficiency and engagement in the process.

Something relatively out-of-the-box (according to PA1) is financial reward based on ratings. This would improve patient management because they would be involved in evaluating the communication, but it may reduce healthcare organisation's desire to join the platform because the payment is less specific. This would assess and highlight the HCPs' performance in communication. Such a mechanism could benefit patients in making informed decisions when choosing a GP or PH. It also supports patient self-management by promoting transparency and accountability within the healthcare system.

Who will reward?
Insurance firms hold a dominant presence in the healthcare industry. healthcare organisations declare insurance-based. Citizens are linked to an insurance provider at a particular degree of protection. healthcare organisations are compensated financially based on the insurance of the patients and further by patients' budgets. When examining the regulations about the scope of the reward system, it is also possible to investigate whether any other actors can be accountable for delivering the budget. If a HCP answers a question for another HCP, the replying HCP can be compensated on a contract or fee basis.

A more creative option would be to investigate how the platform owner might intervene within financial incentives for platform complementors to engage. When would a platform owner be responsible for compensating complementors for their engagement on the platform? Can it be incorporated into a strategy for implementation? This relies on who owns the platform. If the government owns the platform, government funds may be utilised to ensure the successful implementation of communication digitisation. This is less likely if the platform owner is a private entity.

Concluding, a combination of financial incentives and review-based reward mechanisms can effectively motivate HCPs to communicate about the medication process, leading to improved patient care and empowerment. Technically speaking, the budget can be allocated following results from a designed algorithm based on the aggregated data in the review statistics system. The question is instead on what rules the algorithm is based on. To decide those rules, the reward module does need further insights on how to reward healthcare organisations. What happens if the patient and the HCP do not have a treatment relationship? Will the HCP be able to acquire the patient's insurance information? Is a separate financial system, sponsored by the platform owner, required? What will an HCP receive for responding to another HCP? How will that be rewarded financially? Will a financial transaction occur between two HCPs?

6.2.5. Complementor Integration Module

As shown in Figure 6.5, the complementor integration module uses structured agreements to control the complementors' performances on the platform. The agreements themselves should be added to the agreement system by the platform owner. The complementor should discuss this with the platform owner, based on which the platform owner will document the agreements. Adding a complementor to the system will not be handled automatically for now. This aligns with the requirements that need to be realised, as shown in Table 6.5. Those requirements appoint the importance of *supporting* the agreements, not *creating* the agreements. Furthermore, the platform includes *complementor management* to monitor and control if the complementors and the platform meet the agreements in the agreements systems.

More research should be done on how to structure the agreements. What factors should be considered in the agreements? What HCP data can be saved on the platform? Will every complementor keep their contract? What if the contract changes in the future? Will there be a legal staff in charge of the agreements?

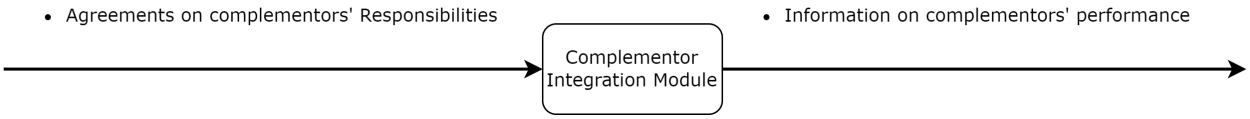


Figure 6.7: Input and Output of Complementor Integration Module.

Table 6.5: Low-Level Requirements Complementor Integration Module.

Req	Requirement	Realised By
4.1	Support local agreements.	Agreements System, Complementor Management
4.2	Support national agreements.	Agreements System, Complementor Management
4.3	Support inter-HCP agreements.	Agreement System, Complementor Management

6.3. General Platform Setup

6.3.1. Structured vs. Unstructured Message

The concept of *accepted structure* has been discussed several times in the explanation of the platform components. However, it is not apparent what this acceptable structure involves or how it is characterised. Unstructured data, such as qualitative information saved in text files, differs from structured data, which consists of numerical and coding data. While no platform can accommodate only unstructured data, the platform's communication function requires the transfer of text files. Despite efforts to reduce the use of text files through code-based communication, expecting all interactions to be 100% code-based is unrealistic. As a result, a combination of structured and unstructured messages is appropriate, with the unstructured portion organised using metadata that includes numbers, codes, labels, and other pertinent information.

A method enabling structure is accepting JSON structures, which is one example among many but is widely used and easy to use for data exchanges within systems (Walker, 2022). It provides a flexible and easily readable framework that allows for the structured

representation of information. By adopting a JSON structure, data can be organised using key-value pairs, making it simple to store, transmit, and interpret data across different platforms and systems (Xin et al., 2018). This versatility and widespread acceptance make JSON a practical choice for structuring data in various applications, including communicating and exchanging information within the described platform.

6.3.2. Platform Integration

Importance of connecting with Patient Systems
Patients currently interact with GP/PH through several systems, for example, PGOs, Patient Platforms, Applications of healthcare organisations, etc. The Ministry of Welfare and Sports strives to support the growth of these PGOs, mainly to ensure every citizen can see and adjust their personal information by themselves (Kuipers, 2023). Since his policy mainly focuses on these PGOs, PGOs are positioned as an essential system to inter-operate with. Kuipers (2023) will put a lot of effort into developing and improving the use of PGOs in healthcare. Therefore, this would be a future-proof direction.

APIs
Tiwana (2014) states that killing the autonomy of app developers will kill the innovation potential within a platform. The API structure that connects with the platform components (equal for all) could be the responsibility of the app developers since then innovation will keep being stimulated. A platform ecosystem must therefore balance autonomy and control (Iansiti & Levien, 2004). This is one objective of using APIs in the design, while the other lies internally. As can be seen in Figure 6.2, the information and technology layer are also connected with internal APIs. Internal use of APIs between these layers improves resilience and maintainability. The internal API will connect a technology solution in the technology layer with an information system in the information layer. When a new technology is developed supporting one information system, this can be easily coupled with the information system through the API.

Tokens are commonly used in API-based systems for authentication and authorisation. They function as a credential, allowing users or apps to access restricted resources or perform specific operations. Updating tokens frequently contributes to the API system's security. You can reduce the risk of unauthorised access and the impact of compromised tokens by introducing token expiration and refreshing methods. Because tokens have a finite lifespan, even if an unauthorised entity obtains a token, it will become invalid after a specific time, decreasing the window of opportunity for potential misuse.

Furthermore, token updates can be used to validate the validity and legitimacy of the requesting party. The API can ensure that the requesting entity is still authorised and authenticated to access the protected resources by requiring token renewal or re-authentication at specific intervals. This helps to prevent unauthorised access and keeps the system secure. To summarise, constantly updating tokens in an API-based system is a critical security practice for preventing unauthorised access and maintaining system integrity. You can improve overall security and control over access to your resources by using token expiration and procedures.

Communication Pattern
To support the functionalities in the platform, Figure 6.8 shows how a three-way handshake communication pattern can be implemented in the platform (Fulber-Garcia, 2022). The concept is only visualised for sending the message from the queue to the API but will also need to be applied to the communication between the other components. The three-way handshake ensures the message arrives at the receiving system. This is necessary since it is essential that the message will arrive at the destination and won't get lost on the platform.

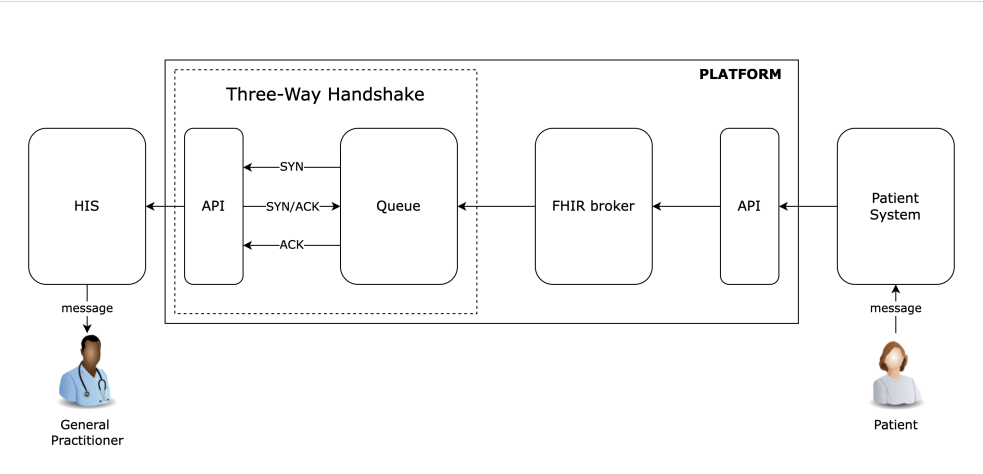


Figure 6.8: An Illustration of the Application of a Three-Way Handshake on the Platform.

6.3.3. Security Measures

Implementing robust security measures is crucial in platform design to safeguard sensitive information and maintain system integrity. This includes incorporating encryption to protect data during transmission, utilising audit logging to maintain a com-

prehensive record of platform activities for security analysis, and implementing monitoring systems to proactively identify and address anomalies, threats, and operational issues. By integrating these measures, platforms can ensure data confidentiality, integrity, and availability while meeting industry standards and regulatory requirements. Considering the security measures, as discussed in Chapter 3, it is important to comply with all the laws constructed for enhancing security in the healthcare context.

6.4. Conclusion Chapter 6

Chapter 6 answers sub-question 3 *How can the platform architecture components be designed that enable the requirements?* by showing the design choices and the description of the final result of the platform architecture design. Next to the insights on how the platform architecture can *look*, the sub-question also intends to answer *how* the requirements are translated to a platform architecture. The look of the platform architecture is one of many feasible options. This design is focused on ensuring the platform's core functionality is clear to a diversity of teams: development teams, management teams, other businesses, or the government. This representation of the system can improve the development of system details since the design is not yet fully detailed. Development teams can brainstorm on the interpretation of the technology layer, while business teams can discuss the stakeholder game following the business processes. The use of the platform architecture to guide the PBIS's design is further discussed in Chapter 6.

Designing platform components enabling the set of requirements, as formalised in Chapter 5, unravelled the following conclusions. The requirement formalisation was a starting point for developing a more platform-based categorisation, the platform modules. This can be supported by the idea that SRS entails several overlapping functionalities, which aligns with the method of Brazier et al. (2018). The SRS can't be used 1:1 for developing the platform modules but functions as a starting point for structuring/categorising. Categorising the low-level requirements from the SRS supported the architecture design process since the low-level requirements directly touched upon the platform modules' functionalities. This made the SRS a helpful starting point for developing the platform modules.

In conclusion, the architecture design process has shed light on the crucial role of platform complementors in the platform's overall success. It has become evident that not all requirements can be fulfilled solely by the platform itself, necessitating further research to determine the trade-offs and responsibilities involved in achieving interoperability requirements. Nonetheless, it shows that the platform design has the potential to significantly enhance innovation, particularly in the first-line healthcare domain, as highlighted by (Kuipers, 2023). It impacts answering sub-question 3, as not all requirements identified in field research can be fully enabled through the platform architecture design. This underscores the dynamic nature of platform development and the need for continuous refinement and adaptation to meet the requirements while keeping in mind overarching criteria (such as innovation).

7

Evaluation: Platform Architecture Enabling Interoperability Requirements

The design as presented in Chapter 6 is the final design, constructed based on three iterations. The iterations are based on semi-structured evaluation interviews with platform experts. This Chapter gives an insight into the evaluation, including the design's usability, validation, and verification. Section 7.1 shows the process of iterating on the design, following the evaluation approach as defined in Section 7.1.1, based on suggestions by the interviewees. Findings are constructed as well on platform criteria (Section 7.1.5), stakeholder interactions and the need for detailing (Section 7.1.6). Evaluating the designed platform iterations with experts touches upon the *experience & expertise* pillar of the knowledge base as represented in the design cycles of Hevner (2007), in Figure 2.1. The evaluation based on earlier constructed requirements is discussed in Section 7.2

7.1. Iteration Process Based on Semi-Structured Evaluation Interviews

7.1.1. Evaluation Approach

An expert evaluation approach will be used to enable iterations based on the evaluation of the platform. First, the experts' overall perspectives on the design will be discussed. Asking for first opinions on the design creates an open setting where the expert should feel free to say anything. The design will be especially validated by discussing the platform components and underlying requirements from Chapter 5. The validation focuses on the following questions: Does it meet the needs of the user? Does the design match the requirements established in the design process? Can the architecture design components meet the requirements? Verification supports the idea of the design to be not missing any requirements (Maropoulos & Ceglarek, 2010). Is the right job done? Are the right technologies used? Could you work with it operationally - with your design team? Does it comply with a set of design criteria?

Following Tiwana (2014), four platform architecture criteria are discussed: simplicity, resilience, maintainability and evolvability. The four properties, as discussed below, cannot all be met fully by the platform architecture, since the properties invoke trade-offs, meaning that focusing on improving one property could decrease another (Tiwana, 2014).

- *Simple* Be comprehensible at a high level of abstraction. Interactions should be well-defined and explicit.
- *Resilient* One defective system should not cause the entire ecosystem to malfunction. Weakly coupled platform applications through stable interfaces.
- *Maintainable* Cost-effectively make any changes within the platform, without breaking applications that depend on it.
- *Evolvable* Can the platform do things in the future for which is was not originally designed?

The iteration process is based on four semi-structured interviews with the experts shown in Table 7.1. Platform architects from different domains are invited to evaluate from a more broad perspective. The interviews resulted in discussions between the researcher and the interviewee, but also led to interesting brainstorming sessions arising questions like: How should the system be further designed? What functionalities can be added? What use cases exist on the platform? Who is responsible for what processes? What is needed additionally to enable successful implementation?

Sections 7.1.2, 7.1.3, 7.1.4 discuss the most relevant insights resulting from the results in Appendix M, considering the suggestions on the platform architecture design and the additional findings on the stakeholder responsibilities. The earlier versions of the platform design are shown in Appendix N, shortly addressing earlier made design choices. The stakeholder responsibilities and interactions were additionally found to result from the flow of the interviews. These insights do not directly affect the design of the platform architecture on the applied abstraction level but are needed for successful implementation and are thus relevant. Furthermore, Section 7.1.5 discusses the perspectives on the platform verification criteria and Section 7.1.6 outlines other relevant findings on needed detailing for the platform design.

Table 7.1: Overview Participants Evaluation Platform Architecture.

Interviewee	Job Position	Years of Experience
PA1	Platform Architect within Healthcare Domain	27 years
PA2	Platform Architect within Education Domain	17 years
PA3	Platform Architect within Healthcare Domain	17 years
PA4	Platform Architect within Production Domain	28 years

7.1.2. Results Semi-Structured Interview with PA1

Section M.1 in Appendix M shows the full insights gathered during the semi-structured evaluation interview with PA1. Platform design V1 in Appendix N was discussed with interviewee PA1.

Suggestions based on Results

An overview of the suggestions considering the platform architecture design stated by PA1 is denoted in Table 7.2. The acknowledged suggestions are included in the iteration of the discussed design. Looking at the findings, it can be concluded that the technical possibilities go beyond the current system. This supports the letter from Kuipers (2023), stating the current healthcare system is limited due to already interwoven standards. An explaining example is the implementation of FHIR building blocks (Zibs). Ensuring a Zib is accepted by the entire healthcare system took years in the case of integrating a Zib for lab results (Interviewee PA1).

Table 7.2: Overview of suggestions to the first iteration based on a semi-structured interview with PA1.

Concept	Suggestion	Acknowledged yes or no
Clarity	The design is hardly readable and needs to minimise the number of lines.	Acknowledged: readability is highly important.
AMQP vs. FHIR	The directing protocols are regulated following the FHIR standard in Dutch healthcare systems. AMQP would be technically possible, but not according to current standards.	Acknowledged: it corresponds to the environment as described in Chapter 3.
Financial System	The external financial system should be replaced by insurance companies since they are responsible for handling declarations based on citizens' insurance.	Acknowledged: it's expected the institutional setup with insurance companies will remain for now.
ICPC Thesaurus	ICPC Thesaurus is part of a bigger concern, namely the NHG-tables. All master tables should be included in the platform.	Acknowledged: all already standardised data must be integrated in the platform.
MP9 Information Database	MP9 Information Database is part of a bigger concern, namely the G-standard as proposed by KNMG. The entire G-standard should be incorporated into the platform.	Acknowledged: all already standardised data must be integrated into the platform.
DVZA	Apply DVZA as a middle party to transfer information from an AIS or HIS to a patient system.	Not acknowledged: transferring the messages from system to system is different than document transfers.
AMO	Ensure the communication is connected directly to the AMO	Not acknowledged: interesting insight, but storing AMOs on this platform causes privacy issues.
Information Pattern	Provide clarity on where the information is stored and when.	Partly acknowledged: not part of architecture design, but will be added additionally.

Additional Insights on Stakeholder Interaction

In this Section, additional insights are discussed.

First of all, the expected role of pharmacies in communication came up. PA1 expects PHs to take on more responsibilities in answering patients since they have more time. Additionally, pharmacies do have a more business perspective, willing to accept possibilities to let their business grow. Secondly, the privacy issues regarding communication storage were discussed. PA1 argued the privacy flag. The privacy flag goes up directly when it concerns the storage of healthcare-related data and hereby delays the process of implementation immediately. Furthermore, the role of the platform owner regarding patient participation. To what extent is the platform responsible for patient participation? PA1 argues that the patient systems should be responsible for creating a user-friendly interface for patients and supports this with an example in the lab results.

> *"When lab results are shown in a PGO, some results that differ from the average are shown in red. This could result in a directly worried patient. While some additional information explaining the outlying results would support the patient in drawing a better-argued conclusion."* (Interviewee PA1)

7.1.3. Results Semi-Structured Interview with PA2 and PA3

Appendix Section M.2 and M.3 show the full insights during the second round of semi-structured evaluation interviews. Interviewees PA2 and PA3 discussed platform design V2 in Appendix N.

Suggestions based on Results

The suggestions aroused by PA2 and PA3 are shown in Table 7.3. The suggestions are focused on clarity in terms of the diagram itself, as well as the interaction pattern, the platform management, the use of terminology, and some additional suggestions supporting the functionalities. Most suggestions were shared by, or a combination of both PA2 and PA3. This supports the importance of assessing the suggestions.

Table 7.3: Overview of suggestions to the second iteration based on semi-structured interviews with PA2 and PA3.

Concept	Suggestions	Acknowledged yes or no
Clarity	According to PA3 the architecture still includes too many lines. Leave out the (...) complementors. Furthermore, the consistency of terminology is addressed by PA3.	Acknowledged: readability is important. It is even chosen only to include one API for the HCP side and one on the patient side to minimise the complexity but still show the main idea. The consistency of terminology is also acknowledged.
Use of Modules	PA2 and PA3 are advised to carefully define the granularity and life cycle of one module to improve the use of modules. Each module should consist of (1) the goal, (2) the performance indicators, and (3) the critical systems within the module.	Partly acknowledged: the life cycle of the modules was not considered by the researcher but is part of using modules in platform design. The goal and performance indicators will be described. All critical systems will not be in the scope of this design.
Platform Management	Agreements, procedures and monitoring are part of platform management. This should be included separately. Furthermore, the monitoring of structured agreements is mentioned by PA2. PA3 also mentions failure management and auditing. What if HCP is fired and deleted from the system? But a message is just sent to that HCP?	Acknowledged: including monitoring, auditing, safety, etc. will be more clear as a separate part of the platform. Following NEN5710 as mentioned in Chapter 3
Document Management	This term is confusing for platform/software architects due to the nature of document management in the domain of IT. Both PA2 and PA3 share this suggestion.	Acknowledged: confusion is undesirable.
Abstraction Level	It is argued by both PA2 and PA3 that defining the technical communication protocol (HTTP/REST) does not belong in this level of abstraction. Defining the communication pattern would contribute to guiding the design. PA3 also advises including the first two layers of Archimate.	Partly acknowledged: the level of abstraction and defining the technical protocol do not correspond together, but the technical standards (on protocol and pattern) will be advised on by the design. The layers will be added since it is supported by literature as described in Chapter 6.
Anonymous Communication	Ensuring anonymous communication is a study on its own, and in case medication-based access is available in the platform, it needs additional attention. For feedback between two HCPs, it should be their responsibility.	Not Acknowledged: a medication-based overview of all questions and communication around it would support research and improvements of a certain medication but can be added in the future (Requirement 2.3 rejected for design).
User Catalog	More detailed description of the user catalog is needed. The user catalog needs functionalities (PA2). How does the user catalog connect patients to HCPs? PA3 also argues for a division of the user catalog more scoped (PA3).	Partly acknowledged: the division of the catalogs won't be made in the architecture design, but the responsibilities need to be described.
Notifications	FHIR broker is not capable of aggregating information. A separate system should be designed to send notifications to the complementors based on an aggregation of information.	Acknowledged: technically important.
Core Interaction	Use cases explain the interaction and information exchange clearly. A clear and basal interaction description is needed to make the platform attractive for complementors. PA2 argues that every commercial platform reap the benefits from a basal core interaction description.	Partly acknowledged: not part of the platform architecture, but will be added additionally. The importance of use cases was also discussed in Chapter 5.
VZVZ	Include the address book provided by VZVZ (Dutch: *Vereniging van Zorgaanbieders voor Zorgcommunicatie*). This address book will be maintained by another party, which means less work on the platform.	Partly acknowledged: there can be a link to VZVZ, but it needs additional addresses.
Queue	Adding a queue to fill two purposes: (1) failure management, (2) enable sending a message to multiple destinations.	Acknowledged: needed to enable the platform functionalities.

Additional Insights on Stakeholder Interaction

In this Section, additional insights are discussed.

Both PA2 and PA3 support the use of API. However, using APIs would need extensive agreement systems considering the stakeholder interaction. Who is allowed to plug into your system? What information is exchanged through the API? What are the conditions for the complementors? To guide the cooperation, each complementor should sign an agreement. If those agreements include conditions for the complementors (such as the need for proper information safety), the need for creating a monitoring team would emerge. Additionally, the differences in complementors were discussed and raised questions. Are there any differences between AISs and HISs? Between an AIS and a PGO? What are the differences in terms of roles? Do they have different rights? Or the same? These questions arise again in case other medical specialists can be considered platform complementors. Furthermore, responsibilities should be decided regarding providing the information needed on the platform. Is the platform responsible for connecting users (HCP<>patient or HCP<>HCP)? Who defines the relationship between individuals? Which patient needs a connection with which HCPs/healthcare organisations? Concluding, it can be said that the technical coupling layer in a platform cannot stand alone. It will need agreements on the coupling layer, institutional interventions should be created on the connection conditions. These institutional interventions are expected to answer previous questions and probably even more.

The responsibilities for the supervision of identifying the users must be defined. The identity of patients is mainly defined by their BSN number. But as already stated in Chapter 3, organisations are not allowed to use BSN numbers easily. Furthermore,

PA3 started the discussion on how to regulate a patient's insurance, which is also linked to the BSN. The need for an additional identifying system was addressed when identifying HCPs, currently handled by BIG registration. The BIG registration cannot cover all HCPs working in the healthcare field, such as assistants, while assistants are genuinely relevant in handling communication.

The responsibilities considering user-friendliness regarding creating the message itself are also discussed extensively. PA2 raised questions while validating the evolvability requirements considering new communication technologies. The preference for making the complementors responsible for user-friendliness is outlined by both PA2 and PA3. This would also be part of the API agreements regarding allowed data. Verifying the patients' data is additional functionality for discussing the responsibilities. Would it be on the patients' side? Or would it be implemented on the healthcare organisation side? Or is it the platform that is responsible for this? PA2 and PA3 both support the headless character of the platform - meaning the platform does not provide any user interface. Also, responsibilities considering the settings around the notifications should not be part of the system according to PA2 and PA3. This came up during the validation of the requirements. If the platform were responsible for this, the platform would need additional information on the complementor and all the users in the complementor. For example, the time zone in which they are. According to PA2 and PA3, this would be the responsibility of the complementors.

Adding the feedback requirement (HCPs asking for feedback on a message from a patient to another HCP) would need to be their own responsibility, according to PA3. They are the ones that are easily capable of creating a new message with the request for feedback on the case anonymously, without disregarding the gist of the message.

Finally, the complexity of the financial system is mentioned by PA3. The process of deciding the agreements on this is, again, a study of its own. Who will receive a budget for answering the question? Only the ones with a treatment relationship with the patient? What will happen if a HCP without treatment relation answers to the patient? How will the HCP or platform connect the time spent answering the question to the declaration? The patient's BSN and insurance policy number should be known to declare to the insurance companies. Or would this be supported by the platform? Would the budget be made available by the government? To support the communication?

7.1.4. Results Semi-Structured Interview with PA4

Section M.4 in Appendix M shows the full insights of the interview with PA4, in which Platform Design V3 in Appendix N was discussed. Table 7.4 shows the suggestions for the third and final iteration of the architecture design. As can be seen, the number of suggestions from the perspective of PA4 is significantly lower than those of earlier discussed interviewees. This could be due to the incentives or attitude of PA4, but it is somewhat expected that the design was developed further, and thus fewer suggestions came up. Still, the suggestions are valuable for the design, mainly since the layered approach was presented for the first time.

Table 7.4: Overview of suggestions for the third iteration based on semi-structured interviews with PA4.

Concept	Suggestions	Acknowledged yes or no
Arrow Definition	Define for each arrow what is represented by that arrow	Not acknowledged: adding definition to all layers would decrease clarity. The semantics of the Archimate language could be used.
Layered Approach	Add the top layer (now called ACTOR) to the platform as the business layer, and change the current business layer to business processes. Furthermore, the responsibilities for each layer should be defined.	Acknowledged: assigning responsibilities for each layer supports the layered approach.
Internal API	Use internal APIs between information and technology layer to connect while maintaining resilience.	

7.1.5. Insights on Platform Criteria

The verification was supported by assessing four platform criteria: simplicity, resilience, maintainability and evolvability. Table 7.5 shows the perspectives indicated by the interviewees. Overall, simplicity was assessed slightly negatively, evolvable was assessed positively, and resilience and maintainability were assessed neutral/positive. Although PA2 specifically mentioned its supporting perspective towards *resilience* and *evolvability*, the interviewees did not mindlessly trust the decision for these validation criteria. Especially PA3 questioned the use of these platform criteria on the presented level of abstraction. The architecture design was not on the technical level PA3 expected it to be for assessing these criteria. In literature, this perspective is also supported by Michael et al. (2009) in terms of software architecture for systems of systems. According to both, firm conclusions on these criteria can only be made if the technical layer is fully described.

Furthermore, a perspective contradicted the perspective of Tiwana (2014). PA1 indicates that reducing the complexity (and thus increasing the simplicity) would also cause the other criteria to improve. At the same time, Tiwana (2014) states that increasing one criterion would cause the others to decrease.

The resilience of the modules is low. When the review statistics system is not working, no statistics will be shared with the declaration module, which means the healthcare organisation will not be financially rewarded. The frequency and based on which pattern the information is sent from the review statistics system to the declaration system should be defined. A three-way handshake prevents information from being lost.

Table 7.5: Insights on Platform Criteria, Distinguished by Positive and Critical Perspectives Considering the Platform Design and the Criterion.

Criterion	Positive Perspectives	Critical Perspective
Simplicity	• High-level abstraction is clear (PA3) • Regarding V3, the architecture is assessed clear (PA4) • Regarding V3, the interaction pattern is clear (PA4)	• Design is too complex due to too many lines (PA1) • Interaction pattern is not yet clear enough (PA2, PA3)
Resilience	• The platform by itself does not affect the complementors' system (PA2)	• A highly complex system will break (PA1) • Manual processes taking over automated ones should be defined as part of a business continuity plan (PA2) • Too high-level abstraction to provide a firm conclusion (PA3, PA4) • Additional non-functional requirements are needed (PA3) • Scenario development would improve insight into resilience (PA4)
Maintainability	• Use of modules supports maintainability (PA1) • Use of FHIR supports maintainability due to versioning (PA3) • Platform management processes in V3 positively affect maintainability (PA4)	• Modules should be defined concerning life cycle (PA3) • Input and output of the modules should be defined and monitored (PA2) • Logging and monitoring should be part of the platform management (PA2) • Behavioural side needs to be regarded: team management, team responsibilities etc. (PA2) • Too high-level abstraction to provide a firm conclusion (PA3)
Evolvability	• Modules added to the system indicate that it's evolvable (PA1) • High-level abstraction is understood (PA1, PA2, PA3) • Headless platform is good for evolvability due to fast-changing user interfaces (PA2) • Standards improve evolvability by releasing new versions (PA2) • API support evolvability (PA3)	• Reducing complexity would increase evolvability (PA1) • How to cope with upcoming communication means such as home speakers? (PA2) • The interaction pattern needs to be more detailed to be future-proof considering new technologies (PA2) • Interaction pattern is needed to add additional functionalities to the core interaction (PA2) • Add a modern API strategy - regarding the evolvability of state-of-the-art programming languages/communication protocols (PA2) • Add even more APIs between the information and technology layer (PA4) • Scenario development considering the two options for evolvability (add-on or improve) would improve evolvability (PA4)

7.1.6. Insights on Need for Detailing

Structured/Unstructured Data
It should be discussed what the exact information is that is needed for each of the sub-systems. What information do patients want to see in response statistics? Are they only interested in the specific HCP? Or as well in the healthcare organisation? Furthermore, the information insights should include the decision on structured or unstructured data (or both). Is a block-based approach used, asking the sender to fill in all the details of the receiver in drop-down menus? Is it allowed to record the name and organisation of the receiver in unstructured data? Will unstructured data be translated into structured data on the platform? What type of data is allowed on the platform? The need for deciding on this is argued by both PA2 and PA3. Both sharing the opinion structuring the data would be outside of the platform.

Labelling
PA2 supports labelling structured data but directly mentions the importance of using unstructured data in case of individual outliers. In the case of the communication system, this would mean that if every part of the message is linked to codes, and the combination of codes raises questions during the interpretation, the unstructured data would be necessary to conclude. Furthermore, the content or labels of the notification should be researched. Will it be helpful to include a notification status? Indicating if the notification is read/unread? Will it improve communication efficiency?

FHIR broker
A level of detail is further needed in the tasks for the FHIR broker. Every task, and every procedure the FHIR broker must know, should be designed and coded. Answers are needed to the following questions. What to do when receiving a message from an API? To whom should it be sent? What is the address of the receiver? Is there more than one receiver? How long should it be queued? What if the message won't be answered? What to respond to the sender while waiting? When to redirect? What information does FHIR need to send to the response statistics system? When? What if complementors are offline? Are any already existing Zibs used? What Zibs should be used?

Storage
The communication storage should be defined based on protocols. Multiple interviewees denote the importance of regulating communication storage.

> *"The communication storage equals the disability of the Dutch healthcare system. The privacy flag goes up, and there is the delay."* (Interviewee PA1).

PA2 introduced the importance by providing an example introducing SSI wallets. Individuals use SSI wallets to save frequently used data (such as marital status, birthplace, and email address) when registering at an institution (university, work, etc.). Questions followed as a consequence of implementing SSI wallets are applied in this case. Is the message encrypted? Is the message stored on the system? If the receiving party doesn't accept the message, will it be deleted? Will it be sent back to the sender? Who will have the message? Do healthcare organisations exchange the message?

7.2. Literature Evaluation of Architecture Design

In addition to an expert examination of the platform design, earlier researched design requirements will be compared to the architecture design presented in this research. Table 7.6 shows the requirements resulting from the research of van Hattum (2020), Groeneveld (2021), and Kong (2023), and if the design conforms to it. These thesis researches are already introduced in Chapter 3.

Looking at Table 7.6, it can be concluded the platform design can be positively compared to the requirements. A software development kit and DevOps tool for debugging application are not included in the design from a HCP perspective but is mentioned by interviewee PA3 as well. Furthermore, Kong (2023) outlined the need for less control by the Dutch government (SR2) and insurance companies (SR1). The Dutch government is expected to support the standards and regulations within the platform. The financial role of the insurance companies is still incorporated to support implementation. However, alternatives for payment are discussed in Chapter 6. How this can be achieved does need further insights into stakeholder responsibilities.

Considering the interfaces, the following can be stated. While this design leaves the interfaces to the platform complementors, van Hattum (2020) found that interfaces for critical functionalities must be qualitative and controllable (PCR4). The need for adaptability of interfaces, however, also mentioned by Kong (2023) (AR8), is supported. In the design of this study, platform complementors are intended to provide their interfaces to the users.

7.3. Conclusion Chapter 7

Chapter 7 showed that evaluating a design based on best practices is useful for realising implementation. First, the design was merely based on the best practices for achieving the functionalities within the system. The interview with PA1 already outlined some significant changes that prevent the architecture from failing in actual implementation; a more domain-specific design was created. Further suggestions improved the clarity of the diagram in terms of aesthetics and interpretation of the core interaction.

Considering the platform criteria, as proposed by Tiwana et al. (2010), it can be concluded that it is too soon to draw firm conclusions on the assessment for these criteria. Simplicity and evolvability were more easily assessed since they rely less on the technology layer in the architecture design. Resilience and maintainability, on the other hand, did raise a critical perspective from the interviewees due to the need for insights into the technology layer.

The evaluation considering literature did result in good insights. The platform design fits most of the earlier researched requirements, specifically for the PBIS, as is being researched during this thesis. The main dissimilarities were found in the use of interfaces.

Table 7.6: Evaluation of Platform Architecture Design by Comparison with Earlier Constructed Requirements for a PBIS in Dutch first-line Healthcare.

Ref	Platform Requirements	Conform Architecture Design?
PCR1	The design should include a meta-platform, facilitating the most essential functionalities.	yes
PCR2	The design should stimulate innovation within the meta-platform by an open-source approach.	yes
PCR3	The design should include proprietary platform cores 'under' the meta-platform to stimulate competition.	not yet, but sub-systems could be additional proprietary platforms
PCR4	The design should include selectively open interfaces for non-critical functionalities while keeping the interfaces for critical functionalities qualitative and controllable.	no interfaces on the platform
PCR5	The design should include stable interfaces for all functionalities since industry-standard interfaces would be hindered by political dynamics.	no interfaces
BR1	The system should support Data standardisation APIs, ensuring documentation of medical data is according to standardised protocols.	yes
BR2	The system should include Database Libraries, enabling applications to connect to databases on the platform. This can be used to connect applications to an EHR database.	yes
BR3	The system should include a software development kit (SDKs) to ensure complementors build applications in accordance with platform core capability and rules.	not yet
BR4	The system should support DevOps tools for debugging applications during development and testing the applications.	not yet
BR5	The system should support Terms and Conditions for proper governance of the platform.	yes
BR6	The system could support REST APIs, allowing applications or software to connect to the web base using the REST-protocol.	yes
BR7	The system could support Product Complementary APIs, ensuring the functionality of having financial transactions between complementors, platform owners and end-users	yes
SR1	There should be less control by insurance companies	discussed, but not yet
SR2	There should be less control by the Dutch government	in terms of standard difficult to obtain
SR3	There should be standardised guidelines for information exchange	yes
SR4	We should give caregivers enough power to interact (access) with others	yes
SR5	We should provide financial incentives for complementors	partly, only HCP perspective
SR6	Digital platforms should have a flexible, agile, cooperative and long-term architecture	yes
SR7	Digital platforms should have a clear mechanism for assigning responsibility	discussed in Chapter 8
SR8	Digital platforms should be designed to ensure alignment with business benefit objectives	yes
SR9	Digital platforms should incorporate new tested technologies for primary care development	possibly
AR1	The architecture should be able to provide access with the same capabilities to actors who have authorisation	yes
AR2	The architecture should be completely open for anyone to use; architecture should be completely open for authorised people to share information	agreement is necessary
AR3	The architecture should have the ability to adapt to changes in the environment	yes, evolvability
AR4	The architecture should provide a domain space for caregivers to interact	what is domain space?
AR5	The architecture should have clear control units for assigning responsibilities	discussed in Chapter 8
AR6	The architecture should provide a clear path to remote/online data storage	yes
AR7	The architecture should have a mechanism to comply with national information exchange regulations	yes
AR8	The architecture should have stable, dependable and adaptable user interfaces that can be used under dynamic situations	interfaces are responsible for complementor
AR9	The architecture should have complements that can be used and meet the dynamic needs of the market	unclear

8

Discussion: from PBIS to Ecosystem Perspective

In the following Chapters, I will reflect on the results. Starting with Chapter 8, mainly focusing on the results to answer the final sub-research question: *Considering the study, what lessons were learned in exploring platform design as part of the Dutch IS ecosystem in first-line healthcare?* Answering this sub-question addresses the main differences and consequences when shifting from the current situation to a PBIS ecosystem. The differences, as also visualised in Figure 1.2 in Chapter 1, are mainly found in (1) additional stakeholders and (2) technology perspectives. First, the effect of a technology-based intervention is discussed in Section 8.1, considering a technology-based intervention in general, the range of future opportunities, and the reflection of a digital platform approach. Hereafter, Section 8.2 discusses the challenges arising considering stakeholders in the area of incentives and responsibilities. Finally, the effect on the feasibility is defined in Section 8.3.

8.1. Technology-Based Intervention

Considering the application of new technologies as an intervention, following the interviewees with whom the design was discussed, the design created in this study showed that a lot is possible from a technological perspective. The results from the environment analysis in Chapter 3 already indicated more flexibility within the application and IT infrastructure layer of the layer model of Nictiz (2022a), since I expected fewer documents assessing the layer would mean fewer restrictions. Looking back at the evaluation interviews of the platform design in Chapter 7, the results show that the fulfilment of this layer is indeed more flexible than the fulfilment of the information or business layer as long as the technology supports the above layers in functionality.

Despite the technological layer's flexibility, the results also show the reliance between the levels, indicating its adaptability must be advantageous to the layers above. The results outlined that teams responsible for developing the technology layer of a system are highly dependent on how the system is described, how the purpose of the system is clarified, and how use cases are created to support decision-making. All focus on the responsibilities of the teams working on a higher abstraction level. Interviewee PA3 explicitely mentioned this: "*It's like s a layer of wrinkles that move with each other*" (Interviewee PA3).

The platform design enables expanding future potential because the information layers are created modularly, allowing for the inclusion of new information systems. Furthermore, it allows the technology layer to be quickly expanded by other technologies due to minimal limits on fulfilment.

8.1.1. Future Opportunities

Platform technology serves not only to achieve the overlapping functionalities examined in this study but also offers the opportunity to capitalise on future opportunities and emerging desires, as revealed by the assessment of the criteria *evolvability* (assessed in Chapter 7). The interviewees supported evolvability positively due to using platform modules and sub-systems in the information layer. The internal API layer supporting the connection between the information and technology layer (added to the final platform architecture design) furthermore supports the evolvability regarding technology since each technology can be easily connected to the sub-system in the information layer.

The requirements used in developing the design are based on a questionnaire specifically asking for communication regarding care around the medication process. When researching or even only discussing future possibilities, it is essential to keep in mind the relevance of those possibilities should be researched. One of those future possibilities could be a different financial system, apart from the current system including insurance companies. This can lead to users wanting to approach other platform users randomly and send requests without any budget-enabling relationship or treatment relationship. The business perspective can extend the platform by supporting a more broad question-and-answer objective.

Furthermore, as already shortly mentioned in Chapter 6, the addition of best practices in AI technology (as complementors or within the platform itself) can be a beneficial addition to the platform. An AI solution can provide less pressure on HCPs by taking over quickly-answered questions or providing HCPs with additional support while assessing requests (for example, as a sparring partner). An outlining example is the radiology case described by Kalse et al. (2023). They base the radiology diagnosis on a large set of X-rays. Kalse et al. (2023) describe why radiology is ahead of other specialisms in using AI. They have been saving

and sending all X-rays for the past 20 years, which improves training AI. This outlines relevance for saving communication on the platform as well.

However, the use of AI in healthcare is still in its early stages. Research, including at TU Delft and Erasmus MC, focuses on mapping AI in healthcare and what is happening around implementing AI solutions. The relevance of these studies is increasing as AI solutions are designed, but implementation often fails to happen (TU Delft, 2023). I expect the drivers for implementation to be negatively affected in the case of complex and sensitive health topics. This would provide opportunities for the design of this study, as communication in primary care is expected to be more often about less complex and sensitive topics. Thus people can be more likely to trust answers from an AI bot. However, these are only speculations and will thus need further investigation to see if AI can play a significant role in this platform-based solution.

Another future possibility also mentioned as a technological incentive for improving the current IS ecosystem, is the application of IoT technologies. IoT is already more adopted in healthcare, looking at patient self-measurement tools using sensors. Connected devices, such as wearables, sensors, and intelligent medical equipment, can collect real-time patient data, which can then be securely transmitted and analysed for timely interventions and personalised treatments. For instance, IoT-enabled remote patient monitoring systems have allowed healthcare providers to remotely monitor vital signs, medication adherence, and overall patient well-being. In the design of this study, IoT can be linked to the communication from the patient to the HCP, sending messages with an updated measurement if a new measurement of the IoT device is ready to be sent. Sending this in a message form, which also allows the HCP to respond directly to the new measurement, would support the idea of improving communication between HCPs and patients.

Considering AI and IoT, including the technologies in independent ISs is possible. Especially interpreting the flexibility in using technologies within a system. However, I think the value of the technologies can be more significant in a larger network. Firstly, the development of AI is expected to improve when it is used by multiple users due to broader support and access to a higher amount of training data. When an AI solution connects to a platform, and the platform uses it to provide faster answers, this is also expected to promote participation. It can be argued that there is a lack of innovation among AI solutions when only one AI solution is used within the platform. However, the driver for innovation with AI is different from other technologies because AI gets better as more questions are asked and used as training data. AI can continue to innovate better without direct competition than other technologies. In terms of IoT, the incentives for innovation do arise more from the idea of multiple IoT vendors connecting to the platform. In case multiple IoT solutions connect to the communication platform and thus offer, for example, that self-measurements are sent directly to the right HCP, other IoT solutions have the incentive to also participate in this innovation and become better so that HCPs and patients choose their solution.

However, both technologies would need additional research on the communication solution. I expect the capacity of the network needs to be much higher since in both cases, the number of data transferred throughout this network will be more frequent and in greater numbers (increased real-time data exchange).

8.1.2. Reflection on the Digital Platform

Despite the observation based on the research that the technological layer is sufficiently flexible to adapt to the layers above and provides many future opportunities, reflection on a digital intervention is needed. In the following section, I will cover various topics, reflecting on digital intervention in general but focusing mainly on investigating a PBIS as an improvement for the IS ecosystem.

Adopting a Digital Intervention in General
Adopting a digital intervention is challenging, as was concluded based on the focus group results. As the platform-based solution will be an additional IT intervention within the healthcare context, the implementation and effect of IT interventions are essential. During the preliminary research, the results showed clearly that the implementation of new technologies in this domain is not streamlined and picked up fast (looking at the example of a 6-year development process for lab values communication, which is still not fully rolled out). As apparent during the focus group already, the use of new technologies strongly differs per healthcare organisation. The perspectives on these variations in designing digital interventions were constrained by the choice not to investigate the implementation challenges for existing technologies but to concentrate on a new direction. Research into the challenges in digital implementation would need to be done to obtain proper insights into the next steps for a successful implementation.

The Platform Perspective
The PBIS situation, as visualised in Figure 1.2b in Chapter 1, differs from this study's findings. The translation of the requirements into the platform architecture design can be better visualised as shown in Figure 8.1. I see realising the specific requirements considering the *communication regarding care around the medication process* as one platform core for a specific goal supporting the interoperability between HCPs and patients. There can be a number of different goals to realise, for example, between an insurance company and a pharmacy considering a more business-related goal. Technically speaking, these different goals/services can be implemented as an additional platform core. The platform modules serve a specific platform core connected to the meta-platform. The independent ISs (platform-based or not) can be connected to the meta-platform, which will regulate the connecting APIs.

The platform cores are expected to be created by so-called service providers. In this study, the *communication* would be the service provided to the systems that connect to the meta-platform. This does raise questions about whether this is possible for any services provided. Now, the systems of patients and HCPs will be connected by an API sending and receiving the messages,

which is the core interaction of the service provided. But if a service is provided, for example, to an AIS and HIS to work on one document simultaneously (e.g. taking notes or brainstorming on regional agreements), this service would need other mechanisms to realise the goal. Then, access to a centralised document or a document provided by one of the two parties must be obtained. As I experienced during this study, centralised documents are complicated considering privacy reasons; thus, such a service would be hard to obtain.

As can be seen in Figure 8.1, the modules connect to a specific platform core. The question mark for the module connected to two platform cores indicates whether this would be possible to obtain. This is not included in this study and needs further research to draw firm conclusions on. But it could be interesting to see how the multi-use of modules can be regulated. This can, for example, be done by providing relatively open-source documentation of the modules, ready to use by other service providers.

In Chapter 1, the role of the complementors was described following the literature provided by Deilen and Wiesche (2021). Then, I defined ISs, patient systems and technologies as platform complementors according to the thought that they would provide knowledge to the platform owner. However, considering the *communication* as a service provided in a platform core, the ISs and patient systems do not exceptionally provide knowledge resources to the platform owner rather than the messages sent to the platform. The creation of customer value through innovative solutions, however, is supported by the ISs and patient systems since they connect the patients and HCPs to communication. These observations result in two perspectives considering ISs and patient systems as platform complementors (a *complementor*, or a *user*).

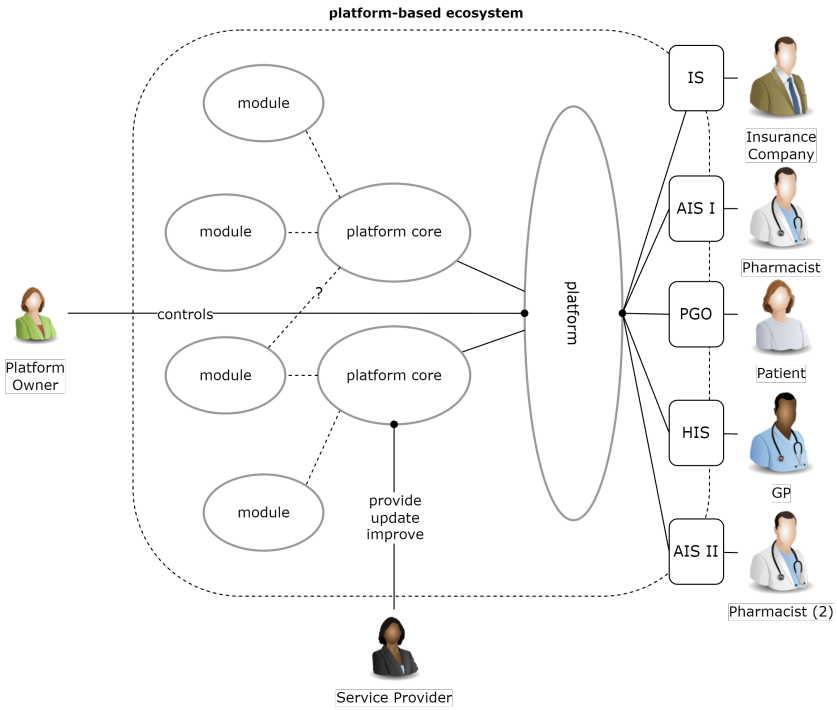


Figure 8.1: Revised Representation of the PBIS (or *platform-based ecosystem*).

For technologies supporting the functionalities, the interpretation continues. I see technologies introduced in the previous Section (AI and IoT in this case) as complementors more convincingly, following the role description of Deilen and Wiesche (2021). This is because those technologies would provide their knowledge to the platform owner more specifically. Namely, the technology they provide as an innovative solution. Although this platform complementor role results in a discussion point, it does not mean the stakeholder's responsibilities cannot be defined.

The platform perspective was introduced in Section 1.1.3 as complex due to political dynamics and involvement of multiple parties by Van der Wielen et al. (2022). They also outlined allocating ownership within the ecosystem requires additional efforts to ensure functional efficiency, which is a barrier to implementation. Considering the discussed confusion about the role of ISs and patient systems already provides a starting point for adopting this statement of Van der Wielen et al. (2022). The differences in the platform perspective according to the first representation presented in Chapter 1 clearly addresses the changes in responsibilities considering the intervention. The stakeholder challenges are discussed more extensively and adjusted based on the results of this study in Section 8.2.

In conclusion, from my perspective, the term *PBIS* does not correctly describe the platform design explored in this study. The term *PBIS* indicates that it's just one or multiple platform-based ISs, instead of an ecosystem. I think the opportunities for the Dutch healthcare domain won't be creating a platform-based *information system* but a platform-based *ecosystem*. When interpreted more as a complete ecosystem supporting the entire first-line healthcare domain, including systems other than ISs, more stakeholders, such as patient systems and new technologies, will be able to get involved.

8.2. Stakeholder Challenges

Intervene within the current system raises positive perspectives but also critical ones. The duality is mostly pinpointed by the findings delineated with the purple text: *In this Section, additional insights are discussed.* These additional insights shed light on tensions arising. This Section discusses the findings in two main areas: stakeholder *incentives* and *responsibilities*.

8.2.1. Incentives

First, the incentives derived from this study are discussed. Tensions in incentives arose considering (1) digital communication in general, (2) the motivation for accepting a separate system for communication, (3) seeing business opportunities for ISs and

patient systems, and (4) the acceptance towards a networked-based care system. These four areas are discussed hereafter. First, it must be mentioned that not all areas directly apply to the platform's exploration. The first two areas: digital communication and separate system, apply to exploring *communication*. The business perspective and networked-based care can directly be linked to the effect of a platform-based ecosystem.

Digital Communication
The clarification results, discussed in Section 4, show tension in incentives towards digital communication among the HCP participants of the survey. While some already see the decrease in phone calls and emails as a highly positive incentive, others have concerns considering the administrative processes related to digitising communication and the time related to those. The motivation to digitise communication is expected to be lower for those seeing the administration as a barrier, negatively affecting the implementation of the communication platform.

Considering the differences between patients and HCPs, two tensions in incentives to participate in digital communication are also found. Where patients want to choose their communication (from a diverse range: phone calls, emails, face-to-face, apps, etc.), HCPs want a technology-mediated communication tool to replace as many of those possibilities as possible. This tension shows that not all communication would go directly by the platform. This is not expected either, but it does indicate that patients should be guided to ask questions through this communication tool. There is already much to complain about by patients about answering phones being used to receive as few calls as possible. I expect this will mainly arise along patients with a higher age.

Furthermore, a disparity is found in the desire for asynchronous communication by HCPs, and the desire for direct communication by the patient. While direct communication turned out to be undesirable, considering the security of message delivery, it is essential to ensure patients do not see this as a barrier to using the platform. Since the patients were not directly involved in the study, more research is needed to understand the tensions around (in)direct communication and the range of communication possibilities.

Separate System for Communication
During the validation of the survey results, it was furthermore found that GP employees, especially GPs, are more reluctant towards an additional communication system than PH employees. An additional system was described as one more application that needs to be used for communication (with the note that it would decrease the number of phone calls and emails). The conclusion was constructed by analysing three categories towards the statement considering the additional system (A3). The categories: Organisation Type, Job Position, and Job Type all showed significant effects, indicating that GPs are, indeed, more reluctant towards an additional system.

This is not seen as a problem for the design in this study, but it will be challenging to decide the responsibilities of HIS providers. Since they create the systems for GPs, they will experience more pressure to integrate the communication service into their IS. It might be possible for pharmacies to offer communication through an additional system linked to the platform. This system could provide the interface. If this were the case, though, more research would be needed on how the communication system is linked to user registration of a healthcare organisation. This example indicates that I expect more opportunities for pharmacies to use multiple systems, but additional research is needed.

Business Perspectives
Implementing the communication platform, as proposed in this thesis, can create new financial business opportunities for healthcare organisations due to their chance to be involved in communication and obtain a financial reward. The business perspective directly results from a platform-based approach for this service. Multiple participants confirmed the positive aspect of new business opportunities. However, there was also some discussion and disagreement regarding how this should be implemented or structured. While the concept was generally beneficial, there were varying opinions on the specific details and mechanisms through which HCPs can realise this capability. The opportunities are primarily found in a financial reward for communication and the expectation that healthcare organisations can also answer questions from patients with whom they don't have a treatment relationship, expanding their patient range.

Furthermore, decoupling the user interface using the API strategy creates space for information system/patient system providers to foster competition and continuous innovation within the systems. This is not a direct financial incentive but points out that system suppliers can keep creating interfaces and excel in the domain (and finally, financially). This idea can, however, be limited by the fact that the information and patient systems do not change significantly. This study does not address the problems considering the large user base that should be transferred and the time and money needed for changing systems.

Networked-Based Care
As suggested by mentioning the opportunities for expanding HCP-patient interaction, the platform offers a more comprehensive network to support care. Not only the HCP-patient relations can be affected by the platform. The platform also supports cooperation between multiple healthcare organisations. This will create a network effect, needing a sufficient number of users (as well as system providers and the individuals using the systems). The higher the number of users, the more comprehensive the network.

However, some HCPs do also refute this idea. During the focus group, the fear from a HCP perspective of sharing or losing patients to other healthcare organisations is present since it can decrease the position of a healthcare organisation within the domain. However, this was only mentioned by one participant, while three other participants in this research indicated that healthcare organisations should go along with the time, including networked-based care. Still, it indicates that not everyone has a positive

attitude towards this network-based situation, which will need more attention to motivate these individuals. More motivated individuals would improve the network effects of this intervention.

8.2.2. Responsibilities

The results also showed diverse perspectives considering the allocation of responsibilities. Again, the first three areas: (1) the responsibility shift in the care process, (2) the patient participation, and (3) the HCP participation, are not directly coupled to the responsibilities concerning the platform-based ecosystem but rather identify different responsibilities in the *communication* process. However, the perspectives found considering the responsibilities regarding (3) the platform owner, (4) API agreements, and (5) the identification of users do directly result from the platform-based ecosystem approach. Some insights considering the incentives discussed in Section 8.2.1 are also used for defining the different responsibility distribution perspectives.

Shift in Care Process
Tensions arose about whether PH employees should be able to accept some of the responsibilities within the care process from GP employees. This shift can release pressure on GP employees, but at the same time, GP employees are also reluctant to transfer responsibilities. GP employees question the capability, knowledge and context of PH employees. At the same time, PH employees are willing to take over responsibilities and also think they do have enough information on the patients' process to take over responsibilities. During the platform architecture evaluation, PA1 also indicated to expect PHs to be more active on the communication platform since they have more time. Despite this, GP employees especially mention they want to retain end-responsible. The IZA and IB legally limit the perspectives variation, as described in Chapter 3, defining the responsibilities regarding the medication process. Whether communication regarding care can be placed in this legal framework arises. This would need more insights into the aspects that are communicated. The shift is less complicated if the platform only supports asking theoretical questions. However, if the communication, as desirable, would also include requests for medication or medication change, the shift would need to be supported by adjustments within the existing documents or by creating new documents.

Supporting Patient Participation
The quantitative and qualitative survey validation results show a lack of confidence in the reliability of patient feedback. Compared to GPAs and PHAs, GPs are more willing to trust patients. This can be due to GPs' experience, resulting in greater trust. The desire for correct information among assistants may make them more sure when it comes to patient input to be more definite in their decisions. Additionally, compared to the Job Type group PH/PHA, the GP/GPA/POH group appears to have higher patient trust. The lack of faith in patient dependability shows the necessity to set defined obligations to decrease this mistrust. While the communication-coding strategy partially meets this obligation, other steps could include HCPs taking on additional responsibilities to improve patient understanding of healthcare subjects. The government, educational institutions, or other institutions can also do this.

Furthermore, I expect patient systems to accept the patient's message can also play an important role. Even though patient systems are relatively new and not fully integrated into the healthcare market yet, I think there is much to gain. Especially creating awareness within target groups that are comfortable with digital tools will have an effect. Patient systems/platforms can provide patients with targeted information about, for example, the medication they are taking, intended to increase patients' knowledge and decrease the number of questions.

In addition to questioning the trustworthiness of patients, there are even concerns among participants regarding the patients' responsibility in determining when to send messages. Five HCPs expressed their belief that patients should be unable to ask questions continuously. This perspective suggests that some participants do not support granting patients complete responsibility in initiating communication. I did not foresee stating this finding in this study. Of course, there is pressure in the healthcare industry, and it affects the ability of healthcare professionals to remain patient and calm during their work, but the fact it was so firmly mentioned by some participants that patients should not be able to have the ability to choose when to ask/request something was shocking.

The platform architecture evaluation interviews extensively discussed the platform's responsibilities for improving patient participation. Platform architects did plead for increasing responsibilities for the patient systems considering patient participation. Assuming that all responsibilities lie with only the platform owner is less realistic and limits innovation. This study adopted this perspective due to the realistic interpretation of distributing responsibilities. The study was intended to show the opportunities within limitations and where the framework should be extended (considering new regulations, for example). But, in the end, practical relevance can only be obtained if the implementation is successful and, thus, realistic.

The responsibilities considering user-friendliness regarding creating the message are also discussed extensively in the design evaluation. PA2 raised questions while validating the evolvability requirements considering new communication technologies. The preference for making the involved systems responsible for user-friendliness is outlined by both PA2 and PA3.

Support HCP participation
Two responsibilities supporting HCP participation are managing incoming notifications and creating a financial incentive. Responsibilities considering the settings around the notifications should not be part of the system according to PA2 and PA3. This came up during the validation of the requirements. If the platform is responsible for this, the platform would need additional information on the involved systems and all the users. For example, the time zone in which they are to adjust notification planning. According to PA2 and PA3, this would be the responsibility of the involved systems.

Considering HCP participation, questions arose in determining responsibilities considering the financial reward, showing the challenges in deciding responsibilities. Who will receive funding for responding? Only those who have a medical relationship with the patient? What will happen if a HCP answers the patient with no treatment relationship? How will the HCP or platform link the amount of time it took to respond to the query to the declaration? The patient's BSN and insurance policy number must be disclosed to the insurance company. Or would the platform support this? Would the government make the budget available? To aid in communication?

The discussed topics show identifying the responsibilities considering settings, interfaces, and motivating participation regarding the communication for involved systems already delineates new decision-making processes. This is due to the platform connecting multiple systems. The discussed responsibilities did, however, primarily focus on the *communication* part. The following sub-sections also discuss more general responsibilities considering the platform for the platform owner, API agreements and the identification of users.

Platform Owner
Considering the platform owner(s), no party is designated. Figure 8.1 shows that the platform-based ecosystem has a platform connecting all the involved systems but also multiple platform cores for the variety of services that can be provided by the overarching platform. For implementing the new ecosystem, decisions should be made considering platform ownership. Will there be multiple platform owners for every platform service? Will all platform cores be provided by one platform owner while other organisations provide the platform owner with the idea? From my perspective, the best decision would be for one party designated for the overarching platform connecting the systems but multiple platform owners for the services provided to the systems. It can be an opportunity for the Dutch government to own the platform ecosystem (the overarching platform) and organisations focusing on improving healthcare (as the organisations in Chapter 3) as platform owners for the platform cores providing services.

API Agreements
It was expressed that the use of API does need an agreement system discussing the responsibilities of involved systems, the platform cores, and the overarching platform. Since the agreements can differ for each involved organisation (the pharmacy, the GP practice, the patients' system, etc.), the agreements need to be defined for each sub-category of systems involved. The responsibilities need to touch upon the content accepted on the platform, the number of messages accepted on the platform, the one responsible for monitoring the agreements, etc.

Following the platform owner's interpretation, as I discussed, the one(s) responsible for providing these agreements needs to be decided. From my perspective, the APIs directly connecting the platform with the systems would best be regulated by the overarching platform, but providing the agreements needs to be based on the service provided by every platform core individually. If the services are provided by the platform *core* owners, they would have the best insights into the content of those agreements.

Identification of Users
Furthermore, it is necessary to specify who is in charge of monitoring the user identification process. Patient's identities are determined mainly by their BSN numbers. As mentioned in Chapter 3, companies cannot use BSN numbers easily. It can be stated that there is no need for patient identification when it's about asking questions considering medication, for example, but this is different looking at the financial flow. Patient insurance regulations, which are currently connected to the BSN, came up for discussion. Processing any financial flows linked to patients in the as-is system is only possible when using BSN. Furthermore, to use communication in care processes considering a patient's process, the platform's utility will be significantly improved by connecting with the BSN. This outlines the utility of patient identification. But who should be responsible for it? Due to security reasons, we want this information to be handled in as few locations as possible. Thus, this would be best regulated by the overarching platform.

Considering HCP identification, this study addressed the requirement for a second identifying mechanism because the BIG registration does not include all HCPs that need to be included; for example, assistants. Since this registration would be specifically applicable to the communication platform service, the responsibilities for the identification mechanism can be discussed again. From this perspective, I propose handling the identification in the *platform cores* supporting the single services. This would mean that the data for identifying the users goes across the *overarching platform*. There may be different security requirements for every type of service, so it is necessary to reevaluate where the identification control will be conducted for every new service.

The various challenges considering the different incentives and the determination of responsibilities, outline the stakeholder challenges. Coping with these challenges can be possible through extensive discussion with involved stakeholders and decision-making to handle trade-offs, but it certainly takes a fair amount of time, effort and money, affecting the feasibility of the implementation.

8.3. Feasibility

The feasibility is affected by the number of different incentives and responsibilities. The effect can be described by looking at (1) the platform internally and (2) the participating systems.

The realisation of internal developments on the platform encompasses several considerations. The overarching platform and its single platform cores, particularly the communication component, present unique challenges and opportunities. Some challenges apply to both, while others are specific to the platform core or the overarching structure. To address these complexities, optimal solutions must be chosen, carefully balancing various incentives and responsibilities. Achieving these solutions will require striking

a delicate trade-off among diverse interests. Anticipating that this process may not please everyone, making tough decisions regarding including or excluding functionalities becomes imperative. In this context, the feasibility of the overarching platform appears more promising, as its top-down approach allows for smoother coordination, resulting in fewer conflicts among various interests.

Secondly, the effect on feasibility, looking at the participating systems. Participating systems that connect to the platform already have a lot of work to do for their own business and will be reluctant to additional responsibilities, such as implementing the chat module in the current IS. Implementing these modifications in their current systems takes a lot of time. Even if development support is available for developers from IS or patient systems, which was not considered in this study since it primarily considers the views of PH and GP, but was mentioned by Groeneveld (2021) considering the IS supplier perspective. Next to the design, monitoring the chat module after implementation includes client communication, consultations, and iterative improvements. There will be many questions and complaints about the performance and utility of system releases. As a result, creating a brand-new module requires a significant time commitment, which will only be accepted if the desire for the chat service is sufficient enough.

8.4. Conclusion Chapter 8

In conclusion, the insights on a platform-based intervention can be found in *technology* and *stakeholders*. In the domain of *technology*, a broad range of possibilities emerges. Technically, the potential seems unlimited, presenting both an opportunity and a challenge in selecting the most fitting technologies. While the versatility of the platform-based design allows for expansion through the integration of IoT and AI solutions, the PBIS perspective adopted in Chapter 1 needs further consideration. While significant, the portrayal and terminology of PBIS fail to encapsulate the full extent of the situation's potential. To rectify this, my perspective, as illustrated in Figure 8.1, considers this research's findings, envisioning an ecosystem shaped not merely by ISs but instead by a comprehensive platform-based ecosystem. This includes platform cores and modules that may include IoT and AI technologies and are positioned strategically to realise their impact, in addition to information and patient systems.

A high number of *stakeholder* challenges emerge considering incentives and responsibilities. New incentives considering the participation of the intervention arise, but these incentives are not aligned, and aligning those will be hard and need trade-off-based decision-making. Additionally, challenges regarding responsibilities further complicate the implementation, as perspectives on who should be accountable for various aspects are not fully aligned.

The combination of time and financial constraints and the multitude of stakeholder challenges affect the feasibility of implementing and completing the design of the PBIS negatively. To enhance feasibility, governance measures, as well as careful schedule and budget planning, should be implemented. These measures can help address the challenges and align stakeholder interests, ultimately increasing the likelihood of successful PBIS implementation. These recommendations are discussed in Chapter 10.

Sub-question 5: *Considering the study, what lessons were learned in exploring platform design as part of the Dutch IS ecosystem in first-line healthcare?* mainly describes the desire to identify lessons learned by comparing a platform design as part of the IS ecosystem. The relevance of the findings around the *communication* is merely found in the fulfilment of a platform service, and it helped in defining additional challenges for that specific purpose in the platform. Which, in the end, provided valuable insights for platform-based solutions in the domain.

9

Reflection and Contribution

The previous Chapter already included a reflection on the platform-based intervention in terms of the technology- and stakeholder effect. In this Chapter, I will first reflect on this research considering four additional domains in Section 9.1. Then, in Section 9.2, the contributions of this study are discussed, based on the practical domain in Section 9.2.1 and the academic domain in Section 9.2.2.

9.1. Reflection

The four domains include a reflection on (1) the participants in Section 9.1.1, (2) the research process in Section 9.1.2, (3) the research findings in general in Section 9.1.3, and (4) more specifically the findings compared to the current situation in Section 9.1.4.

9.1.1. Participant Reflection

This study could not have been completed without the involvement of participants. Nearly two-hundred individuals were somehow involved in this research, of which the input of one hundred-fourteen is used for this study directly (due to some neglected survey results). In this Section, I pay additional attention to the effect of including particular job positions in the study, the lack of direct patient participation, and the contribution of Sanday.

Sanday's Contribution
Executing this thesis at Sanday provided opportunities to contact field experts and employees within pharmacies and GP practices. In all phases, Sanday contributed to information gathering by supporting the visibility expansion, sending the survey in their newsletter, and inviting me to the Mosadex Experience. It could be argued that only including participants through Sanday's channels is biased due to company loyalty or a limited perspective. However, this was not the case since I also contacted participants outside of Sanday's network, such as LinkedIn, personal networks, and visitors of the Mosadex Experience. It can be concluded that Sanday did speed up the process and significantly supported the number of participants in this research. Still, the research also involved participants outside of Sanday's network.

Furthermore, the discussion in Chapter 8 on the shift from platform-based *information system* towards platform-based *ecosystem* is considered in the reflection on Sanday's contribution. Since Sanday is an IS supplier within the first-line healthcare domain, the direction to a platform-based *IS* aligns more with the expectations. Therefore, it comes as little surprise that I have discovered that achieving interoperability from a HCP perspective is more about an overarching platform that connects ISs (platform-based or not) to certain services than an IS in general.

Limited Job Positions within first-line Healthcare Context
For this master's thesis, the focus has been placed on the involvement of GP, GPA, POH, PH, and PHA primarily due to the accessibility through the network of Sanday and the contacted GPAs during the Mosadex Experience. This selection was made based on scope considerations and time constraints. However, it is crucial to acknowledge that a complete understanding of the interoperability requirements between healthcare providers in the Dutch first-line healthcare system needs additional perspectives, including district nurses, dentists, physiotherapists, etc. Their perspectives and insights would contribute significantly to obtaining a complete and holistic image of the interoperability requirements in the healthcare domain and improvement of the practical contribution of the communication platform. More specifically, reflecting on the platform-based ecosystem, I expect that researching every pair or triplet of organisations can result in the need for an additional platform core supporting another service.

Lack of Patient Participation
The exclusion of patients from the research was primarily driven by time constraints and research limits considering the opportunity to engage directly with patients and collect sensitive healthcare data thoroughly and securely. Not including patients directly in the research process and relying solely on HCP perspectives or existing literature poses certain limitations. By not directly involving patients, there is a potential gap in capturing their perspectives and experiences, which could provide valuable insights

into the research topic. Despite attempts to include patient-responsible organisations to discuss the patients' perspective, no successful cooperation was established. This was due to the financial limitations of this research since those patient-responsible organisations asked for a budget.

Furthermore, including patients in research requires more careful consideration and adherence to the data management plan. As patient involvement may involve the handling of sensitive personal data, privacy issues and ethical guidelines arise. When patients are involved in the future, an appropriate data management plan to address their concerns and safeguard the security of patient information throughout the research process is needed. Furthermore, looking at the positive perspective, not involving the patients directly provided an in-depth insight into GP practice and pharmacy employees' needs and perspectives due to sufficient time. This indicates that when the patient's perspective needs to be examined, this again needs to be taken into account by focusing on freeing up enough time to include the patient's perspective in detail.

9.1.2. Reflection on Research

The first note to reflect on the research process must be made on the decision to follow the direction of the idea generation in the focus group. The direction for improving *communication regarding care around the medication process* is based on the idea and support of three participants, which could indicate a lack of support. Since the idea was never neglected or questioned strongly by the participants involved in further research processes, this research step is seen as adequate.

This research was constructed based on a high number of different data-gathering processes. The diversity of research activities was generally experienced positively by looking at the findings. Involving participants during multiple steps in the research process brought the research relevance to life. A disadvantage of having this many diverse research processes is the limited support by earlier conducted research supporting significance. Is this process valid? What are the principles for this process? These are questions that cannot be confirmed by literature quickly. However, still, a lot of literature was applied during this study. The following Sections will discuss the reflection of the research processes, specifically focused on the methods and theories used during the research processes.

Design Principles from Hanseth and Lyytinen (2010)
Applying the design principles from Hanseth and Lyytinen (2010) gave a hold on the relevance of research processes. Table 9.1 shows the reflection for each design principle as introduced in Chapter 2. The design principles focus on the design of IS in general. And, as discussed in Chapter 8, I interpret the design more like a part of the platform-based ecosystem rather than a platform-based IS. Logically this differing interpretation resulted in some principles not explicitly supporting the platform-based designs. I propose further research would instead focus on platform design principles, which are further discussed as recommendations in Chapter 10.

Table 9.1: Reflection on Design Principles for IS.

Design Principle	Description	Reflection
Design initially for direct usefulness	The solution must persuade the initial users through targeting their needs and solving their problems; easy to use and implement; useful without a larger user base	Highly relevant for the platform cores in the ecosystem. Considering the overarching platform, this will not be relevant if platform cores are responsible for users.
Build upon existing installed base	Exploit existing infrastructures, platforms or communication formats already in use; no need for new support infrastructures	Was highly applicable to this study. The design focused on including existing systems. Considering the development of new services on the platform, I highly recommend looking at what is already created and ready to use.
Expand the installed base by persuasive tactics to gain momentum	Generate positive network effects from extending the user base; before adding new technology, ensure that the user base has grown to sustain the added cost of development and learning	This is especially focused on the perspective of one organisation. I used this idea differently, focusing on the network effect by increasing the platform's users (HCP ISs or patient systems).
Make the IT capability as simple as possible	Make the information infrastructure as simple as possible (both technically and socially); promote overlapping IT capabilities	Difficult to assess. Socially I've discussed many challenges already. In the network-based character of the ecosystem, this was not used. Using the same modules for different platform cores (as shown in Figure 8.1) would support this principle.
Modularise the information infrastructure	Separate the layers of infrastructure from each other and exploit gateways to connect different layers	Also relevant for the platform-based solutions. But it is already expected to be incorporated into a platform-based architecture. Platforms focus on modularity (Tiwana, 2014).

Focus Group vs Semi-Structured Interviews
The focus group carried out the first data-gathering process, including participants. However, as already reflected in Chapter 4, the number of participants (3) in the focus group is too low to consider it a focus group following the literature. The position of the focus group in a more extensive preliminary research process creates a better position for the focus group. The big-scale survey provided some extra input on the opportunities. Furthermore, choosing a scheduled moment to invite participants three weeks in advance was not experienced positively. This can be improved by planning it further in advance. Finally, the number of focus groups. There was just one focus group organised to get information about the community's needs, while it could be interesting to have more focus groups in the beginning. I would propose to organise two or more focus groups to obtain support and enough ideas to consider for the relevance of the research. Especially comparing the results of the focus group to the results of the 1-on-1

semi-structured interviews. From my perspective, the semi-structured interviews in the exploration phase did not significantly affect this study.

Although I am more optimistic about the effect of semi-structured interviews for the platform architecture evaluation considering the achieved depth, I would still recommend organising a focus group with different stakeholders in the design process rather than another semi-structured interview. For example, with an information specialist, a developer, a business specialist and an IT architect. This focus group would provide insight into which parts are still missing, which parts need more attention, what processes are a priority, etc.

Interoperability Layers of Nictiz (2022a)
The utility of the interoperability layers in the design process can be improved. In this study, the utility mainly lies in structuring the effect of the systems in the environment and structuring the statements for the semi-structured interviews and the survey. Especially structuring the environment systems support the design by creating an overview of where the relevance of these documents. I expect the structuring for the participants could have been done differently since they were unfamiliar with the layers, but the layers were still helpful. The layer model could have been used more actively, considering the platform design. Initially, I proposed a layered architecture approach and rejected the established connection between the organisational levels and the ADM cycle proposed by Nictiz (2022a). I proposed this to create a more basic platform design without layers to promote comprehension among the many sorts of participants (developers, businesspeople, etc.).

Looking back at this decision, the goal of the platform architecture design was not correctly formulated before I started designing. The goal of the architecture is, namely, to support the actual design of the platform. An actual design does need a more complex architecture, including the technology layer, supporting the developers more effectively. In the end, the evaluation interviews raised many questions, which provided new insights into platform governance, supporting me as a layman in this domain. Despite that cheerful note, if this process is applied in the future, the goal of the platform architecture should be specified more precisely, and in case it is needed for the design, a layered approach, including the technology layer, will be needed.

Formalisation by following the System Requirement Structure of Brazier and van Langen (2020)
The design was created based on the SRS as a starting point. However, as mentioned in the conclusion of Chapter 6, the SRS did not result directly in the platform modules. The question arises: what was the effect of creating the SRS in designing a platform architecture? The effect lies in structuring, and creating a more comprehensive understanding of the requirements, since the SRS resulted in additional requirements, supporting a more overarching- or low-level. Furthermore, the low-level requirements in the SRS were used to define the functionality of the platform modules. Altogether, the SRS supported the platform architecture design sufficiently.

Design Science Research Methodology
The Design Science Research Methodology (DSRM) provided effective research guidance. However, I want to discuss several essential aspects that should be considered concerning Hevner et al. (2004) design science research activities. Firstly, the incorporation of the first activity: *problem identification and motivation*. Part of the problem introduction is already addressed in Chapter 1 before determining the research methodology. It was confusing to incorporate the activity as part of the research methodology. In this study, I interpreted the activity as giving extra attention to current environmental requirements. Additionally, as evident in the placement of activities in Figure 2.2, activities: *demonstrate* (4) and *evaluate* (5) were merged within my research. This aggregation appeared more relevant and aligned with the design/evaluation component of the cycles introduced a few years later (Hevner, 2007). Furthermore, the final activity, *communication* (6), also encompasses a demonstration aspect, mainly when showcasing the designed solutions.

I strongly recommend integrating the activities with the design cycles proposed by Hevner (2007) to enhance the research. The design cycles clarify how the activities relate and can be connected to multiple components within the entire design process. By combining the DSRM activities with the design cycles, a more comprehensive framework can be established to effectively facilitate the research and design process.

The iterative evaluation process proposed by the Design Science Research component in the design cycles of Hevner (2007), where I combined the *demonstration* (5) and *evaluation* (6) of Hevner et al. (2004), showed success. Using semi-structured interviews to demonstrate and discuss the platform design resulted in the finding that the high level of abstraction of the platform is a suitable means to discuss and brainstorm on the additional decision-making process. All interviews led to a set of questions to be answered for a successful implementation. The use of the platform criteria was criticised during the evaluation interviews. Still, it resulted in being a suitable means to provide insights into what needs to be done from a higher level of abstraction (the business and information layer).

9.1.3. Reflection on the Findings

Generally, this study shows new results in (1) needs considering the cooperation between patients, pharmacies and GP practices and (2) how a platform-based solution can be created. This Section reflects on the general finding for improving communication, the requirements gathered, and the design created.

Digitising Communication Regarding Care around the Medication Process
I want to start reflecting on the findings resulting from the idea generation during the focus group. The fact that the *communication regarding care around the medication process* was outlined during the focus group guided the entire study. Ultimately, I can see

that the possibilities for improvement do not mainly stay within the scope of *care around the medication process*. I think the utility of the service provided by the platform goes beyond the medication process—for example, the relevance of using digital communication in research.

This research outlines the relevance of digitising communication as additional data within healthcare systems, supported by literature of D'Souza et al. (2021), Lavertu et al. (2021), and Rocca (2017). According to D'Souza et al. (2021), standardisation and digitisation of clinical data in MS are anticipated to produce new insights into the changes of the illness and to contribute to individualised patient therapy, despite the hurdles created by regulatory, ethical, and data-privacy considerations. Comparing this with the practical incentives explicitly outlined in this research (Section 8.2.1), it can be concluded that D'Souza et al. (2021) provides a more academic perspective. In contrast, the participants in this research were merely focused on the practical effect of improving communication. Saving the data stored medication-based was mentioned as an opportunity by one of the survey respondents, but did not experiences high support. Medication- or illness-based storage as an additional platform feature would be closer to D'Souza et al. (2021).

Lavertu et al. (2021) and Rocca (2017) focus on post-market monitoring of medication, so-called *pharmacovigilance* methods. Experiments are run through online discussions, social media monitoring, sensor data, mobile devices, and reporting apps. Enabling communication through the PBIS can support monitoring medication if patients are motivated to communicate through the communication platform. In case research is connected to pharmacovigilance, it can also be the case that such an institution is involved as a complementor.

Elicited Requirements
Concerning the requirements from the preliminary research, survey results and SRS discussion, I want to address the most impressive and surprising requirements from my perspective. Considering this reflection, I neglected most of the requirements from a patient's perspective since they were based on existing literature or the HCP perspective rather than the patients themselves. Except for the patient-related requirements from a HCP perspective, as listed below.

- Support asynchronous communication (1.1.1.3);
- Enable HCPs to manage the level of urgency for incoming notifications (1.3.1.1);
- Ensure the patient's input is verified (3.2.1.2).

The requirements express an opposing viewpoint towards being open to patients. Asynchronous communication arises from a desire not to be interrupted during their work. This includes not only patient inquiries but also communication from other HCPs. This was even demonstrated during one of the interviews: when PH4 received a call from a GP asking for feedback. The desire for asynchronous communication becomes more critical for HCPs due to how frequently they engage in consultations and conversations. The same remains for all requests and inquiries from patients.

Even though it makes sense that HCPs would want to handle disruptions well, this condition and the other two striking ones highlight that not all HCPs are sympathetic to giving patients more authority. The criterion about the level of urgency, which implies that some HCPs wish to choose whether or not to receive specific questions, is the first area wherein this is apparent. The urgency of a question or statement might, however, differ dramatically from person to person from a patient's viewpoint. Prioritising life-threatening situations is undoubtedly essential, but when combined with the third need (taking the patient's input into regard), it becomes clear that patients are not always taken seriously, despite their concerns. This shows a lack of understanding of the patient's viewpoint.

It must be mentioned that many participants expressed that patient self-management is essential, and they pleaded for a more patient-centred healthcare system. Still, the critical patient-related findings were surprising. Considering the non-patient-related requirements, the following requirements interestingly affected the design and development of findings.

- Enable HCPs to get feedback on the care around the medication process (1.3.2);
- Include a funding mechanism for taking over responsibilities (1.1.2.1);
- Provide links between communication regarding care around the medication process and ICPC codes (1.2.2);
- Enable medication-based selection for communication transparency (2.3);
- Ensure easy-to-find codes (3.1.3).

The initial finding, logically resulting from a focus group comprised solely of HCPs (and no patients), highlighted the significance of involving patients in the digitalisation process. This was a dimension I had not immediately expected. The challenges related to communication through email and phone were consistently mentioned during discussions and the survey. Retrospectively, these findings provide a strong incentive for healthcare organisations to actively participate in this platform, as it offers the opportunity to address communication obstacles effectively and support the preferences of both HCPs and patients.

The need for financial compensation for the time invested is an exciting aspect, as emphasised by Kong (2023) in the requirements. This requirement stands out because it calls for establishing entirely new rules, and its relevance becomes exceptionally high, especially when the impact of integrating this communication system on reducing employee pressure has not yet been demonstrated. The financial incentive becomes even more crucial if the network-based concept is implemented and HCPs can address patient requests without an existing treatment relationship. Ensuring proper compensation in such scenarios is essential for motivating HCPs to engage in the platform.

Finally, it is essential to pay attention to the codification requirements. This idea emerged during the focus group discussions and was further reinforced through explanations provided in the survey responses. Code-based communication, in general, holds

great promise and opens up numerous opportunities for improving communication and facilitating research and selection of appropriate communication methods. An example of this potential lies in medication-based selection, highlighting the need for further research on how medicines are accepted in society. What also took me by surprise was the requirement for easily accessible codes. This can suggest that the currently utilised codes from NHG tables and G-standards might not be easily available for HCPs. Although this perspective was not extensively mentioned, I avoid drawing definitive conclusions. Nevertheless, delving into the perspectives surrounding these codes could prove to be an intriguing area of research, shedding light on their usability and potential impact on the communication platform's overall effectiveness.

The Platform Architecture Design
The platform architecture is reflected by considering (1) the possible iteration bias, (2) the moderate first version, (3) the abstraction level of the design, and (4) the versatility of improvements.

The design was created following multiple iterations based on expert interviews with platform architects. It is possible including the ideas of platform architects considered stakeholder governance resulted in a biased approach. Platform architects are expected to prefer fewer responsibilities regarding the design, resulting in less complexity for themselves. Therefore, the number of requirements presented as responsibilities for the connected systems is expected to be relatively high. But, it should also be mentioned that simplicity on a platform is seen as a positive criterion, according to Tiwana (2014).

The fact that the first version of the design involved preemptively solvable facts indicate that the first design was improperly constructed following the known limitations. However, the interviewee was informed that the interview was planned too early for a complete architectural design. Nonetheless, the meeting was planned and found to be very relevant, even though it was early in the process and thus documented in this thesis report.

The architecture design shows a high-level abstraction. As already discussed, this provides a suitable means to guide the design process. But it can be concluded the design is not yet complete. It does need further insights into technology. During the requirement discussion, it was clear that platform development teams, in practice, cannot develop everything. The process is limited by time, capacity and money. Furthermore, information system suppliers and patient platforms/PGOs should be incentives to integrate communication within their platform/system/application. Technically speaking, the integration is possible, but incentives for the suppliers of systems to integrate this is a different area, and research would be valuable to indicate what is needed for them to integrate. This could be based on how much work they would be asked to put into it (time/cost), if they know the company to arrange the integration, etc.

Finally, it should be remembered that the design is a *possible* way of implementing the requirements, outlining the versatility of the solutions. This does not imply any other designs can effectively enable the requirements. The best practices of platform architecture design can be considered more actively. Reaching out to platform architects supported the platform's validity, but it also showed the first version of the design was not assessed as sufficient.

9.1.4. Reflection on the Findings regarding the Current Situation

Looking at the current situation and problems as described in Section 1.1.1 resulted in the following questions for reflection. Can the results of this study affect the inefficiencies mentioned positively? What about the power of IS suppliers? The long-term contracts? The poor interoperability and data portability? The scarcity of healthcare resources? The over-development of ISs? The possibilities for innovation? In this Section, these questions are discussed.

The Power of IS Suppliers and Long-Term Contracts
The platform-based ecosystem, as designed in this study, does not solve the power within the market, as described by Kuipers (2023). The designed artefact does not solve the fact that IS suppliers can obtain power within the market by entering long-term contracts with healthcare organisations, resulting in challenging transfers of ISs. The artefact is designed considering the multitude of ISs available in the domain. Proposing a service to existing ISs can affect the dependency of HCPs on the ISs. This provides even additional challenges when not all ISs incorporate the communication service. Then situations arise where healthcare organisations want to switch to a certain IS providing the communication service while they're stuck with their current IS not providing it. However, it can be interesting if all ISs connected to the platform-based ecosystem are also platform-based and can add platform services individually, depending on the healthcare organisation's desires. Then they can still provide long-term contracts but more modularly, decreasing the feeling of healthcare organisations being stuck with certain functionalities of one IS. Thus, the results of this study do not resolve long-term contracts, but the effect on it can be researched more in-depth.

The Poor Interoperability and Data Portability
The definition of data portability entails the ability of a patient to access their personal data. Although this aspect was not the primary focus of the research, it aligns with whether patient-related communication between two HCPs should be accessible to the patient. From a data portability perspective, advocating for transparency in communication seems reasonable. However, according to legislation, data portability concerns personal data. I believe communication about a patient may not necessarily be classified as personal data.

Regarding interoperability, significant attention has been devoted to this aspect by the study. The investigation of communication, as part of interoperability, focused mainly on communication following the chosen direction determined during the preliminary research phase and is discussed extensively. However, the actual exchange and automatic data updating in ISs have not been

thoroughly examined. Nonetheless, it has been acknowledged that such developments would be highly valued. It can be supported by this design by transmitting updates regarding patients from both patients and HCPs as messages via the communication platform. However, individual changes would still need to occur within each IS to enable updating of specific documents in the systems. Upon receiving the message, the receiving system would then establish a connection with the appropriate data entry field in the relevant document. The platform could provide guidelines to facilitate these developments. However, this aspect was not included in the research, and thus, no further conclusions can be drawn from it.

The Scarcity of Healthcare Resources
Considering the scarcity of healthcare resources, one concern is the potential increase in questions directed towards HCPs and the resulting impact on their workload. The overarching issue of scarcity is compounded by an ageing population, which has been identified as a contributing factor. However, it is worth noting that the older generation's limited proficiency with technology raises doubts about the effectiveness of technological solutions in mitigating HCPs' workload. Assigning specific nursing services to older people is suggested to alleviate pressure, but its efficacy remains speculative as it lacks research. Consequently, the effect on HCPs' workload, particularly when caring for older people, remains uncertain, and further research is needed to explore viable strategies to address these challenges.

The increasing number of chronic patients has also put significant pressure on healthcare services. By enabling more accessible and quicker communication for chronic patients without requiring in-person visits, it could reduce consultations and related demands. Moreover, it is essential to note that chronic patients are not exclusively elderly, making them more amenable to technological solutions. As a result, I anticipate a higher likelihood of success in implementing these solutions for chronic patients.

The financial burden on healthcare organisations is expected to remain stable regarding the scarcity of costs if a financial reimbursement system is implemented. However, the question of who is responsible for covering these costs, either through the health insurance system or directly by the patients, remains unclear, making it challenging to determine the potential effect of cost scarcity. The hope is that streamlining the handling of questions through healthcare organisations will lead to a healthier society and, most importantly, more care situations resolved without needing patient consultations. Consequently, a reduced number of consultations is likely to result in decreased overall costs. In the best-case scenario, where patients can efficiently and directly address concerns without needing in-person visits, which contributes to a healthier society, I expect the costs associated with improving the entire population's health also decrease.

In conclusion, implementing this solution may increase the workload, especially when there is a surge in patient inquiries. This highlights the importance of effectively informing patients and incorporating a mechanism to manage the communication flow to some extent. Additionally, conducting observations to map out the precise timings and communication processes could prove beneficial in estimating the potential time-saving benefits for healthcare workers. By addressing these aspects, the solution can be fine-tuned to alleviate the pressure and enhance the overall efficiency of the communication system.

The Over-Development of ISs
The issue of over-development of ISs, as introduced by Kuipers (2023), is not addressed in the designed artefact. As discussed in the reflection on long-term contracts, the number of available ISs is not necessarily reduced. Even with a platform-based ecosystem perspective, a variation of ISs is still expected. However, if these ISs are all platform-based and modular, adaptable to different healthcare organisations, they become heterogeneous systems that are more precisely tailored to meet the diverse needs of those organisations. In this situation, heterogeneity is used to meet the actual needs of healthcare companies. Consequently, as the systems get more tailored to HCP preferences, concerns regarding over-development become less critical. From an organisational standpoint, this will considerably challenge IS suppliers. More positively, the constant development of ISs offers chances for innovations, supporting ongoing developments in the healthcare industry.

The Possibilities for Innovation
As discussed extensively in Chapter 8, the possibilities for innovation are supported. Namely, the platform-based ecosystem approach provides opportunities for system complementors to keep innovating, for platform core providers to keep creating services, and for technologies to enter the platform-based ecosystem. But, it should be mentioned this innovation is also lacking due to the hurdles considering the user base they must transfer when shifting from one IS to another. This problem/challenge is not assessed considering the solution proposed in this study, but as discussed earlier, it could be resolved by the modularity of the individual ISs.

Concluding, the findings do not solve all problems mentioned as problems in the current situation in Chapter 1, but they most certainly touch upon interoperability and innovation.

9.2. Contributions

How this research contributes to practice and science is discussed in respectively Section 9.2.1 and Section 9.2.2. While defining the contributions, I highly considered the reflection on the shift from an IS ecosystem to a platform-based ecosystem, discussed in Chapter 8, and the reflection discussed in Section 9.1.

9.2.1. Practical Contributions

The practical contribution of the designed platform lies in the insights gathered considering the GP and PH perspectives and the created requirements and platform architecture. It provides insights on how to obtain one (of many) objectives in the platform-based ecosystem.

Communication as a Service
The practical relevance of this research lies firstly in highlighting the need to *improve communication*. The focus on communication outlines a dominant area from a HCP perspective. Even if not in a platform-based ecosystem, healthcare organisations can still take steps to enhance communication. Some organisations already apply improved communication practices for patient-related requests within their direct patient network. However, healthcare organisations' communication relies heavily on emails and phone calls, resulting in chaos and lack of clarity. Improving this inter-HCP communication and enabling direct integration of patient inquiries into the current IS would be a valuable improvement, which can be relatively more straightforward to implement than the entire platform-based ecosystem. Healthcare organisations can significantly enhance communication efficiency and collaboration by addressing these aspects, improving patient care and organisational outcomes. The practical significance of this research thus extends to immediate and feasible solutions that can positively impact the healthcare sector's communication landscape.

Furthermore, the communication can, for example, be extended to accommodate requests by district nursing services. Implementing this feature allows an issue identified by van Eijndhoven (2023) to be effectively addressed via the communication platform. This issue regarded the inefficient collaboration within the first-line healthcare domain and the time-consuming locating of district nursing services (they had to call dozens of times to place a patient).

Additionally, the platform architecture design aligns with the idea of a Communication Platform as a Service (CPaaS). CPaaS aims to integrate communication platforms in real-time API integration (CM, n.d.). The integration of communication using APIs can be instructive to further the development of API strategies in the PBIS. However, it should be noted that CPaaS is primarily utilised in commercial domains such as sales and business support, customer service, and marketing. These applications of CPaaS often prioritise efficient communication and may not strongly emphasise message safety or adhere to healthcare-specific standards and technologies.

Development of a Platform-Based Ecosystem
Secondly, for developing a platform-based ecosystem, the perspectives, particularly the product owners and platform architects, that contributed to this research were insightful. It contributes by giving a broad overview of viewpoints from the healthcare- and platform domain. Practically speaking, the discussion and thoughts on roles within the platform-based ecosystem are most important for future development. It does not imply that the choices are infallible, but it demonstrates their feasibility and offers some options that can be considered. From my point of view, discussing already described options in this situation will be more effective for the development than creating them from scratch.

9.2.2. Academic Contribution

Placing this research in scientific literature results in the following perspectives. Firstly, this research contributes to the outlined research agenda of (De Reuver et al., 2018). In their research agenda, they proposed a research agenda on digital platforms, indicating many opportunities to conduct platform research. This thesis focuses on defining what design choices should be made in observance of the perspectives of the individual users of the complementors' systems. The results and reflection illustrate how the platform-based ecosystem for the healthcare sector can be conceptualised. Moreover, it demonstrates that utilising multiple platform cores is feasible for offering various services to users connected through the overarching platform.

The created ecosystem provides opportunities for further investigation into whether the ISs should be platform-based and whether this approach is feasible. My findings strongly indicate the necessity to explore the feasibility aspects thoroughly. More targeted research can now be conducted by mapping out the relationships between the systems, specifically focusing on the feasibility and financial implications of implementing the platform. The study's results not only present a blueprint for the platform-based ecosystem but also act as a catalyst for delving into crucial aspects such as feasibility and financial viability, leading to more informed decisions regarding the implementation and sustainability of the platform in the healthcare domain.

Currently, healthcare platforms are primarily focused on supporting one organisation or process. The way the platform-based ecosystem is represented in Chapter 8 shows the versatility of services that can be added to the ecosystem. Connecting organisations with this multitude of services adds to the current healthcare platforms. Despite this, it is crucial to keep feasibility in mind, especially given that most platforms focus on a small number of organisations. This scoping is likely caused by the incentives that result from looking at development from a business case perspective. However, a deeper comprehension of the roles of each organisation is necessary when attempting to build an overall platform.

Interoperability Improvements in Information Systems
The interoperability improvement of Gottumukkala (2023), which depends primarily on the synchronisation of documents between two different ISs (data portability), is discussed in Chapter 1. Although it was noted in earlier reflections on data portability in Section 9.1.4 that the proposed solution in this study does not directly affect the removal of patient data from patient dossiers, it is still possible to decrease some pressure by sending an updated report to the ISs where it is known that patient data are stored. As a result, these ISs can manually or automatically update the data. The value of this solution for data portability in ISs

is in its ability to connect numerous systems using an external API strategy. This ecosystem has many more connections than the Gottumukkala (2023) approach, which depends on creating a connection between two systems. As a result, it offers a more extensive network resulting in a more effective solution.

Positioning the Contribution in DSR

Gregor and Hevner (2013) introduce the grid in Figure 9.1 to place contributions to the knowledge base that result from design science research. The grid shows four categories: (1) improvement, (2) invention, (3) routine design, and (4) exaptation. For the results within this study, the grid is assessed for the *communication improvement* and the *platform-based ecosystem perspective* since, from my perspective, both contribute in different ways.

First, the platform design based on the requirements enabling interoperability needs in terms of communication regarding the care around the medication process can be seen as an *improvement*. It is not new for patients and HCPs to communicate unorganised and disorganised. Still, the communication solution is new and specifically designed to support the requirements directly from the field. The design can improve the current phone calls, emails, face-to-face, sticky notes, etc., by including communication as a service in the platform-based ecosystem. But, the solution, the communication service, must be developed further.

Considering the platform-based ecosystem, the findings can be categorised as *exaptation*, providing a known solution - a platform-based ecosystem - to a new problem in the healthcare context - the problem of interconnecting different systems to each other and new services and technologies. The exaptation does need further research on how the responsibilities in this context will be divided.

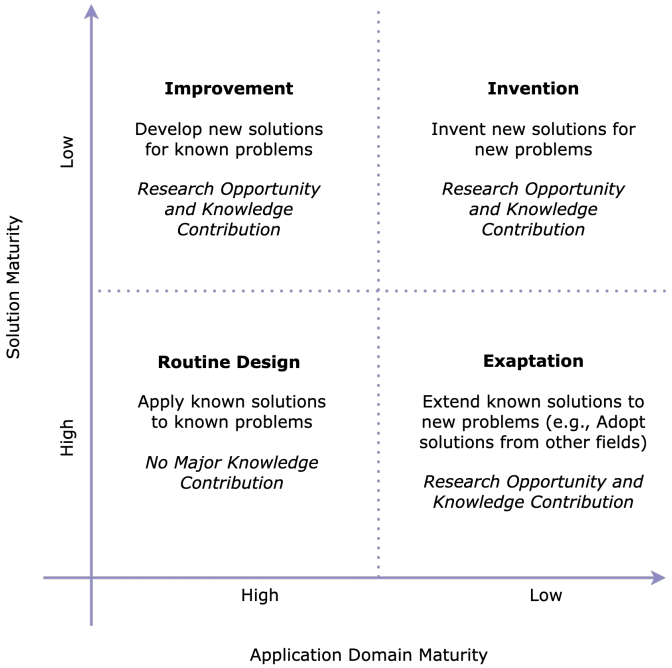


Figure 9.1: DSR Knowledge Contribution Framework (Gregor & Hevner, 2013).

Reuse of Findings

At first, considering the platform-based ecosystem perspective, the reuse contribution can be extended within the platform-based ecosystem itself. For example, insights into responsibilities regarding user identification, the platform owner, and the API agreements in the communication service can be used for other platform cores providing different services. Or as shown in Figure 8.1, the modules for one platform may be reused for other cores.

More broadly, considering the findings discussed in Chapter 8, I see the potential for reuse in two focus areas. First, the reuse of insights considering the *communication*, and second, the reuse of insights considering the *platform-based ecosystem*. The insights are given for potential reuse within other healthcare lines, countries, and domains. Table 9.2 shows a simplified overview of the potential for reusing the findings and the processes discussed in the next Section.

The insights into poor communication between GPs and PHs, and the requirements related to that communication improvement can motivate other healthcare lines and healthcare systems within other countries to see if that is also the case within their systems. The findings of this study can be used as a starting point for research. The requirements can be used as statements to find if stakeholders within their systems agree or see it from a different perspective. The significance is modest when considering how these communication requirements can be reused in other domains. Although general communication may be a topic for research in other fields, most requirements directly relate to the care process.

Considering the platform-based ecosystem perspective for other healthcare lines, I think combining the healthcare lines would be more beneficial instead of creating new platform-based ecosystems for Dutch second and third-line healthcare. For healthcare systems in other countries, I would suggest researching how to create a 'new' platform-based ecosystem supporting their healthcare system because such benefits will be minimal, while the efforts required would be exceedingly high. However, I could make one plausible argument in favour creating a mega communication database to support research concerning medication and healthcare processes. This could potentially provide valuable insights into healthcare-related issues and foster international collaboration among research institutions with access to this communication data. Such a collaborative approach may lead to a robust knowledge base, ultimately contributing to advancements in healthcare on a global scale. Still, I would not recommend combining any systems internationally but creating new ones.

Domains in which ISs are integral to daily operations are, for example, education and governments. The education sector heavily relies on ISs. Establishing a platform for educational systems can facilitate further advancements, such as streamlining transferring students to specific schools. Is there sufficient potential for such a platform, or are there limitations? It became evident during the conversation with PA2 that the domain is already highly active in platform design. However, PA2 found the ideas from the presented design intriguing, supported by the citation below on interaction handling in a healthcare context.

"I thought it was exciting to see the differences in importance for fast response in the healthcare context. Overall, I learned a lot from looking at it from this perspective." (Interviewee PA2)

Furthermore, municipalities utilise ISs. Currently, residents log in via digID, but it is restricted to specific ISs of individual municipalities. Could a platform-based ecosystem serve as a solution? Are there any challenges concerning interoperability or innovation in this context? Using a platform-based ecosystem inside the government may be easier to implement than in the healthcare setting. The platform's advantages will stay within the company because the various ISs and services will be connected to a single entity. I predict that platform service providers will receive more significant incentives.

Reuse of Research Processes

In this study, many research processes were conducted and reflected on in Section 9.1.2. Research processes like the focus group, semi-structured interviews, conducting a survey and formalisation via SRS have all been applied in literature for years. However, using interoperability layers was novel and refreshing for this study in particular. Therefore, the reuse of interoperability layers will be the main emphasis of research process reuse discussed in this final contribution Section.

While the interoperability experts indicated that the interoperability layers were currently mainly used as an assessment or improvement method for IT systems in healthcare, this research uses the layers to construct the IT system. The layers are only 1 year old; therefore, many IT systems are not built following them. This research provides insights into the utility of these layers in the design process of an IT system. From the process, I conclude that the layers contributed to structuring the requirements and ensuring the availability of each layer among the requirements for successful implementation. The requirements were not directly translated to the business, information, and technology layer as proposed in Figure 6.1. Instead, the low-level requirements in the SRS were used. Researching how the requirements constructed based on the interoperability layers would directly affect the platform design would be interesting to see.

The research process employed in this study can be directly applied and adapted within the healthcare context, including incorporating the interoperability layers. These interoperability layers served as valuable tools to categorise the relevant literature, effectively limiting and guiding the developments within the healthcare context. During this study, my main focus was on integrating the perspective of healthcare professionals (HCPs) in the design, which led to some information in the documents (related to the layers in Chapter 3) not being fully included due to time constraints. However, for the further development of the design (the communication *and* ecosystem), it will be essential to ensure complete alignment with all the relevant information, especially legal documents. Utilising the interoperability layers in the design process is valuable, providing strong guidance and support to researchers, ultimately enhancing the effectiveness and applicability of the design within the healthcare domain.

Although the interoperability layers did not significantly impact the results and the final design, the research process can still be modified slightly to yield valuable insights for developing platform cores as services provided on the overarching platform. However, one might question whether these interoperability layers can be generalised for other IS domains. While the care process focuses explicitly on the healthcare context, the other layers have broader applicability. I believe these layers could prove beneficial even in IS ecosystems within the educational or governmental domain, showcasing their versatility and potential for cross-domain application.

Moreover, some changes to the research method may be necessary given that the interoperability layers had little impact on the outcomes and the final design. Nevertheless, the process continues to be very helpful in providing information for creating platform cores and services offered on the central platform. The interoperability layers need experimentation to be effectively generalised for other IS domains. The care process, however, is specially designed for the healthcare environment, whereas the other levels have more general applicability. In my opinion, these layers have the potential to go beyond the domain of healthcare.

Table 9.2: Overview of Potential for Reusing Findings and Processes

Reuse Area	Application of Communication	Application of Platform-Based Ecosystem
Other healthcare lines	Research (poor) communication; Use requirements for research; Use interoperability layers for design support; Use interoperability layers to categorise and include all regulations;	Try to connect the platforms; Use this study's design to discuss responsibilities; Use interoperability layers to categorise and include all regulations;
International	Research (poor) communication; Use requirements for research; Use interoperability layers for design support; Use interoperability layers to categorise and include all regulations;	Create own platform-based ecosystem; Use this study's design to discuss responsibilities; Use interoperability layers to categorise and include all regulations;
Other domains	Get inspired by healthcare context; Use adjusted interoperability layers for design support; Use interoperability layers to categorise and include all regulations	Obtain easier incentives within one (large) organisation; Use this study's design to discuss responsibilities; Use interoperability layers to categorise and include all regulations;

The academic contribution also entails identifying knowledge gaps that need to be filled in the future. There are knowledge gaps due to the research activities, particularly in technology definition, information detailing, and stakeholder governance. Section 10.2 in Chapter 10 discusses the suggestions for further research.

10

Conclusion and Recommendations

This final Chapter concludes the study by answering the five sub-questions and the main research question. Each sub-question introduced in Chapter 2 is answered in Section 10.1.1. The main research question is answered in Section 10.1.2. Then, while considering the reflection and contribution in Chapter 9, and the knowledge gaps answered in Section 10.1.1 and 10.1.2, the recommendations are given in Section 10.2. The recommendations include recommendations for further research in Section 10.2.1 and policy recommendations in Section 10.2.2.

10.1. Conclusions

This Section concludes the study following the research questions constructed in Chapter 2. The sub-questions following the Design Science Research Methodology are answered in Section 10.1.1, while the main research question is answered in Section 10.1.2.

10.1.1. Answering Sub-Research Questions

Sub-question 1

Which known requirements related to a PBIS in Dutch first-line healthcare should be considered?

The requirements that should be considered for designing a technology-based intervention in Dutch first-line healthcare are defined by legal institutions (including laws and regulations) and initiatives on standards and programs by organisations within the domain. In Chapter 3, not all initiatives are defined, but only the ones relevant to this research. However, the high number of initiatives does outline the willingness to take action in society.

The relevance of interoperability layers is highlighted to categorise requirements supporting the design. The seven interoperability layers are proposed for interoperability between two healthcare organisations around a year ago, thus including a relatively new area (Nictiz, 2022a). However, the interoperability layers were expected to support the design and thus used as a means to categorise the requirements in the environment. The following list shows the applied requirement areas for the design.

- Wvpz requirements for BSN use within systems;
- Audit Logging according to NEN7512;
- Data sharing regulations by Wegiz;
- Guidelines on cooperation by IZA, Informatieberaad Zorg;
- Standards by NEN7510, MedMij, OPEN, KNMG, NHG, HL7.

The results indicate that the requirements primarily focus on *security*, *laws and regulations*, *organisation policy, care process*, and *information* layers, encompassing safety and care process aspects. The *application* and *IT infrastructure* layers receive less attention, suggesting more flexibility in decision-making for the design.

It was also found that earlier researched PBIS architecture included construction requirements by van Hattum (2020), Groeneveld (2021), and Kong (2023), focusing on the IS expert perspective. Since those requirements were constructed following a master thesis research, of which results are not directly accepted in literature, it was decided to use them as an evaluation rather than predefined requirements. Sub-question 4 discusses the evaluation based on these requirements.

Contrarily, it is proven that the existing literature lacks specific requirements concerning the perspectives of HCPs and patients regarding a PBIS. By engaging GP practice and pharmacy employees, valuable input will be gathered to inform the configuration of the interoperability layers, aligning with the proposed goals by Nictiz (2022a).

Sub-question 2

What requirements meet pharmacists', general practitioners' and patients' interoperability needs in Dutch first-line healthcare?

The preliminary research explored pharmacists' and general practitioners' interoperability needs, starting with a focus group. This focus group not only supported the knowledge of the current situation and the participants' attitude towards this situation but did directed the research towards the *communication regarding care around the medication process*. This desire was brought up by one participant and supported by the others. The requirements resulting from preliminary research were categorised following the layers of Nictiz (2022a). The patients' perspective is included by looking at the HCP's input and values in the literature. The values from the literature resulted in additional requirements in the area of (1) self-management, (2) personal care, and (3) patient trust in the system.

The further requirement engineering processes (including the survey to support requirement elicitation, requirement analysis, formalisation and evaluation) outlined the requirements considering communication needs in Dutch first-line healthcare. Concluding, they are found in five dimensions. The dimensions are listed and explained shortly below, while an overview of all the requirements for the dimensions can be found in Appendix L.

1. *HCP-Participation*
   The HCP participation requirements include enhancing *communication control*, *integration*, and *cooperation*. Making communication *simpler*, promoting *responsibility transfers*, and empowering HCPs to respond to requests from their peers. Managing incoming notifications, data storage, and cooperation with other medical experts are all intended to support integration. HCPs consider it important to incorporate communication into their existing procedures. Furthermore, control against message overload is essential since HCPs like to manage messages according to their schedule and preferences

2. *Access Regulation*
   Organisation, *discipline*, and *medication* are the three categories for access regulation. Organisation- and discipline-based access ensures messages are sent to the right HCPs. Medication-based access largely serves as a source of research and insights, offering data on patients' perspectives and commonly asked topics.

3. *Clear and Concise Content*
   The resistance among HCPs considering chaotic communication regarding care around the medication process is present. Managing the patients' input will ensure the input will be limited within a certain framework, realised by managing the expectations and increasing the trustworthiness by providing patients with sufficient information. Furthermore, the communication needed to be connected to a code list, labelling parts of the communication and situation. This code list will include existing codes and a specific code base based on frequently communicated areas. HCPs argued for the *usability* of codes in terms of a sufficient amount of included communication areas, well-documented codes, and easy-to-find codes.

4. *Agreement Support*
   Upholding regional or national agreements helps to ensure the system's credibility, which also impacts patients' perspectives. If healthcare organisations adhere to the agreements and transparency is intended, patients will be more likely to trust them. Supporting regional, statewide, and inter-HCP agreements was already discovered to be crucial in the preliminary research, followed by the survey analysis.

5. *Patient-Participation*
   Usability, self-management, and personal communication are the primary concern of patient-centred needs. It is crucial to recognise that not all patients are expected to want a different option for contact, particularly the elderly, who may have trouble using technology and would instead use more conventional techniques like phone calls. Consequently, allowing patients to select their preferred communication style improves their engagement. The platform for communication should assist this change without displacing current tools. Key elements in encouraging patient engagement include *creating trust*, supporting *self-management*, and providing *personal care*.

Sub-question 3

How can the platform architecture components be designed that meet the requirements?

The design (Figure 6.2 in Chapter 6) of the platform architecture, while representing one feasible option, focuses on ensuring clarity of the *core functionality* and what systems are needed to support that functionality. The clarity is supported by creating a representation of the business layer, the information layer, and the technology layer and how these layers connect.

The architecture design process has provided valuable insights into the critical role of systems connected to the platform in the overall success of the platform. It has become evident that the platform cannot fulfil all the identified requirements, emphasising the need for further research to explore the trade-offs and responsibilities involved in achieving interoperability requirements. However, it underscores the dynamic nature of platform development and the need for iterative refinement and adaptation.

The process of creating the platform architecture design did show one opportunity to design a platform enabling the requirements. The requirements were already structured during the requirement formalisation process, intended to answer sub-question 2, and supported the design process. Formalising the requirements enhanced a structured and complete overview of the requirement and provided the low-level requirements as the starting point for creating platform modules. Platform modules supported the platform's design regarding the partitioning of functionalities.

Sub-question 4

To what extent is the platform architecture design an effective means to the design of a PBIS supporting Dutch first-line healthcare?

Initially, the results of the semi-structured evaluation interviews revealed many suggestions for improvement on the first two versions of the platform design demonstrated to the interviewee. This did indicate the platform design was not yet of the expected quality. Still, even when the design did not yet provide the right quality to support the development directly, the indirect effect on the design was there. Namely, the discussions with the platform architects resulted in an improved version of the architecture design and many insights on further research needed to design the functionality within the PBIS. Despite, or *by*, the unfinished character of the architecture design in the first place, the list of insights on the design (processes) was higher than expected.

The evaluation of the platform criteria, *simplicity*, *resilience*, *maintainability*, and *evolvability*, resulted in the finding no firm conclusions can be made on resilience and maintainability. After two iterations, the simplicity was assessed positively, meaning the high-level abstraction is clear. The evolvability was already assessed positively from the start. However, further technology insights are needed to assess resilience and maintainability, according to the interviewees. Not only the technology layer should then be defined clearly, but also the need for defining use cases was proposed.

Finally, the previously established requirements, part of answering sub-question 1, were compared with the architecture design. A good fit with those requirements shows that the design is suitable for creating the PBIS because complying with requirements from multiple perspectives raises support for implementation. Most requirements align with those previously drafted, with a few exceptions. There were still some dissimilarities in interfaces, software development kit, DevOps tool for debugging, less government control and data storage.

Concluding, the architecture design is an effective means to the design in terms of (1) expressing the core functionalities, (2) expressing core information systems needed to fulfil the core interaction, and (3) creating active brainstorming sessions on further design choices. The effect of the design can be improved by (1) researching the technology layer in more detail, (2) adhering fully to the other requirements, and (3) paying attention to developing use case scenarios.

Sub-question 5

Considering the study, what lessons were learned in exploring platform design as part of the Dutch IS ecosystem in first-line healthcare?

Exploring platform design as part of the Dutch IS ecosystem in first-line healthcare provided insights into two domains: *technology* and *stakeholders*. Considering the technology, this study supports the idea that, technically, a lot is possible. This study's design outlines the technological opportunities in platform architecture design and the possibilities for including innovative technologies. Additionally, the platform-based perspective was refined according to the study's findings. I refined the perspective of a platform-based *information system* into a platform-based *ecosystem* since the full potential of the intervention is better described as an ecosystem rather than an information system.

The platform-based *ecosystem* perspective significantly impacts the stakeholder area due to the many challenges emerging, considering incentives and responsibilities. New incentives considering the participation of the intervention arise, but these incentives are not aligned, and aligning those will be hard. Additionally, challenges regarding responsibilities further complicate the implementation, as perspectives on who should be accountable for various aspects are not fully aligned. The combination of time constraints, financial constraints, and the multitude of stakeholder challenges affects the feasibility of implementing and completing the design of the platform-based ecosystem negatively. To enhance feasibility, governance measures, as well as careful schedule and budget planning, should be implemented. These measures can help address the challenges and align stakeholder interests, ultimately increasing the likelihood of successful implementation. Furthermore, keeping the platform responsibilities limited can help. Make sure only the core functionalities are implemented by the platform cores.

10.1.2. Answering Main Research Question

The sub-sections addressed in Section 10.1.1 helped to fill the knowledge gap identified in Chapter 1 by answering the main research question.

Main Research Question

How should the requirements, enabling patients' and HCPs' needs regarding interoperability, be incorporated in the digital architecture design of a platform-based information system supporting Dutch first-line healthcare?

The embodiment of the answer to the main research question is shown by the platform architecture directly resulting from the requirements and the platform-based ecosystem perspective. The needs will be enabled by the (1) platform cores supporting a particular service, (2) the overarching platform, and (3) the systems connected to the platform, so there won't be just one involved party responsible for fulfilling the requirements. Constructing requirements from the individual users of systems connected to the potential platform has proven valuable results. Further conclusions provide insights on *how* the design process is beneficial in general.

In designing platform-based solutions to support Dutch first-line healthcare, it is essential to consider the interaction between involved systems and how it can be realised by the platform. In this case, improving communication regarding care around the medication process. Rather than only researching support on a bigger scale using a survey or other validation process, detailed use cases must be defined since it provides valuable insights into the relevance of these requirements and helps validate their necessity and potential impact. Developing detailed use cases results from identifying specific responsibilities within the interaction and enabling effective failure management, considering various interaction scenarios. It is expected including the use case design would result in additional requirements.

While gathering the requirements in the healthcare domain from *users*, it is important to consider four interoperability layers: *organisation policy*, *care process*, *information*, and *application*. Each layer plays a crucial role in ensuring seamless communication and coordination within the PBIS; thus, no layer can be disregarded. By categorising requirements based on a structured approach that distinguishes higher- and lower-level requirements, it is easier to define the lower-level requirements and identify the specific functionalities the platform needs to realise. Those functionalities provide an accessible means to start designing the platform modules that need to be fulfilled by the platform.

While the platform owner has specific responsibilities, it should also be acknowledged that not all requirements can or should be met solely by the platform. Complementors (including ISs) play a significant role in fulfilling these requirements. This distribution of responsibility is a topic of debate. From a more business-oriented standpoint, the platform owner could make this decision alone; however, since the solution is meant to benefit society as a whole, opening the responsibility discussion is seen as the better choice, in line with the wishes of the Minister of Health, Welfare, and Sports (Kuipers, 2023).

The statement of Interviewee PA2: *"Placing a new world into an already existing world is complex since you don't know everything within that new world"*, outlined creating a solution in a currently very active domain is challenging. The research processes in this study indicated that opening the conversation with people in the field results in a good starting position to gather information about that *world*, leading to successful implementation. However, the abovementioned considerations highlight the need for additional research and interventions to address the complex nature of a platform-based ecosystem supporting Dutch first-line healthcare. These additional research and interventions are discussed in the following Section.

10.2. Recommendations

In this Section, I present the recommendations in two domains. First, in Section 10.2.1, the recommendations for further research focus on supporting the development of the solutions and academic knowledge gaps. In Section 10.2.2, I propose policy recommendations supporting the implementation and research.

10.2.1. Recommendations for Further Research

Additional research is necessary to support the development of the platform-based ecosystem and the communication service. In addition to providing practical support, expanding the information necessary for generating the solutions covers knowledge gaps by exploring stakeholder- and technology perspectives that might be useful for other domains or contexts. My first recommendation would be to explore the patient's perspective towards communication.

Explore the Patient's Perspective
The patient perspective is only included based on input from HCPs and literature. However, discussing the subject with patients is highly recommended, especially in the *Zeitgeist*, where patient-centred healthcare is developing and will become the norm. As already discussed in Chapter 9, I was highly enthusiastic about the effect of organising focus groups. I would also recommend applying the focus group method to discover the patient's perspective.

As the reflection in Chapter 9 already shows, the patient perspective does need additional data management, although nearly every citizen can be seen as a patient from the first-line healthcare system. I recommend diving into the embodiment of personal healthcare data in advance. This way, the researcher can more precisely indicate what data can be saved/used for research purposes. The patient perspectives that are the most relevant for further development are perspectives (1) towards digitisation of healthcare contact, (2) towards patient supporting platforms (PGO, platform portal, etc.), and (3) towards relationships with HCPs. Moreover, the patient perspective can support the information details the platform needs.

Information Detailing
The information details are currently lacking and need improvement. What is the expected content on the platform? What user details are necessary? The explanation of the communication is now supported by a limited amount of examples. Insights on the variety of communication that takes place using phone calls, emails, and face-to-face communication, should be researched. Researching the variety can be done by observing patients and HCPs in their daily communication or by organising focus groups or brainstorming sessions, using the effect those meetings have on the participation of the attendees.

Follow the ADM Cycle
To obtain a successful implementation of the requirements (in the form of the designed platform), the systems life cycle and processes in the ADM should be considered. What will be the next steps? The ADM cycle proposes various additional steps to implement the architecture successfully. Figure 10.1 shows which steps need to be taken in addition to the design. Following the ADM cycle does need to be supported by the idea that implementing an IT intervention is challenging and delayed often, as outlined in Chapter 8. The best practices need to be addressed to see what steps need to be taken to support an implementation process.

Figure 10.1: Next Steps ADM cycle.

The use of architecture layers directly shows the need for research on the specification of technologies in the platform. Deciding on the technologies enabling the information layer merely lies in the domain of more technical-related studies or within development teams.

Expanding the architecture further is essential for platform development. These processes can be *complicated* due to the technical knowledge needed. However, from my perspective, the implementation governance (G) mostly touches upon the *complex* knowledge gaps identified by this study. The *complexity* makes the knowledge gap more relevant from the CoSEM perspective. By this, I do not want to imply that the other is irrelevant, but I believe these knowledge gaps are where the academic importance of a CoSEM-related topic rests. Furthermore, considering the feasibility impact discussed in Chapter 8, governance is one of the proposed solutions to increase feasibility.

Increase Feasibility
Despite facing time constraints and financial considerations, successfully deploying the solution poses challenges regarding allocating costs. While the responsibility for funding such a platform remains uncertain, the demand stems from healthcare providers, potentially influencing cost-sharing decisions. As I already discussed the reuse of platform modules internally, the dilemma of build-or-buy trade-offs externally can also be considered. Is it necessary for one party to build every platform system? Or are readily available platform solutions, such as Software as a Service (SaaS), Platform as a Service (PaaS), or Communication Platform as a Service (CPaaS), viable options? This needs exploration of the overarching and individual platform cores' scales.

Furthermore, institutional frameworks to guide and control stakeholders' responsibilities become essential to increase the feasibility of implementation. Effective stakeholder governance, grounded in open and continuous communication, is pivotal in harmonising different incentives and addressing uncertainties. As discussed in Chapter 8, researching the governance is necessary before implementing the platform-based ecosystem or parts of the platform-based ecosystem. Mapping roles and responsibilities to provide insights on the institutions necessary for supporting the implementation can be done by research based on the institutional framework, such as the Institutional Analysis and Development (IAD) framework as introduced by Ostrom (2011), or the generic model to guide the process of designing institutions in complex technological systems of Koppenjan and Groenewegen (2005). From my perspective, these are highly useful for expanding this study since the utility of these frameworks and theories is especially proven in complex socio-technical contexts.

Some additional insights on governance aspects are listed below.

- Prioritising employee training to ensure the platform complies with the NEN7510 guideline, as discussed in Chapter 3 is essential.
- Addressing and managing undesirable behaviours, such as excessive patient questions or inappropriate actions by healthcare providers, as described by Evans (2012) is needed.
- Integrating digital platform design features into the governance process to achieve desired outcomes and value creation, where users can access and utilise information effectively, is needed (Evans, 2012).
- Finally, maintaining ongoing *communication* with all involved parties fosters collaboration and alignment, as proven in this study.

By implementing these governance strategies, the platform can overcome challenges, foster a conducive environment for stakeholders, and ultimately achieve the intended value and positive impact on healthcare practices.

Design Principles and Guidelines
Furthermore, the reflection on the design principles in Chapter 9 outlines the importance of insights into new design principles for digital platform design in an information system ecosystem. For example, by comparing the IS design principles introduced in Chapter 2 with design principles specifically for platform design. Analysing how these design principles affected the design and what changes need to be made to the design principles to provide sufficient support will be helpful for the further development of platform-based solutions within and beyond the healthcare domain. Developing new design principles is even more valuable because the guidelines are dated from 2010. Updated design principles can support design processes for expanding or improving this platform-based ecosystem with multiple platform cores and expanding to a broader field.

10.2.2. Policy Recommendations

The government/policymakers can play a crucial role in implementation of this study by (1) standardising communication, (2) subsidising platform-based ecosystem development, and (3) applying a well-designed implementation program.

Standardise Communication
To improve communication and data exchange in first-line healthcare, it is crucial to implement standardised communication protocols and formats. Encouraging the adoption of widely accepted standards needs national agreements. This does not particularly need to be created by the government itself, but creating these communication standards probably needs support from the government.

Subsidise
Subsidies are required to create communication standards and research and development around the platform-based ecosystem. Consider providing financial incentives or subsidies to healthcare providers who embrace and integrate such platforms to encourage the adoption of platform-based ecosystems in the industry. This financial support can help defray the expenses of initial deployment while motivating healthcare organisations to join the ecosystem. The initiator must work with critical stakeholders, such as insurance firms and governmental organisations, to design a sustainable funding strategy to support these platforms' continued growth and upkeep.

Implementation Programme
The communication service can be compared to the implementation programme VIPP focusing on the accessibility of medical information between HCP and patients and between HCPs. The VIPP 5, however, focuses on the medical information concerning a specific patient (Dienst Uitvoering Subsidies aan Instellingen, 2023). The VIPP programme focuses more on data portability, meaning the organisations need to give patients access to the information the organisation has about that patient. The interesting aspect of including the programme as an example is the implementation programme provided by the government. The VIPP programme was introduced and implemented, supported by the government. This support mainly included planning, providing sufficient information, providing frequent updates, and providing clear responsibilities in the programme. This is an excellent example of how implementing the platform-based ecosystem and services provided through the platform can be achieved.

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A

Appendix: Search Strategy

This appendix described the research process for literature to indicate the knowledge gap. The literature is found using the databases Google Scholar and PubMed. Google Scholar provides a broad range of articles (Wageningen University, n.d.), while PubMed is additionally used to find more healthcare-related literature on the research topic (Jayaratne et al., 2019). During the process, *backward snowballing* has been applied to find additional related literature, defined as "using the reference list of a paper or the citations to the paper to identify additional papers" (Vassar et al., 2016). Articles derived by snowballing are denoted with an asterisk (*). An overview of the articles and the discussed topics can be found in Table A.1.

This literature review stems from a desire to extend previous research regarding PBIS design in Dutch first-line healthcare. These studies form the reason for further literature review. Reading this literature confirmed the urgency for designing an architecture supporting the design of a PBIS. A PBIS is a type of digital ecosystem infrastructure. To gain more insight into how such an infrastructure should be designed, the following search string was used.

The term "Information Infrastructure" is added to the search string, since this term has also been used by Aanestad and Jensen (2011) and Lenert and McSwain (2020) to indicate the same concept as "Information System". Both refer to a collection of components (people, organisations, agencies, policies, processes, and technologies) supporting the development, operation and management of information services.

Search String 1:
("digital platform" OR "ecosystem infrastructure" OR "digital ecosystem" OR "ecosystem") AND ("information system" OR "information infrastructure") AND ("healthcare" OR "health care" OR "first-line healthcare") AND ("design" OR "architecture design")

From the results, articles were scanned and read through. Based on the characteristics described in Figure A.1, they were excluded. The articles concerning the architecture design of digital ecosystem infrastructures indicated the relevance of approaching requirement engineering significantly. To develop an architecture design, good requirements are needed that match the needs of users. The following search string was used to find literature discussing the importance of functional requirements in the architecture design of healthcare information infrastructures:

Search String 2:
("design" OR "architecture design") AND ("information system" OR "information infrastructure") AND ("functionalities" OR "requirements" OR "functional requirements") AND ("healthcare" OR "health care" OR "first-line healthcare")

Assessing the included literature also resulted in additional articles, added by snowballing. The articles included by snowballing are indicated with an asterisk in table A.1.

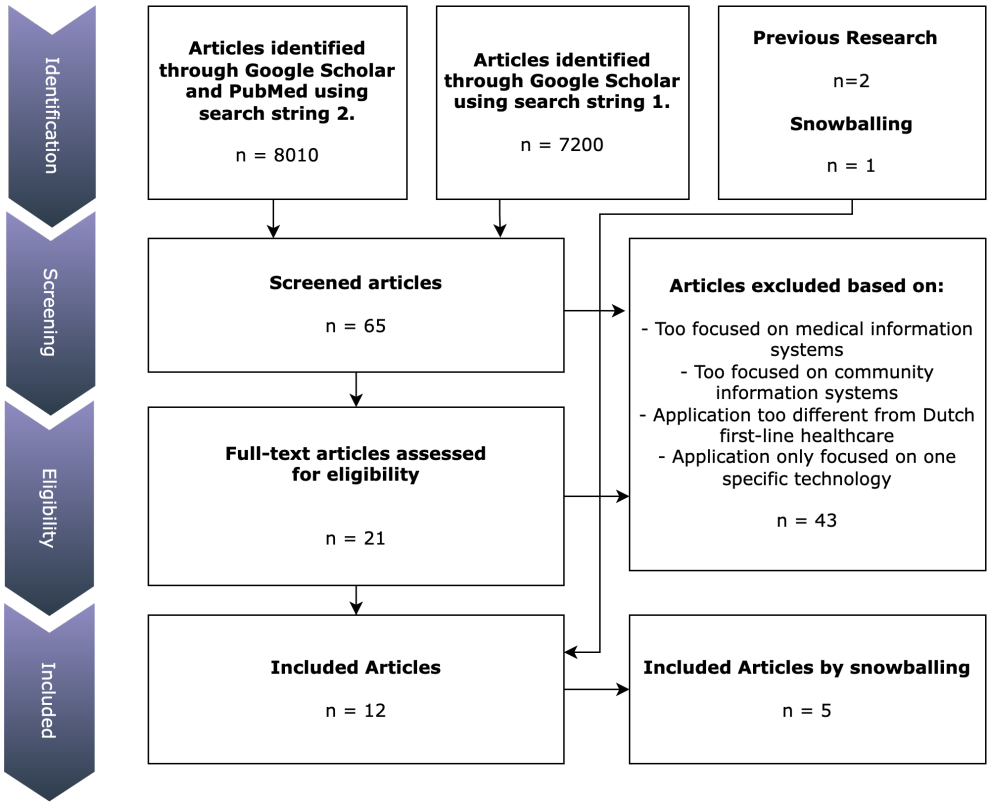


Figure A.1: Search Strategy Literature Review.

Table A.1: Overview Used Literature during Exploration.

Literature	Cited	IS Digital Ecosystem	PBIS Dutch first-line Healthcare	User-Centered Requirements Engineering	Architecture Design
Groeneveld (2021)	0		x		
van Hattum (2020)	0		x		
Aanestad and Jensen (2011)*	288	x		x	x
Haux (2006)	463			x	
Sheikh et al. (2021)	50			x	
Epstein et al. (2010)	674			x	
Jayaratne et al. (2019)	33	x			
Wutzkowsky and Böckmann (2018)*	6			x	
Lin et al. (2020)	1	x			
Yari et al. (2021)	3			x	
Morita et al. (2019)*	25			x	
Moner et al. (2006)	11	x			x
Marcos et al. (2015)	11				x
Hanseth and Lyytinen (2004)*	257	x			
Hanseth and Monteiro (1998)*	398	x			
Hanseth and Lyytinen (2010)	1052	x			
Janssen (2021a, 2021b)	0				x

B

Appendix: Insights in Current Processes

Literature and preliminary research resulted in these sequence diagrams showing three processes within first-line healthcare. The diagrams mostly supported the study by showing the as-is situation. Showing some processes are already taken care of, while other processes would need more improvements.

Figure B.1 shows three variations on the start of a medication process.

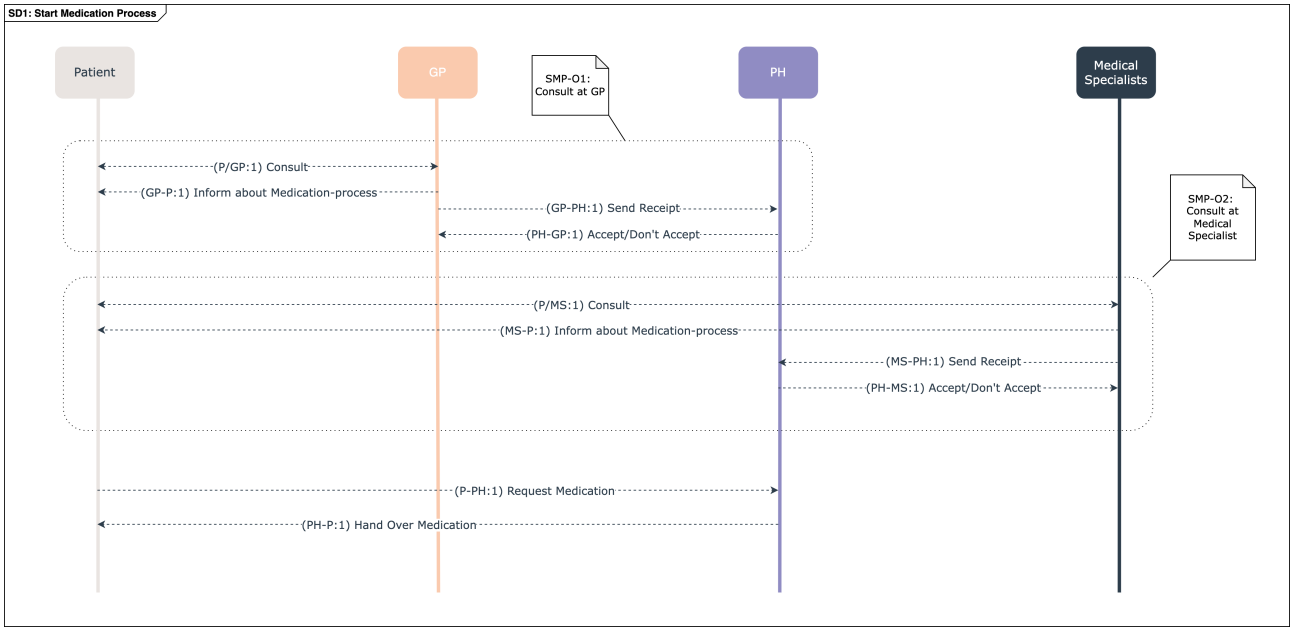


Figure B.1: Sequence Diagram Representing Multiple Possible Starts for the Medication Process.

In Figure B.2 six variation of repeat recipe processes are shown.

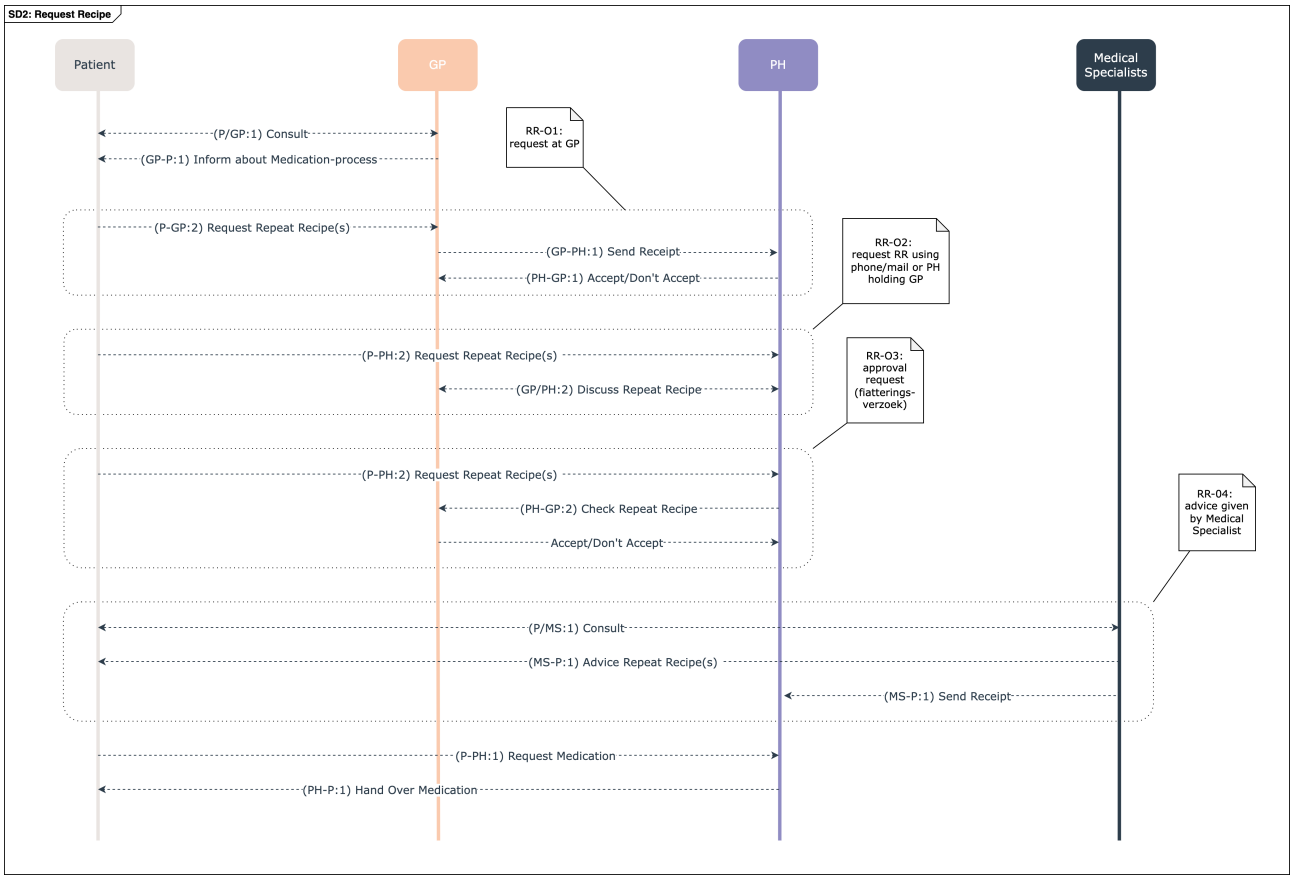


Figure B.2: Sequence Diagram Representing Multiple Repeat Recipe Processes.

In Figure B.3 two variations of care processes are visualised.

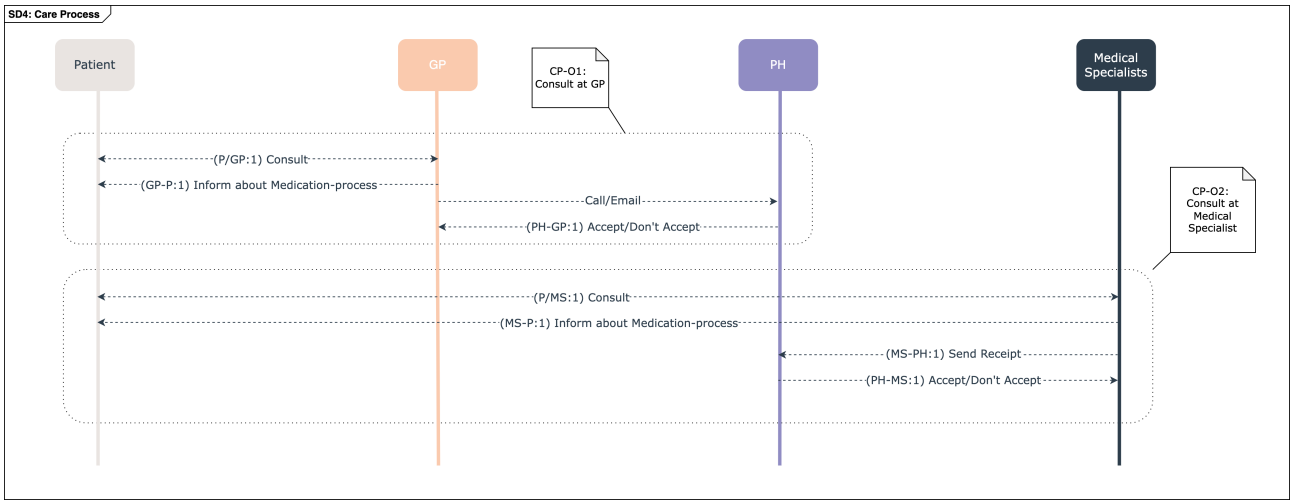


Figure B.3: Care Process.

C

Appendix: Consent Forms

This Appendix shows the consent forms for the focus group and semi-structured interviews and the consent message starting the survey, which was spread among pharmacists and general practitioners. All consent forms were translated into Dutch for Dutch-speaking participants. The signed consent forms are safely stored on the TU Delft One-Drive. Figure C.2 shows the consent form for the focus group session. Figure C.3 shows the consent form for the semi-structured interviews during preliminary research. Figure C.4 shows the consent form for the semi-structured evaluation interviews. Figure C.1 shows the consent text as shown in the survey.

Consent Text Survey TU Delft

You are being invited to participate in a research study titled '*A study on how the functional requirements, enabling patients'- and healthcare professionals' needs regarding interoperability, should be designed in the digital architecture of a platform-based information system supporting Dutch first-line healthcare*'. This study is being done by Maureen Zwart from the TU Delft.

The purpose of this research study is to contribute to the design of a platform-based information system as a substitute for information systems, with the aim to improve interoperability and innovation in Dutch first-line healthcare, and will take you approximately 15 minutes to complete. The data will be used for assessing the needs for interoperability within first-line healthcare providers.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. The survey is designed to be anonymous, please don't leave personal details in your answers. The answers will be preserved for up to 2 years at TU Delft, and may be used for further studies in the domain of interoperability and openness within Dutch first-line healthcare. The results from the survey will be made publicly available in an aggregated and anonymized format in the master thesis.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you still have any questions left, you can contact Maureen on m.zwart@student.tudelft.nl.

By starting the survey, you consent with the above mentioned.

Figure C.1: Survey Consent Message.

You are being invited to participate in a research study titled '*A study on how the functional requirements, enabling patients'- and healthcare professionals' needs regarding interoperability, should be designed in the digital architecture of a platform-based information system supporting Dutch first-line healthcare*'. This study is being done by Maureen Zwart from the TU Delft.

The purpose of this research study is to contribute to the design of a platform-based information system as a substitute for information systems, with the aim to improve interoperability and innovation in Dutch first-line healthcare, and will take you approximately 90 minutes to complete. The focus group results will be used for assessing the current functionalities within first-line healthcare regarding interoperability and end-users' needs.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by storing the recording and results of this focus group safely, on a TU Delft institutional database. The recording and your data (name and email address) will be saved for +- 2 years. Your name, email address and recording will only be stored and made available for the research team. Only a summary of the focus group will be made publicly available together with the master thesis.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you have any questions left, please contact the researcher Maureen on m.zwart@student.tudelft.nl, or the supervisor Mark de Reuver on g.a.dereuver@tudelft.nl.

PLEASE TICK THE APPROPRIATE BOXES	**Consent**
1. I have read and understood the study information above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐ yes ☐ no
2. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐ yes ☐ no
3. I give consent to the information above.	☐ yes ☐ no

Signatures

Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Maureen Zwart		
Researcher Name	Signature	Date

Study contact details for further information:

- Maureen Zwart, m.zwart@student.tudelft.nl
- Mark de Reuver, g.a.dereuver@student.tudelft.nl

Figure C.2: Consent Form Focus Group.

You are being invited to participate in a research study titled '*A study on how the functional requirements, enabling patients'- and healthcare professionals' needs regarding interoperability, should be designed in the digital architecture of a platform-based information system supporting Dutch first-line healthcare*'. This study is being done by Maureen Zwart from the TU Delft.

The purpose of this research study is to contribute to the design of a platform-based information system as a substitute for information systems, with the aim to improve interoperability and innovation in Dutch first-line healthcare, and will take you approximately 45 minutes to complete.The results of the interview will be used as preliminary research for preparing a questionnaire.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by storing the recording and results of this interview safely, on a TU Delft institutional database. The recording and your data (name and email address) will be saved for +- 2 years. Your name, email address and recording will only be stored and made available for the research team. A summary of the interview will be made publicly available together with the master thesis.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you have any questions left, please contact the researcher Maureen on m.zwart@student.tudelft.nl, or the supervisor Mark de Reuver on g.a.dereuver@tudelft.nl.

PLEASE TICK THE APPROPRIATE BOXES	Consent
1. I have read and understood the study information above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐ yes ☐ no
2. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐ yes ☐ no
3. I give consent to the information above.	☐ yes ☐ no

Signatures

Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Maureen Zwart		
Researcher Name	Signature	Date

Study contact details for further information:

- Maureen Zwart, m.zwart@student.tudelft.nl
- Mark de Reuver, g.a.dereuver@student.tudelft.nl

Figure C.3: Consent Form Semi-Structured Interviews Phase 1.

You are being invited to participate in a research study titled '*A study on how the functional requirements, enabling patients'- and healthcare professionals' needs regarding interoperability, should be designed in the digital architecture of a platform-based information system supporting Dutch first-line healthcare*'. This study is being done by Maureen Zwart from the TU Delft.

The purpose of this research study is to contribute to the design of a platform-based information system as a substitute for information systems, with the aim to improve interoperability and innovation in Dutch first-line healthcare, and will take you approximately 45 minutes to complete. The interview results will be used for assessing the architecture design, designed by the researcher.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by storing the recording and results of this interview safely, on a TU Delft institutional database. The recording and your data (name and email address) will be saved for +- 2 years. Your name, email address and recording will only be stored and made available for the research team. A summary of the interview will be made publicly available together with the master thesis.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you have any questions left, please contact the researcher Maureen on m.zwart@student.tudelft.nl, or the supervisor Mark de Reuver on g.a.dereuver@tudelft.nl.

PLEASE TICK THE APPROPRIATE BOXES	**Consent**
1. I have read and understood the study information above, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐ yes ☐ no
2. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐ yes ☐ no
3. I give consent to the information above.	☐ yes ☐ no

Signatures

Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Maureen Zwart		
Researcher Name	Signature	Date

Study contact details for further information:

- Maureen Zwart, m.zwart@student.tudelft.nl
- Mark de Reuver, g.a.dereuver@student.tudelft.nl

Figure C.4: Consent Form Semi-Structured Interviews Phase 3.

D

Appendix: Focus Group

D.1. Focus Group Preparations

D.1.1. Participant Involvement

The scope of job positions is restricted to GP, PH, GPA or PHA. Through discussions with colleagues at Sanday, it is anticipated that they possess comprehensive knowledge of the system's functions and actively utilise them. The decision not to involve every job position associated with pharmacy and/or general practitioners is driven by the potential for an unwieldy focus group or multiple focus groups, which is presently impractical due to time constraints. The goal was to find an equal number of participants from both pharmacists and general practitioners, to support an equal 'voice' during the discussion.

Besides job position, 2 other things are considered important: 1) The participant should use a system that has been in use for at least 6 months so that teething problems within the system have been eliminated; 2) The participant should have used the system for at least 6 months, to ensure significant experience with their system.

D.1.2. Online Facilitation

An online meeting serves as an inclusive and accessible method for inviting participants. While it may result in a slight reduction in non-verbal communication, which often offers valuable insights into individuals' opinions on a specific subject, the considerable advantages of its low-threshold nature outweigh this limitation in the given context. The scheduled online meeting is set to take place on Thursday, March 30, from 3:00 to 4:30 p.m. This timing selection stems from research conducted to identify the most opportune times for group gatherings, specifically targeting the period after the midweek slump, encompassing Tuesday, Wednesday, or Thursday.

D.1.3. Language Use

Firstly, the focus group is conducted in Dutch to enhance accessibility for employees, considering their predominant use of the language in their work. This decision was reached following discussions with several employees at Sanday, who confirmed that the systems are currently utilised exclusively in Dutch. Furthermore, the language used has been adjusted to align with the expected terminology employed by healthcare professionals operating within this field. For instance, it was discovered during conversations with Sanday's marketing team, and the interoperability experts that not all employees within the respective practices are familiar with the term "interoperability". Consequently, the combination of the terms *information exchange* and *collaboration* as a means of collaboration was chosen as an alternative that is more recognisable and comprehensible to all participants.

D.2. Focus Group Guidance

D.2.1. Focus Group Moderator

Participants are aware that they are engaging in an open conversation aimed at identifying their needs. To ensure a low threshold and avoid overwhelming participants with excessive information, minimal prior project details were provided. Also, it was crucial to introduce and guide participants with appropriate questions, as this guidance is essential for extracting valuable insights (Greenbaum, 1998). Moreover, ongoing guidance during the conversation is equally important, especially to balance the participation of talkative individuals by actively involving and engaging quieter participants.

Regarding feedback on the focus group's usefulness and criticism of the questions, the following points are of significance: (1) the researcher should listen to and incorporate the feedback, and (2) efforts will be made to clearly explain the purpose behind certain choices to ensure participants understand the rationale of the research.

Initially, it was decided to employ slides as supportive materials for the focus group. However, upon testing the technical settings and relevance of the slides, it was determined that their inclusion was unnecessary. The slides did not contribute to the participants' comprehension during testing. Moreover, due to the online nature of the conversation, the slides hindered genuine

connection between participants and the moderator, resulting in distractions and limited visibility of one another, as the slides occupied the entire screen.

D.2.2. Focus Group Agenda

Table D.1 shows the agenda used during the interview as supporting means of the researcher. The table shows 5 Phases: introduction, current usage, attitude, idea generation, and finishing up. Each phase consists of several actions. The subject, goal, task, time, and supporting comment for each activity are shown.

Table D.1: Focus Group Agenda.

Subject	Goal	Task or Question	Supporting Comment	Time
INTRODUCTION (15 min)				
personal introduction	welcoming	short intro about researcher and research at TU	keep it short and understandable (language)	00:05
explain the focus group	information	*Do you have any questions before we proceed?*	purpose and scope should be clear; participants should feel safe	00:05
consent check	consent	*Do you have any questions about the consent form?*	haven't read it; give short summary and send later on	00:01
introduction participants	warm-up	*Can you briefly introduce yourselves; Pharmacy/ GP and what position?*	pay close attention to time; max 1 min per participant (depending on the number of participants)	00:05
CURRENT USAGE AND INFORMATION-EXCHANGE (20 min)				
usage	determine what info they exchange	*What information do you exchange with each other?*	Make sure they do not talk about other collaborations (e.g., with the hospital)	00:10
usage	determine in what form they exchange this	*In what form is this information being exchanged now?*	have examples at hand	00:09
control	intermediate check	*Is the conversation/speed okay for you?*	make sure everyone nods and/or concedes for a moment	00:01
ATTITUDE (20 min) Given the subjective nature of an opinion, it is important that participants feel they can say anything.				
attitude	attitude	*What do you think of the current situation?*	open; try not to constrain their sincere opinions; body attitude through teams is difficult, but should be kept in mind	00:10
attitude	respond to	continue questioning based on answers		00:10
IDEA GENERATION (20 min) Again, make sure they are open, make sure they listen to each other in order to release appropriate creativity.				
idea generation	open question	*How do you see this situation in the future for you?*	see if they already come up with their own directions	00:10
idea generation	focus on information	*What information would you like to exchange with each other in the future?*	or do they want to exchange information differently	00:05
idea generation	focus on the form of information	*In what form would you like to exchange information?*		00:05
FINISHING UP (15 min) Wrap up together, aiming to receive questions and feedback, thank them for their participation, and briefly explain follow-up research.				
follow-up research	keep them interested in the research	briefly explain what will be done with these results; what is the follow-up research	keep it short	00:01
questions	answering questions	*Do you have any closing questions?*	they can ask anything; open attitude	00:08
feedback	receive further comments	*Do you have any other comments about this conversation/investigation?*	comments other than questions; feedback; things that suddenly occur to them now	00:05
acknowledgements	expressing gratitude	*Thank you for your participation!*	be grateful - tell them they can still contact you if something comes to mind	00:01

D.3. Focus Group Results

The recording was used to create a summary of the focus group, following the goals as formulated in Chapter 4: *usage, attitude* and *idea generation*.

D.3.1. Usage

The information discussed in this section was mainly used to improve the researcher's understanding of the current situation. During this phase of the focus group, already some discussion had arisen about what should be improved or changed in the future. The summaries of these discussions are documented in Section D.3.3.

Prescription Sharing
The current use of information exchange in the process involving pharmacies and general practitioners (GPs) is mainly limited to sharing prescriptions. It is not possible to share patient information. Recently, PH2 has added lab results to the prescriptions in work-around fields that have been introduced through HiX (an electronic patient file), while PH1 reports that this is not yet possible for them using Omnihis in Farmacon. This already indicated the differences in practices and pharmacies considering the level of interoperability.

Repeat Prescription Process and Validation Requests
A PH sends a validation request back to the GP as part of the repeat prescription process. This request asks for the GP's approval for a patient's repeat prescription. GPA1 finds validation requests (Dutch: *fiatteringsverzoeken*) to be helpful in their practice. PH2 goes a step further with validation requests. Patients can request medication with the right prescription from them, which allows them to place an order for the correct medication earlier in the process. For instance, Baxter rolls, etc. Validation requests seem to replace phone calls. The validation request includes a three-month repeat prescription, but the medication information at the GP and pharmacy may not always match. For example, the GP may indicate the need for 60 tablets once, while the pharmacy requests 90 tablets. Validation requests make it easier to monitor therapy adherence. Therapy adherence refers to the patient following the treatment as agreed with the healthcare professionals. This is not always the case, intentionally or unintentionally. Involving the patient in some form of communication could be an interesting turn in the medication process (in fact, the interaction between GP, pharmacy, and patient). It is assumed that reducing therapy adherence could lead to more illness, mortality, and higher costs. Therefore, involving the patient during the medication process can have societal relevance. Regarding the potential/workload of validation requests, at first, the pharmacy may think that receiving requests will increase their workload, but according to PH2, this is not the case as it only requires a few clicks, and the chance of subsequent corrections is smaller. PH1 agrees by nodding and saying 'yes.' These corrections will no longer be necessary, making the process more efficient, particularly if the shift occurs towards pharmacies only initiating repeat prescriptions. GPA1 confirms this from the GP's side. PH1 then mentions a downside of validation requests, which is that they cannot be changed after sending, and the request cannot be withdrawn. Is it essential that validation requests can be adjusted? PH2 notes that GPAs reject requests, and they have to call to ask why the request was rejected. It would be helpful to have a reason for rejection stated in the validation request. GPA1 mentions that they, as GPAs, must already provide this explanation when they reject the validation request by clicking on a red button. This is beneficial for all three participants.

D.3.2. Attitude

Attitude Towards Digitisation of Systems Used by HCPs
It is clear that there is a difference in opinion about this matter. The situation is being discussed from two different perspectives by two participants. PH1 sees the digitisation of processes as a setup for the competition from parties who can perform the same function without being in direct contact with the patient. PH2 sees the opportunities in optimising the availability of resources in the pharmacy, being friendly to patients, and thus keeping them with their pharmacy.

PH1 also brings up the negative side of easier digital communication between healthcare providers. If it becomes easier for others to do it, parties can more easily provide the right care to someone in the form of medication. PH1 indicates that a less personal pharmacist can also respond to a patient's requests regarding medication use, and indicates that for PH1 the existence of pharmacies relies, among other things, on the "homely" feeling. PH1 suggests that it becomes easier to communicate between a general practitioner and a pharmacy who do not know each other. PH2 agrees that this is indeed the perspective if you take into account the factor of your own business. However, looking at healthcare in a general sense, it mainly benefits the quality of care, according to PH2. PH2 outlines the advantage of being able to quickly arrange things, having a good supply of medicines, etc. Healthcare becomes less personal (PH1), and digital communication makes it easier, then it also becomes easier for other parties. The discussion ends by PH1 refuting the opinion at the end by admitting that other parties can already plug into the system - although it is less easy than it will be in the future.

When the moderator briefly mentioned that a change in the system could provide these opportunities, it became clear that changing the system is really not preferred, as evidenced by the laughing and shocking reaction of the participants. PH2 is very pleased with the open connections of AIS APRO. The aim to connect with as many other systems as possible is very pleasant. Pharmacon is different from CGM (CompuGroup Medical), where you had to pay for each connection. This is not the case with Pharmacon, indicating the importance of financial incentives.

Attitude Towards Regional and/or National Perspective
There is a lot of discussion about rules that are imposed by the government. PH2 indicates that rules imposed from above are often focused on money. PH2 sees the importance of allowing every healthcare provider to choose which system they use, but they should still be able to communicate with each other.

D.3.3. Idea Generation

It is important that it is possible to connect their own system to the overarching meta-platform. The links must be intertwined in the complementors of a platform. After the moderator asked for other information that the participants would still like to exchange, the first thing that came up was the lab values.

Lab values
There are currently several solutions for this. PH2 indicates that they can send a number of lab values with the prescription. This is done in APRO. But every time a prescription is issued, everything inside is also sent, even if it is already known to the pharmacies. But for now, it is useful in the initial phase. When it is up-to-date, it will mainly be redundant information. PH1 indicates that this is not the case with them. PH1 receives it through the lab, and otherwise via email. GPA1: EGFR value is sometimes on the prescription. The pharmacy does not always see it. Could it be because a certain weight is needed for DOAX? - picks up the most recent value - if the values are requested by the general practitioner, the pharmacy receives them via the lab. PH2: logistics around medication will be included in 9.0 around lab values → This is an information standard for the medication process. Indicates that this will be taken into account higher up and research does not have to reinvent the wheel. It is a good insight into the requirements of the PBIS design. Because it should definitely meet this information. Collective developments.

The care process
PH2 initiates the importance of the care process around the medication process. The care around the patient about medication. Long-term - interested in exchanging information through electronic messages. PH2 now receives a call from a general practitioner about a patient with questions about medication treatment and medication appointments with the patient. It works for PH2, but with more structure and assurance: via AIS and HIS, according to PH2. PH1 adds to this; it hooks up on the tapering schedule - that it cannot be forwarded between the pharmacy and general practitioner.

According to PH2, it is important that this does not happen automatically > because you then get bulk quantities from the systems. You only want to receive this information when you have a specific request about specific patients. Making a difference within pharmacies, namely by focusing on care around the patient. He sees outsourcing care from the general practitioner to the pharmacy as a way forward. The care around the substances you provide. Communication about that - think about what you can do with it. GPA1 then says it also goes straight into the general practitioner's dossier, to which PH1 nods and agrees. PH2 indicates a task screen on which requests can be placed about that patient PH1 and GPA1 nod in agreement.

Documentation according to the structures of the system - not just a chat function. After the moderator asks whether patients would also have access to this, a discussion ensues. The participants do not agree on this. PH2 indicates that this is the future. After being silent for a while, the moderator asks GPA1 for an opinion on this connection around the medication process. GPA1 indicates that he sees potential in this, especially if it can go directly into the dossier. Now the general practitioner's assistant receives this via email. The data is transferred to the dossier. Then still a link from the general practitioner. PH2 adds: working in a system, is important!

It also became clear that the role of the assistant differs per healthcare organisation. In one healthcare organisation, the assistants are way more involved than within another healthcare organisation.

Future Regarding Patient Involvement
PH2 is very curious about how this will unfold. Patients have to create a different personal health environment (PGO) with various healthcare providers. PH2 indicates that the information exchange on those PGOs must also be in line with a standard for information exchange. It is really frustrating to have a different app for each healthcare provider. So, the connections between them must also be well arranged. It became clear in the conversation that the participants do not yet fully understand the arrival of PGOs and their function - what information is included. PH2: there is a set of requirements before you can connect to the LSP.

The moderator outlines a situation in which a tab within a PGO contains information about the medication process. PH2 responds approvingly, also mentioning medication adherence. For example, a change where the patient experiences more or fewer symptoms and consequently increases or decreases medication (scenarios are discussed). Communicating these decisions, independently of consultation with the doctor, immediately clarifies the situation. The pharmacist can then respond more quickly. Providing the patient with extra input. PH1 finds this really complicated. PH1 thinks a chat function with all kinds of healthcare providers is complicated. PH2 discusses the future: the information that is available, that you can have. PH2 keeps a personal record, patients let them know what has been stopped or not. PH2 says it involves a lot of work. For example, in a scenario where the patient stops taking blood pressure medication but shouldn't have according to the GP. PH1 says that taking on healthcare is really difficult and that it becomes overwhelming. Not that the patient says that the specialist said something should be stopped.

PGO is still in a position where you have to actively look at it. According to PH2, an ideal situation would be a task list in your own system, where you can also schedule tasks. GPA1 indicates that they have this at general practitioners as well, with a link to ZorgOnline. They have to verify that those who request access are real patients of the practice, and then they can make the link. At general practitioners, patients can make online appointments, look at their medical records, check test results, etc. GPA1 clearly indicates that patients are completely unaware of the fact that a general practitioner cannot access the data that hospitals place. PH2 agrees with PH1's idea that it is something extra, but that it is necessary to establish its existence.

Changes in the Medical Process of a Patient
Stop prescriptions are a thorn in the eye. PH1 does not want the patient to stop anything. PH2 argues that patients can make a choice to adjust medication as a result of side effects on their own initiative. This change is something that can be taken into account in the future. PH1 describes a situation in which the patient himself remembers the wrong medication that a medical specialist or general practitioner advised to stop, and then also gives this information incorrectly to the pharmacy. This is a situation that PH1 is afraid of, which denotes a different interpretation. Medication changes discussed by specialists and general practitioners with the patient should be visible to the pharmacist. Insight into agreements between the medical specialist/general practitioner and the patient also ensures that patients who have a tendency to request more medication than necessary can be identified and addressed. PH1 brings the conversation back to the initial remark about the use of a function where patients can also communicate. PH1 does not want to sit in the doctor's chair.

Communication Codes
Communication codes regarding the healthcare process surrounding medication with patients should be designed. PH1 proposes a communication code that links a care action to a code. There are already codes for indications as well. They are now creating codes themselves for care actions. PH2

Involving Medical Specialists
The medical specialist's input is crucial in the validation process, as they can increase or decrease the dosage. While the GP sends the old dosage in the prescription, the pharmacist or medical specialist can document the correct dosage in the record. Validation requests provide more clarity in this regard.

E

Appendix: Research Graphic Mosadex Experience

Figure E.1 shows the research graphic that was shown during the Mosadex Experience. The number of people that left their e-mail addresses in the Qualtrics Survey that showed this research graphic is 87. Among the respondents were mostly pharmacists' assistants and pharmacists, since the fair was organised for pharmacy employees.

Figure E.1: Research Graphic for Mosadex Experience.

F

Appendix: Semi-Structured Interviews for Statement Discussion

F.1. Statements Resulting from Focus Group

The focus group findings led to the statements in Table F.1, the findings are formulated in the focus group conclusions in Chapter 4. The codes for these findings are noted as FF[number] (Focus group Finding). The statement results from the formalisation of the to-be-tested finding.

Table F.1: First Formalisation of Statements.

Nr	Findings	Statement
Organisation Policy		
P1	FF2	Pharmacists and General Practitioners are not willing to sacrifice patients for more digital, open primary care.
P2	FF3	Pharmacists and General Practitioners find local agreements on care around the medication process sufficient.
P3	FF3	Pharmacists and General Practitioners are willing to make national agreements on communication about care around the medication process.
Care Process		
CP1	FF5, FF6	Pharmacists and General Practitioners want to be able to consult with each other about the patient's medication process more than they do now.
CP2	FF5, FF6	Pharmacists and General Practitioners want to engage patients in the communication around the medication process to improve treatment adherence.
CP3	FF1	Pharmacists want to obtain more responsibilities in the medication process, and GPs want to transfer some of these responsibilities.
CP4	FF13	Assistants are sufficiently involved in the medication process to take and process requests.
CP5	FF13	Assistants are sufficiently involved in the medication process to make contact with the primary care physician about the medication process.
Information		
I1	FF1, FF14	Pharmacists, General Practitioners and assistants want to exchange information with the patient/other specialists about his/her developments within the personal medication process.
I2	FF13	Pharmacists, General Practitioners and assistants think that information exchanged about the process of care should be linked to certain codes.
I3	FF10, FF11, FF12	Pharmacists, General Practitioners and assistants find patient input reliable and can immediately take it as truth.
I4	FF9	Pharmacists, General Practitioners and assistants want to be able to choose whether they receive notifications in real-time in their system.
I5	FF5	Pharmacists, General Practitioners and assistants want to share information about the medication process with other HCPs and patients.
Application		
A1	FF7	Pharmacists, General Practitioners and assistants want to exchange information about the medication process in their current information system.
A2	FF7	Pharmacists, General Practitioners and assistants want to use as few systems as possible during their workday.
A3	FF7, FF8	Pharmacists, General Practitioners and assistants are willing to use an additional system for a communication function to replace phone/email.

F.2. Setup

To discuss the proposed statements, two one-on-one semi-structured interviews are conducted with a pharmacist (PH3) and a general practitioners' assistant (GPA2). The slides in Figure F.1 are used to support the semi-structured interview with PH3, the slides used in the one-on-one session with GPA2 had the same setup, but adjusted to the discipline.

Figure F.1: Slides used in Semi-Structured Session with PH3.

F.3. Results

The statements discussed and the results of the semi-structured session with PH3 and GPA2 are shown in Table F.2 and F.3. The conclusions of the results are discussed in Chapter 4. Next to the statement discussion, the summary of other insights resulting from the one-on-one interviews is provided.

Summary Additional Insights from PH3

The pharmacist was highly sure of the expectation that the Dutch healthcare system is going to get bogged down in the coming years. Considering the digitisation concern, PH3 provided an outline where internet pharmacies are expected to focus on the simpler patients, while current pharmacies could still handle substantively more complex situations. The hardest part will be to balance the interests of all pharmacies and general practitioners. Furthermore, the importance of patient involvement is once more mentioned. The patients decide how the care will be formed, they are seen as the carters of the healthcare system.

Summary Additional Insights from GPA2

GPA2 was strongly enthusiastic about documenting the *soft* communication between pharmacies, GP practices and patients. The interviewee did outline the fact that GPAs do have an important role in noting therapy adherence among patients. Currently, GPAs receive medication requesting calls from the patients, if the situation occurs that a patient requests a medication which should have already been requested months ago, the GPA should intervene by discussing the therapy adherence with the patient, or by planning a consult between the GP and the patient to discuss the therapy adherence.

Table F.2: Results Semi-Structured Sessions. (1/2)

Nr	Statement	Results Session PH3	Results Session GPA2
Organisation Policy			
P1	Pharmacists are willing to surrender patients for more digital, open primary care.	Everyone will say no to it; Surrendering patients hurts; Pharmacies want to get bigger; But this is not something that should hold innovation of systems	only applicable for Pharmacists
P2	Pharmacists find local agreements on care around the medication process insufficient.	Problem is dependence on relationships between GP and PHs; which Varies very much by region; Good relationships make it easier to make good arrangements; At a minimum, you know what you have in GP/pharmacy and can build on that; Innovations often start locally, and are picked up if locally successful; Quirky and therefore difficult	There are many; problems with prescribing due to poorly supplied medication, this creates a lot of noise; they cannot make this digital now. The pharmacy is next to them. Despite the respondent sitting next to the pharmacy, this still creates noise. Local is more pleasant than national; locally you can bend
P3	Pharmacists are willing to make national agreements on communication about care around the medication process.	Interests are different; Old systems now in place since 1980 create a rigid environment; You are stuck with pharmacy systems that are not yet modernly developed (such as Pharmacom); Each pharmacist or general practitioner stands up for their own interests when the chips are down; Pharmacies won't initiate large chances, this should come from above	Nationwide is far from your bed show; suppose there is something in the system that is nationwide; does see potential; but wants local and nationwide. If something is agreed upon nationwide, it does make it easier. That communication is the same.
Care Process			
CP1	Pharmacists want to be able to consult with the family physician about the patient's medication process more than they do now.	Not so much more consultation, but easier consultation with GP; Pharmacists also sometimes find it "scary" to call GPs; Was called by GP during this conversation, which indicates that communication is therefore going wrong; You want to be able to shoot communication into some kind of list from the GP.	especially more contact about continuity of care. For example, when using medication twice, the pharmacist can say that things are not going so well. Also depends on the pharmacist if he/she is more on top of it. The pharmacist then requests kidney function when acute things happen. But a little more monitoring does no improvement.
CP2	Pharmacists want to engage patients to improve treatment adherence (Dutch: *therapietrouw*).	Pharmacists want to engage patients to improve treatment adherence.; Of course, goes without saying; If the patient doesn't want to take it, it stops	They already do this regularly at check-ups; pharmacy assistants can also see this. With chronic diseases such as diabetes or CVRM (Cardiovascular Risk Management). If we have the idea that someone is not compliant, we start talking to them
CP3	Pharmacists want to shift from GP to the pharmacy in terms of the medication process.	Domain discussion is relevant here; Dosage adjustments due to renal function/weight change must now be by consent; Filling up GP indicates the relevance of this shift; GPs jump into allergy mode because it is their domain; ICT support in this shift can be very relevant	Very difficult; insurers also have fingers in the pie regarding choices for medication; switching to another drug can be initiated from the pharmacy, of course. But she is reluctant to shift because the family doctor has a lot of knowledge about what works and what doesn't work.
CP4	Pharmacy assistants are sufficiently involved in the medication process to take and process requests.	Depends a lot on the pharmacist; Are they involved in the process?; In terms of patients; Input from prescriptions they have to switch	Yes, assistants are in contact with all lines. Will may differ by GP
CP5	Pharmacy assistants are sufficiently involved in the medication process to make contact with the primary care physician about the medication process.	A pharmacist should always call a doctor; When the assistant is in between, PH3 finds this irritating; They sometimes can't give a link anymore, no substantive discussion; Assistants have good ideas in practice; How can we organise things faster; Where is the patient's input; Assistant's input is underestimated; think little now; Pharmacists not on the shop floor, but have input on it; Pharmacy assistant can talk to the GP assistant	Each GP has different thoughts on it, but indicates that she can kind of see how the GP sees this.

Table F.3: Results Semi-Structured Sessions. (2/2)

Nr	Statement	Results Session PH3	Results Session GPA2
Information			
I1	Pharmacies want to exchange information with the patient about his/her developments within the personal medication process.	Highly desirable; Patient decides who gets to see what or not; Opt-in it has to be; If it's about the patient and medicines you want to know the relevant information for that; Outline example: ICPC code included, while this is not actually information relevant to the medication process, which is the linchpin in this type of situation	Huge proponent of it. You get a more complete package from that. The pharmacy can also look back into it, so results in a little less noise.
I2	Pharmacists and assistants feel that information exchanged about the process of care should be linked to certain codes.	Importance here is that you can share relevant information with each other; How that happens is not a big deal; Would be nice if the codes could be tuned locally	Not always. Certainly not at the medication level. Untruths are mainly based on ignorance or forgetfulness. Improvement can be achieved by more instruction from GP and pharmacies. The patient should be more involved.
I3	Pharmacists and assistants find patient input reliable and can immediately take it as truth.	Depends on the patient; Clear rules about it; if we don't trust it we have to discuss it with the prescriber; If they get a Baxter roll and stop this, they want a stop prescription.; MS finds it too much work to send out stop prescriptions; When the patient themselves say they won't take it, they won't take it. The patient decides whether to take it. ; So that information is seen as reliable, yes. Pharmacy is there to advise.	Personal response: Yes, I do want to just get them in, I will choose what to do with them.
I4	Pharmacies want to be able to choose whether they receive notifications in real-time in their system.	LabForAPRO; Kidney functions, for example, you want to know immediately if it has consequences; A list of notifications to process	If the patient indicates a desire to taper off this is discussed in the coffee break (not recorded); we do now have the e-consult with patients. Involving the pharmacy in this conversation does not happen now. The GP consults with the patient and then links this to the pharmacy. Sceptical about gaining profit by involving pharmacy in this e-consult. E-consult is an email-based communication moment and does end up in the HIS. Sits in a mailroom tab.
I5	Pharmacists want to share information about the medication process with primary care physicians and patients.	Yes they would like to know that; Now sometimes they come, sometimes they don't.; Sometimes they pick it up neatly every 3 months, they don't swallow it, but suddenly they are dead, and a bag of pills comes back.	In terms of acceleration/improvement not very relevant whether the GP sends the prescription to the pharmacy or the pharmacist reads along with the request for help. Request for help via e-consult then remains with the GP. She expects that the GP wants to keep the responsibility himself. But for questions regarding phasing out, they do come to the pharmacies. Maybe they don't have to do their pee-pee about it too, but the documentation of the process should be stored. Now it wanders around too often and gets lost, and the wheel has to be reinvented the next day.
Application			
A1	Pharmacists and assistants want to exchange information about the medication process in their current information system.	The more out of a system the better	
A2	Pharmacists and assistants want to use as few systems as possible during their workday.	Yes of course	Yes, definitely a yes. We have so much to solve already. The very best thing would be if it could just be done nicely in the HIS. An extra tab is perfect for this.
A3	Pharmacists and assistants are willing to use an additional system for a communication function to replace phone/email.	Preferably integrated with the AIS	We already do a little bit through the GP portal. Via email is not secure with them. Can communicate via open though. Security within HIS/AIS is guaranteed, so communication there would be good.

G

Appendix: Insights Expert Talk

G.1. Insights Unstructured Talk with Pharmacist PH4

Digitisation Concern
According to the expert, internet pharmacies aiming to leverage the convenience of digital healthcare delivery may possess specific vulnerabilities. The expert highlighted the possibility of some individuals exploiting specific aspects of the system for competitive purposes. However, the expert emphasised the importance of being prepared for such challenges while acknowledging the necessity of creating the system.

The expert also discussed pharmacists' perspectives regarding general practitioner prescribing, with some considering it a hindrance. The expert acknowledged the growing trend towards online services and questioned how pharmacies can effectively adapt to this shift. In particular, the expert emphasised the value of acquiring data from Internet pharmacies.

The readiness of pharmacies to assume greater responsibilities was a topic of discussion. The expert noted the presence of diversity among pharmacists, not in terms of region but individual pharmacists themselves. PA4 mentioned the need for specific legislative changes at an umbrella/government level to support the increasing responsibilities of pharmacies concerning patient care.

Patient Involvement
Prescribing was highlighted as not being the core business of pharmacists. The expert emphasised the pressure on primary care/general practitioners and posed questions regarding the nature of prescribing. The expert expressed a desire to gain insights into the well-being of patients.

The expert emphasised the significance of documenting communication surrounding the care process. The expert stressed the importance of equivalent data for pharmacies, general practitioners, and medical specialists. For instance, the expert noted the reluctance towards patients randomly inputting various information into electronic systems and suggested implementing additional checks to ensure the accuracy of patient-provided information.

Regarding the healthcare system, the expert proposed raising patient awareness about the need for medication and simplifying the process for non-psychiatric conditions. PA4 highlighted the importance of patients' comprehensive knowledge about the medications PA4 are taking, enabling them to make informed decisions, such as when to stop taking medication in specific situations like severe diarrhoea or kidney problems.

The expert also mentioned the need to provide patients with more insight into the medications being used, as it would make the profession more engaging and interesting. The expert discussed the role of GP practices and pharmacies in providing initial healthcare services for minor issues and the importance of recording self-help medications in the medication record. The different categories of medicines were outlined, including prescription-only medications, pharmacy-only medications (such as strong painkillers and nasal sprays), pharmacy/drugstore-only medications, and over-the-counter medications (such as paracetamol).

Regarding medication transfer, the expert acknowledged the effectiveness of well-arranged hard transfer but expressed the need for improvements in soft communication. The expert highlighted the importance of understanding the patient's condition and the potential benefits of information exchange between healthcare providers. The expert provided examples such as the Electronic Patient Dossier (EPD) as a means of soft information transfer while acknowledging the limitations of the current systems in capturing crucial details about the patient, such as conversations about alcohol and medication.

The expert stressed the importance of including relevant information in the system to ensure continuity of care, even when a patient switches to a new pharmacy. PA4 mentioned the "Samen Beslissen" initiative and the need for comprehensive patient information, including personal preferences. The expert highlighted the challenges of communicating such information effectively between pharmacists and treated doctors, as current methods primarily involve email communication, which may not be seamlessly integrated into the systems. The expert expressed concern that small medication notes often reach general practitioners

with insufficient time to review them. PA4 advocated for involving pharmacists and other doctors in the process. The expert pointed out the excessive focus on hard medication transfer and the dominance of billing-oriented software systems, which may overshadow the importance of human work, thought, and common sense in healthcare.

Lastly, the expert encouraged increased patient engagement and proactive interaction regarding medication. PA4 emphasised the need for entrepreneurial thinking and effective ways to engage with patients to optimise healthcare outcomes.

H

Appendix: Survey Setup

Figure H.1, H.2, H.3, H.4 provide screenshots of the layout from the survey, created in the Qualtrics software, supported by TU Delft. A go-back button was provided to ensure the respondent was able to go back to certain questions if they changed their mind. A progress bar is provided at the top to provide the progress. This could positively influence the respondent to finish the survey, when he/she is almost near the end but start to feel like it takes a long time. It could also work the other way around. However, it is decided to include this, also for transparency towards the respondent about the progress.

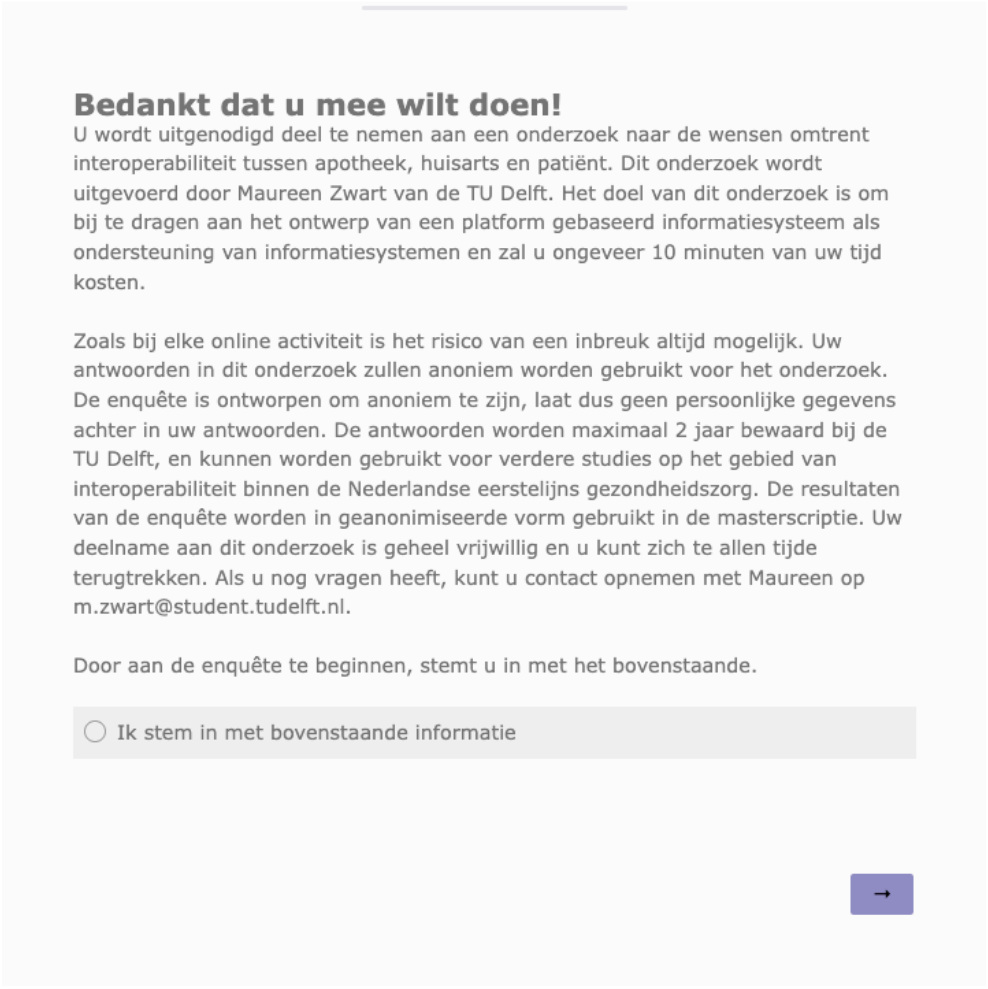


Figure H.1: Survey Example: Consent Page.

Figure H.2: Survey Example: Demographic Characteristics *Years of Experience* and *Municipality*.

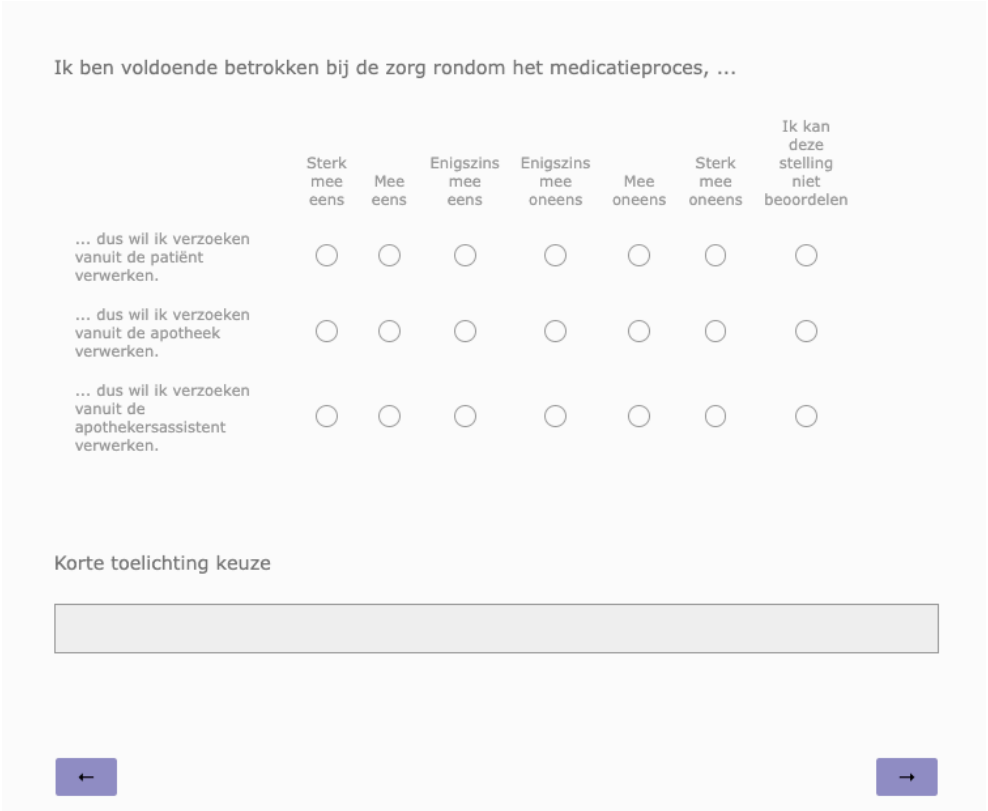


Figure H.3: Survey Example: Statement CP1a, CP1b, and CP1c positioned in a Matrix.

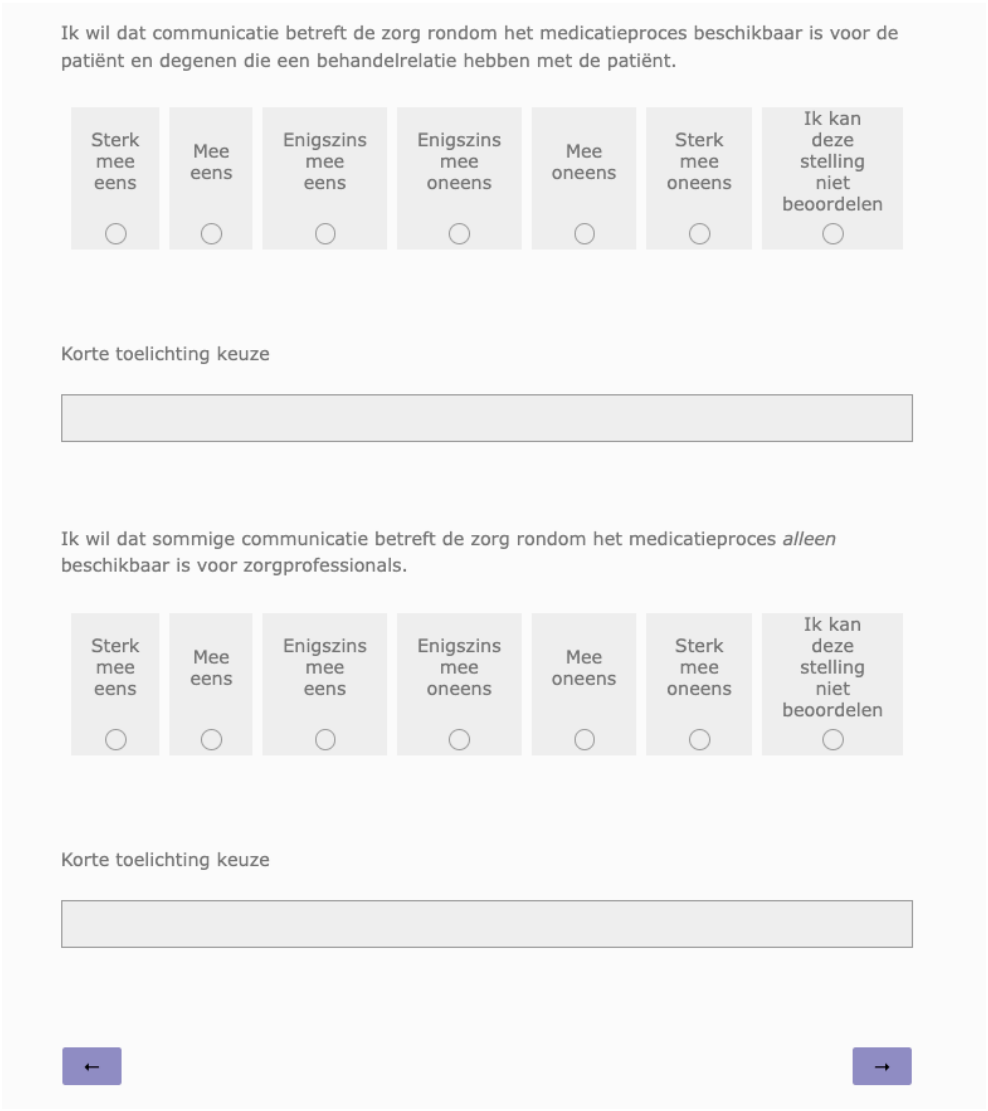


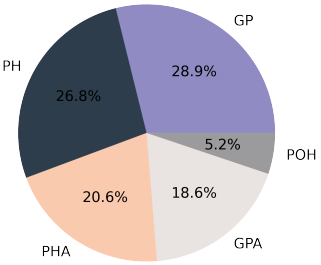
Figure H.4: Survey Example: Statement I5 and I6 as Independent Statements.

I

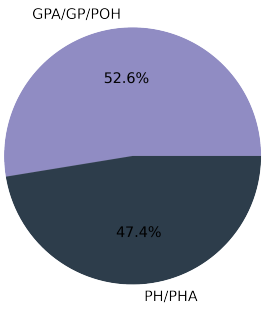
Appendix: Survey Results

I.1. Insights in Respondents' Characteristics

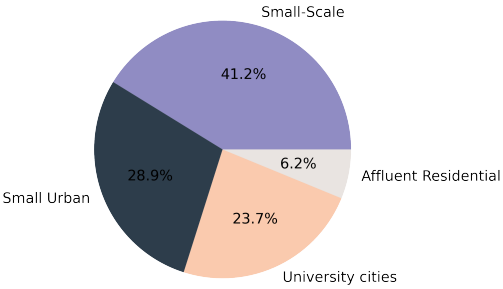
Figure I.1 shows the distribution of respondents' characteristics as discussed in Chapter 4.



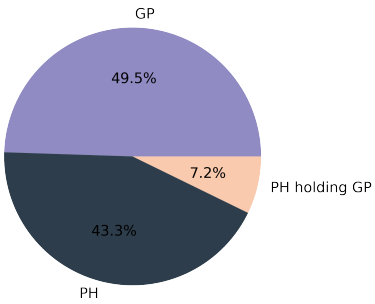
(a) Job Position



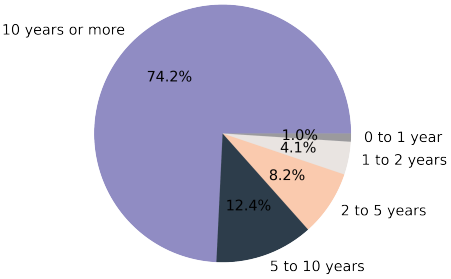
(b) Job Type



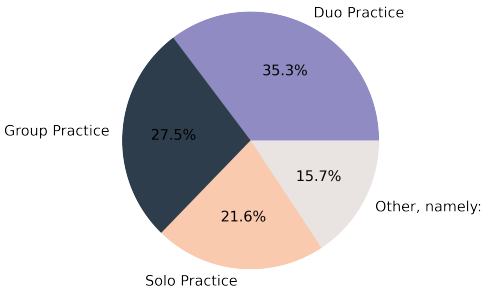
(c) Municipality Type



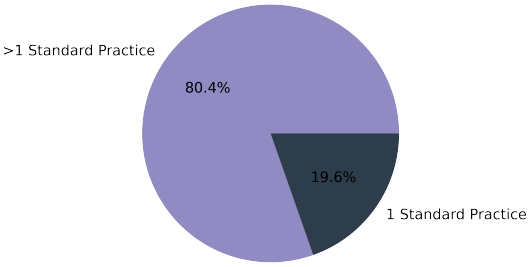
(d) Organization Type



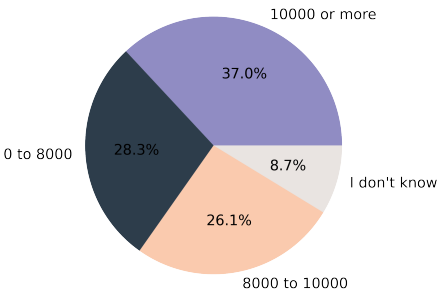
(e) Years of Experience



(f) Type of Practice



(g) Size of Practice



(h) Size of Pharmacy

Figure I.1: Box Plots of Distributions of Respondents Characteristics.

I.2. Overview of Quantitative Results

This Appendix shows an overview of the quantitative results used in determining the effect of the demographic variables on assessing the statements.

Reading Guide Tables
The rows with a (-) had only one of the categories available with enough data points. With only one category, comparing the means of categories is logically impossible. Some statements are not shown: those statements were shown to the respondent based on the tested demographic variable. This means those statements have no data points in the tested demographic variable. If this was the case, the statement was not included in the analysis or shown in the table. The statements of which the assessment significantly depends on the demographic characteristic, the p-value (< 0.05), and significant statements or groups are visualised in bold. For each analysed demographic characteristic, the clarification of the analysis is given.

Table I.1: Results ANOVA test for Organisation Type.

	Organisation Type (GP, PH, PH holding GP)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	0.21	0.81	75	2	72	all
I2a	2.82	0.07	89	2	86	all
I2b	2.52	0.09	92	2	89	all
I3	0.48	0.62	85	2	82	all
I4	0.18	0.84	95	2	92	all
I5	1.05	0.35	94	2	91	all
I6	0.24	0.79	89	2	86	all
A1	0.08	0.93	93	2	90	all
A2	1.93	0.15	97	2	94	all
A3	11.68	**0.00**	95	2	92	all
P1	1.79	0.17	92	2	89	all
P2	5.07	**0.01**	92	2	89	all
CP2	1.61	0.20	95	2	92	all
CP4a	0.19	0.83	96	2	93	all
CP4b_A	2.90	0.09	49	1	47	GP, PH holding GP
CP4c_A	0.45	0.57	51	1	49	GP, PH holding GP
CP3_A	0.01	0.92	47	1	45	GP, PH holding GP
CP4b_B	0.00	0.99	45	1	43	PH, PH holding GP
CP4c_B	0.15	0.70	46	1	44	PH, PH holding GP
CP3_B	1.14	0.29	46	1	44	PH, PH holding GP
GP_CP1a	0.39	0.54	28	1	26	GP, PH holding GP
GP_CP1b	0.61	0.44	23	1	21	GP, PH holding GP
GP_CP1c	0.65	0.43	23	1	26	GP, PH holding GP
GPA_CP1a	-	-	-	-	-	-
GPA_CP1b	-	-	-	-	-	-
GPA_CP1c	-	-	-	-	-	-
PH_CP1a	-	-	-	-	-	-
PH_CP1b	-	-	-	-	-	-
PH_CP1c	-	-	-	-	-	-
PHA_CP1a	0.58	0.46	19	1	17	PH, PH holding GP
PHA_CP1b	0.01	0.92	20	1	18	PH, PH holding GP
PHA_CP1c	0.10	0.76	20	1	18	PH, PH holding GP
POH_CP1a	-	-	-	-	-	-
POH_CP1b	-	-	-	-	-	-
POH_CP1c	-	-	-	-	-	-
POH_CP1d	-	-	-	-	-	-

The tests for statements only assessed by GPA, PH and POH did not have enough data points per category and could thus not be used to perform the ANOVA (or T-) test. Table I.1 shows a p-value < 0.5 for statements A3 and P2, indicating a significant effect of the categorical variable Organisation Type on the assessment (mean) of statements A3 and P2.

Table I.2: Results ANOVA test for Years of Experience.

	Years of Experience (1 to 2 years, 2 to 5 years, 5 to 10 years, 10 or more)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	1.07	0.37	75	3	72	all
I2a	0.31	0.82	89	3	86	all
I2b	1.21	0.31	92	3	89	all
I3	1.71	0.17	85	3	82	all
I4	0.88	0.45	95	3	92	all
I5	0.83	0.48	94	3	91	all
I6	1.09	0.36	89	3	86	all
A1	1.58	0.20	93	3	90	all
A2	1.09	0.36	97	3	94	all
A3	0.45	0.71	95	3	92	all
P1	1.16	0.45	92	3	89	all
P2	0.48	0.70	92	3	89	all
CP2	0.47	0.70	95	3	92	all
CP4a	0.44	0.73	96	3	93	all
CP4b_A	0.00	0.97	49	1	47	10 years or +, 5 to 10 years
CP4c_A	0.21	0.81	51	2	48	10 years or +, 1 to 2 years, 5 to 10 years
CP3_A	0.04	0.85	47	1	45	10 years or +, 5 to 10 years
CP4b_B	3.39	**0.03**	45	3	43	all
CP4c_B	3.46	**0.02**	46	3	44	all
CP3_B	0.35	0.79	46	3	44	all
GP_CP1a	0.34	0.57	28	1	26	10 years or +, 5 to 10 years
GP_CP1b	-	-	-	-	-	-
GP_CP1c	0.06	0.81	28	1	26	10 years or +, 5 to 10 years
GPA_CP1a	0.98	0.34	18	1	16	10 years or +, 5 to 10 years
GPA_CP1b	0.74	0.41	18	1	16	10 years or +, 5 to 10 years
GPA_CP1c	0.61	0.45	16	1	14	10 years or +, 5 to 10 years
PH_CP1a	0.86	0.48	25	3	21	all
PH_CP1b	0.63	0.61	26	3	22	all
PH_CP1c	0.92	0.45	26	3	22	all
PHA_CP1a	0.18	0.67	19	1	17	2 to 5 years, 10 years or +
PHA_CP1b	0.18	0.67	20	1	18	2 to 5 years, 10 years or +
PHA_CP1c	0.08	0.78	20	1	18	2 to 5 years, 10 years or +
POH_CP1a	0.14	0.73	5	1	3	-
POH_CP1b	-	-	-	-	-	-
POH_CP1c	-	-	-	-	-	-
POH_CP1d	0.60	0.50	5	1	3	10 more years, 5 to 10 years

It should be considered that the category *0 to 1 year* of experience is not considered in the dependency analysis. Only one respondent had *0 to 1 year* of experience. Therefore, the dependency of the category cannot be decided based on these tests. When in column 'categories included' Table I.2 shows *all*, this is without the category *0 to 1 year*. Table I.2 shows a significant effect of Years of Experience on assessing the statements CP4b_B and CP4c_B.

Table I.3: Results ANOVA test for Municipality Type.

	Municipality Type (Small-Scale, Small Urban, University cities, Affluent Residential)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	0.60	0.62	75	2	71	all
I2a	0.56	0.64	89	2	85	all
I2b	0.46	0.71	92	2	88	all
I3	1.67	0.18	85	2	81	all
I4	0.50	0.69	95	2	91	all
I5	0.29	0.83	94	2	90	all
I6	0.63	0.60	89	2	85	all
A1	1.45	0.23	93	2	89	all
A2	0.68	0.57	97	2	93	all
A3	0.06	0.98	95	2	91	all
P1	1.67	0.18	92	2	88	all
P2	0.32	0.81	92	2	88	all
CP2	1.44	0.24	95	2	91	all
CP4a	0.76	0.52	96	2	92	all
CP4b_A	1.56	0.22	49	2	46	Small-Scale, Small Urban, University cities
CP4c_A	2.67	0.08	51	2	48	Small-Scale, Small Urban, University cities
CP3_A	1.88	0.17	47	2	44	Small-Scale, Small Urban, University cities
CP4b_B	0.30	0.83	45	3	41	all
CP4c_B	0.53	0.66	46	3	42	all
CP3_B	1.65	0.19	46	3	42	all
GP_CP1a	0.65	0.53	28	2	25	Small-Scale, Small Urban, University cities
GP_CP1b	0.46	0.64	23	2	20	Small-Scale, Small Urban, University cities
GP_CP1c	1.31	0.29	23	2	25	Small-Scale, Small Urban, University cities
GPA_CP1a	1.93	0.18	18	2	15	Small-Scale, Small Urban, University cities
GPA_CP1b	0.27	0.77	18	2	15	Small-Scale, Small Urban, University cities
GPA_CP1c	0.89	0.43	16	2	13	Small-Scale, Small Urban, University cities
PH_CP1a	0.73	0.50	25	2	22	Small-Scale, Small Urban, University cities
PH_CP1b	0.46	0.71	26	3	22	all
PH_CP1c	0.38	0.77	26	3	22	all
PHA_CP1a	0.73	0.55	19	3	15	all
PHA_CP1b	0.24	0.87	20	3	16	all
PHA_CP1c	1.07	0.39	20	3	16	all
POH_CP1a	-	-	-	-	-	-
POH_CP1b	-	-	-	-	-	-
POH_CP1c	-	-	-	-	-	-
POH_CP1d	-	-	-	-	-	-

As seen in Table I.3, the demographic characteristic municipality type affects none of the statements' assessments. The statements, specifically asked to the POHs, did not have enough data points to conduct an ANOVA test on the results.

Table I.4: Results ANOVA test for Type of Practice.

	Type of Practice (Group, Duo, Solo, Other namely)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	0.25	0.86	36	3	32	all
I2a	0.18	0.91	47	3	43	all
I2b	0.51	0.68	48	3	44	all
I3	0.37	0.77	44	3	40	all
I4	1.10	0.36	50	3	46	all
I5	0.29	0.83	49	3	45	all
I6	1.20	0.32	47	3	43	all
A1	2.29	0.09	50	3	46	all
A2	0.28	0.84	51	3	45	all
A3	0.90	0.45	50	3	43	all
P1	0.10	0.96	47	3	46	all
P2	0.49	0.69	47	3	43	all
CP2	1.77	0.17	50	3	43	all
CP4a	0.27	0.84	50	3	46	all
CP4b_A	0.21	0.89	49	3	45	all
CP4c_A	0.12	0.95	51	3	47	all
CP3_A	4.49	**0.01**	47	3	43	all
GP_CP1a	2.18	0.12	28	3	24	all
GP_CP1b	2.58	0.08	23	3	19	all
GP_CP1c	1.45	0.25	28	3	24	all
GPA_CP1a	0.37	0.78	18	3	14	all
GPA_CP1b	1.18	0.35	18	3	14	all
GPA_CP1c	0.27	0.77	16	2	13	Solo, Duo, Group
POH_CP1a	-	-	-	-	-	-
POH_CP1b	-	-	-	-	-	-
POH_CP1c	-	-	-	-	-	-
POH_CP1d	-	-	-	-	-	-

Table I.4 shows a significant effect of Type of Practice on assessing statement CP3_A. Furthermore, the POH statements did not have enough data points to be involved in an ANOVA or T-Test.

Table I.5: Results ANOVA test for Care Group.

	Care Group (Yes, namely:, I don't know, We are not connected with a care group)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	1.55	0.23	36	2	33	all
I2a	2.15	0.13	47	2	44	all
I2b	1.38	0.26	48	2	45	all
I3	2.54	0.09	44	2	41	all
I4	0.03	0.97	50	2	47	all
I5	0.72	0.49	49	2	46	all
I6	3.78	**0.03**	47	2	44	all
A1	1.13	0.45	50	2	47	all
A2	0.39	0.68	51	2	48	all
A3	0.42	0.66	50	2	47	all
P1	1.33	0.27	47	2	44	all
P2	0.27	0.76	47	2	44	all
CP2	0.60	0.55	50	2	47	all
CP4a	0.46	0.64	50	2	47	all
CP4b_A	1.27	0.29	49	2	46	all
CP4c_A	0.82	0.45	51	2	48	all
CP3_A	0.30	0.74	47	2	44	all
GP_CP1a	0.00	1.00	28	1	26	Yes, namely:, I don't know
GP_CP1b	1.43	0.24	23	1	21	Yes, namely:, I don't know
GP_CP1c	0.15	0.70	28	1	26	Yes, namely:, I don't know
GPA_CP1a	0.90	0.43	18	2	15	Yes, namely:, I don't know
GPA_CP1b	0.66	0.53	18	2	15	Yes, namely:, I don't know
GPA_CP1c	0.70	0.52	16	2	13	Yes, namely:, I don't know
POH_CP1a	-	-	-	-	-	-
POH_CP1b	-	-	-	-	-	-
POH_CP1c	-	-	-	-	-	-
POH_CP1d	-	-	-	-	-	-

Table I.5 shows the Care Group category significantly affects the assessment of statement I6. Note that the "no" category is excluded in all tests since just one respondent answered the Care Group question with a "no". "Yes, namely:" means they have connections with other healthcare professionals. It can be concluded that the ANOVA test for the GP/GPA dependent statements only included two categories.

Table I.6: Results ANOVA test for Size Pharmacy.

	Size Pharmacy (0 to 8000, 8000 to 10000, 10000 or more, I don;t know)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories included**
I1	1.38	0.26	39	3	35	all
I2a	0.48	0.70	42	3	38	all
I2b	0.40	0.76	44	3	40	all
I3	0.22	0.88	41	3	37	all
I4	0.22	0.88	45	2	41	all
I5	0.91	0.44	45	2	41	all
I6	1.73	0.18	42	2	38	all
A1	2.21	0.10	43	2	39	all
A2	4.56	**0.01**	46	2	42	all
A3	0.64	0.59	45	2	41	all
P1	0.41	0.75	45	2	41	all
P2	0.36	0.78	45	2	41	all
CP2	0.17	0.92	45	2	41	all
CP4a	0.60	0.62	46	2	42	all
CP4b_B	0.04	0.99	45	3	41	all
CP4c_B	0.45	0.80	46	3	42	all
CP3_B	0.50	0.68	46	3	42	all
PH_CP1a	0.31	0.73	25	2	22	0 to 8000, 10000 or more, 8000 to 10000
PH_CP1b	0.06	0.94	26	2	23	0 to 8000, 10000 or more, 8000 to 10000
PH_CP1c	0.31	0.73	26	2	23	0 to 8000, 10000 or more, 8000 to 10000
PHA_CP1a	6.75	**0.00**	19	3	15	all
PHA_CP1b	0.94	0.44	20	3	16	all
PHA_CP1c	1.47	0.26	20	3	16	all

The categorical variable Size Pharmacy has a significant effect on the assessment of the statements A2 (p = 0.01) and PHA_CP1a (p = 0.00), as can be seen in Table I.6.

Table I.7: Results ANOVA test for Job Position.

	Job Position (GP, GPA, POH, PH, PHA)					
Statement	**ANOVA**	**p-value**	**n**	**df_between**	**df_within**	**categories**
I1	1.34	0.26	75	4	70	all
I2a	2.54	**0.05**	89	4	84	all
I2b	4.30	**0.00**	92	4	87	all
I3	0.26	0.90	85	4	80	all
I4	3.20	**0.02**	95	4	90	all
I5	0.98	0.42	94	4	89	all
I6	0.82	0.52	89	4	84	all
A1	0.32	0.86	93	4	88	all
A2	2.33	0.06	97	4	92	all
A3	8.57	**0.00**	95	4	90	all
P1	1.14	0.34	92	4	87	all
P2	3.49	**0.01**	92	4	87	all
CP2	1.71	0.15	95	4	90	all
CP4a	4.67	**0.00**	96	4	91	all
CP4b_A	0.42	0.66	49	2	46	GP, GPA, POH
CP4c_A	1.13	0.45	51	2	48	GP, GPA, POH
CP3_A	0.24	0.79	47	2	44	GP, GPA, POH
CP4b_B	1.22	0.28	45	1	43	PH, PHA
CP4c_B	0.86	0.36	46	1	44	PH, PHA
CP3_B	7.44	**0.01**	46	1	44	PH, PHA

The statements made explicitly for one Job Position were excluded in Table I.7, since logically, the effect of Job Position could not

be analysed for those statements. 0.05 for I2a is included since the sample size is large.

Table I.8: Results T-test for Size of Practice.

	Size Practice (1 Standard, > 1)			
Statement	**t-test**	**p-value**	**n1**	**n2**
I1	-0.06	0.95	6	30
I2a	-0.85	0.40	9	38
I2b	-0.72	0.48	9	39
I3	-1.95	0.06	7	37
I4	-0.87	0.39	10	40
I5	-0.08	0.94	10	39
I6	-3.38	**0.00**	10	37
A1	0.36	0.72	10	40
A2	-1.45	0.15	10	41
A3	-0.40	0.69	9	41
P1	-0.16	0.88	9	38
P2	-0.93	0.36	9	38
CP2	-1.09	0.28	10	40
CP4a	-0.91	0.37	10	40
CP4b_A	-1.08	0.28	10	39
CP4c_A	-1.55	0.13	10	41
CP3_A	-0.29	0.77	10	37
GP_CP1a	0.42	0.68	5	23
GP_CP1b	0.75	0.46	3	20
GP_CP1c	-0.19	0.85	5	23
GPA_CP1a	-0.36	0.72	5	13
GPA_CP1b	-0.16	0.87	5	13
GPA_CP1c	0.57	0.58	4	12
POH_CP1a	-	-	-	-
POH_CP1b	-	-	-	-
POH_CP1c	-	-	-	-
POH_CP1d	-	-	-	-

Table I.9: Results T-test for Job Type.

	Job Type (GPA/GP/POH, PH/PHA)			
Statement	**t-test**	**p-value**	**n1**	**n2**
I1	0.34	0.73	39	36
I2a	-2.35	**0.02**	42	47
I2b	-2.24	**0.03**	44	48
I3	-0.72	0.48	41	44
I4	0.04	0.97	45	50
I5	-1.61	0.11	45	49
I6	0.46	0.65	42	47
A1	-0.36	0.72	43	50
A2	-1.35	0.18	46	51
A3	5.14	**0.00**	45	50
P1	-0.56	0.58	45	47
P2	3.02	**0.00**	45	47
CP2	-2.01	0.05	45	50
CP4a	-0.06	0.95	46	50
CP4b_A	-	-	-	-
CP4c_A	-	-	-	-
CP3_A	-	-	-	-
CP4b_B	-	-	-	-
CP4c_B	-	-	-	-
CP3_B	-	-	-	-

For Size of Practice, it is found that the means for statement I6 for the categories in Size of Practice is significantly different. Looking at Table I.9, four assessments of statements (means) are significantly different considering the categories in Job Type. Namely, the means as an assessment result for statements I2a, I2b, A3 and P2.

I.2.1. Tukey-HSD Results Significant Pairs ANOVA

This section shows the results for the [Demographic Characteristic:Statement] pairs, of which the ANOVA test indicated a significant effect. The Tukey-HSD test determines which categories in the Demographic Characteristics significantly differ. Table I.10 show the Tukey Test results for Organisation Type, and Table I.11 show the Tukey Test results for Type of Practice. In these two tables, it can be seen that considering the Organisation Type GP and PH for A3 and P2 significantly differ. Considering the Type of Practice, all types differ, comparing them to *Other, namely:*. However, because the answers within *Other, namely:* are fragmented and could not result in any valuable conclusion, these are excluded (as can also be seen in Table I.16).

Table I.10: Results Tukey Tests: Organisation Type.

Group 1	**Group 2**	**△ Mean**	**p-value**	**lower**	**upper**
Tukey Test for A3 by Organisation Type					
GP	**PH**	1.56	**0.00**	0.79	2.33
GP	PH holding GP	0.44	0.76	-1.14	2.02
PH	PH holding GP	-1.12	0.22	-2.71	0.47
Tukey Test for P2 by Organisation Type					
GP	**PH**	0.78	**0.01**	0.19	1.37
GP	PH holding GP	0.62	0.43	-0.57	1.81
PH	PH holding GP	-0.15	0.90	-1.35	1.04

Table I.11: Results Tukey Tests: Type of Practice.

Group 1	**Group 2**	**△ Mean**	**p-value**	**lower**	**upper**
Tukey Test for CP3_A by Type of Practice					
Duo Practice	Group Practice	0.27	0.9	-0.80	1.34
Duo Practice	**Other, namely:**	-1.36	**0.04**	-2.63	-0.09
Duo Practice	Solo Practice	0.35	0.80	-0.74	1.45
Group Practice	**Other, namely:**	-1.63	**0.01**	-2.98	-0.28
Group Practice	Solo Practice	0.08	0.90	-1.10	1.26
Other, namely:	**Solo Practice**	1.71	**0.01**	0.35	3.08

Table I.12: Results Tukey Tests: Years of Experience.

Group 1	Group 2	△ Mean	p-value	lower	upper
Tukey Test for A1 by Years of Experience					
0 to 1 year	1 to 2 years	3.25	0.14	-0.62	7.12
0 to 1 year	10 years or +	3.10	0.11	-0.38	6.59
0 to 1 year	2 to 5 years	3.50	0.07	-0.17	7.17
0 to 1 year	**5 to 10 years**	3.92	**0.03**	0.31	7.52
1 to 2 years	10 years or +	-0.15	0.90	-1.92	1.63
1 to 2 years	2 to 5 years	0.25	0.90	-1.87	2.37
1 to 2 years	5 to 10 years	0.67	0.88	-1.33	2.67
10 years or +	2 to 5 years	0.40	0.90	-0.90	1.70
10 years or +	5 to 10 years	0.81	0.23	-0.27	1.90
2 to 5 years	5 to 10 years	0.42	0.90	-1.16	2.00
Tukey Test for CP4b_B by Years of Experience					
0 to 1 year	1 to 2 years	-3.00	0.15	-6.64	0.64
0 to 1 year	10 years or +	-0.69	0.90	-3.70	2.33
0 to 1 year	2 to 5 years	-0.57	0.90	-3.75	2.60
0 to 1 year	5 to 10 years	-0.33	0.90	-3.77	3.10
1 to 2 years	**10 years or +**	2.31	**0.03**	0.15	4.48
1 to 2 years	**2 to 5 years**	2.43	**0.04**	0.05	4.81
1 to 2 years	5 to 10 years	2.67	0.06	-0.05	5.38
10 years or +	2 to 5 years	0.12	0.90	-1.12	1.36
10 years or +	5 to 10 years	0.35	0.90	-1.44	2.15
2 to 5 years	5 to 10 years	0.24	0.90	-1.81	2.29
Tukey Test for CP4c_B by Years of Experience					
0 to 1 year	1 to 2 years	-3.00	0.09	-6.29	0.29
0 to 1 year	10 years or +	-0.82	0.90	-3.55	1.91
0 to 1 year	2 to 5 years	-0.86	0.90	-3.77	2.44
0 to 1 year	5 to 10 years	-0.33	0.90	-3.76	3.10
1 to 2 years	**10 years or +**	2.31	**0.03**	1.15	4.48
1 to 2 years	**2 to 5 years**	2.43	**0.04**	0.47	4.81
1 to 2 years	5 to 10 years	2.67	0.06	-0.04	5.38
10 years or +	2 to 5 years	0.12	0.90	-1.12	1.36
10 years or +	5 to 10 years	0.35	0.90	-1.44	2.15
2 to 5 years	5 to 10 years	0.24	0.90	-1.81	2.29

Table I.13: Results Tukey Tests: Job Type, Size of Practice, Care Group.

Group 1	Group 2	△ Mean	p-value	lower	upper
Tukey Test for A3 by Job Type					
GPA/GP/POH	**PH/PHA**	1.58	**0.00**	0.97	2.20
Tukey Test for I2a by Job Type					
GPA/GP/POH	**PH/PHA**	-0.72	**0.02**	-1.34	-0.11
Tukey Test for P2 by Job Type					
GPA/GP/POH	**PH/PHA**	0.722	**0.00**	0.25	1.20
Tukey Test for CP2 by Job Type					
GPA/GP/POH	**PH/PHA**	0.722	**0.00**	0.25	1.20
Tukey Test for I6 by Size of Practice					
1 SP	**>1 SP**	1.47	**0.00**	0.59	2.34
Tukey Test for I6 by Care Group					
I don't know	No	0.27	0.90	0.59	2.34
I don't know	Not affiliated to	1.94	0.11	-0.30	4.17
I don't know	Yes	1.02	0.12	-0.18	2.22
No	Not affiliated to	1.67	0.66	-2.29	5.63
No	Yes	0.75	0.90	-2.73	4.23
Not affiliated to	Yes	-0.92	0.63	-2.99	1.15

Table I.12 show the Tukey Test results for Years of Experience. Considering statement A1, the difference between the mean from a 0 to 1 year perspective and 5 to 10 years perspective is significantly different. Considering the statements CP4b_B and CP4c_B it can be stated that the mean differs between the groups 1 to 2 years and 10 years or more, and 1 to 2 years and 2 to 5 years. However, the categories included too few data points - as seen in Table I.16 - and are therefore excluded.

In table I.13, the Tukey Test results for Job Type, Size of Practice and Care Group are shown. Looking at the results for the Care Group and statement I6, it can be concluded that there is not enough evidence to suggest that any specific pairs have significantly different means of statement assessment when considering the multiple comparisons. However, it does not invalidate the significant result of the ANOVA test.

Table I.14: Results Tukey Tests: Job Position. (1/2)

Group 1	Group 2	△ Mean	p-value	lower	upper
Tukey Test for A3 by Job Position					
GP	GPA	1.13	0.09	-0.12	2.37
GP	**PH**	2.01	**0.00**	0.89	3.14
GP	**PHA**	2.16	**0.00**	0.93	3.38
GP	POH	0.83	0.75	-1.16	2.82
GPA	PH	0.88	0.29	-0.37	2.14
GPA	PHA	1.03	0.22	-0.32	2.37
GPA	POH	-0.30	0.90	-2.37	1.77
PH	PHA	0.14	0.90	-1.09	1.38
PH	POH	-1.18	0.47	-3.18	0.81
PHA	POH	-1.33	0.38	-3.38	0.73
Tukey Test for I2a by Job Position					
GP	GPA	-0.83	0.38	-2.12	0.46
GP	PH	-0.80	0.29	-1.92	0.33
GP	PHA	-1.18	0.06	-2.41	0.04
GP	POH	0.24	0.90	-1.72	2.19
GPA	PH	0.03	0.90	-1.28	1.35
GPA	PHA	-0.36	0.90	-1.75	1.05
GPA	POH	1.07	0.59	-1.01	3.14
PH	PHA	-0.39	0.90	-1.64	0.86
PH	POH	1.03	0.58	-0.94	3.01
PHA	POH	1.42	0.30	-0.61	2.45
Tukey Test for I2b by Job Position					
GP	**GPA**	-1.29	**0.03**	-2.50	-0.08
GP	PH	-0.89	0.15	-1.97	0.18
GP	**PHA**	-1.55	**0.00**	-2.68	-0.42
GP	POH	-0.85	0.68	-2.72	1.01
GPA	PH	0.40	0.90	-0.84	1.63
GPA	PHA	-0.26	0.90	-1.55	1.02
GPA	POH	0.44	0.90	-1.52	2.40
PH	PHA	-0.66	0.51	-1.81	0.50
PH	POH	0.04	0.90	-1.84	1.92
PHA	POH	0.70	0.83	-1.22	2.62

Table I.15: Results Tukey Tests: Job Position. (2/2)

Group 1	Group 2	△ Mean	p-value	lower	upper
Tukey Test for I4 by Job Position					
GP	**GPA**	0.96	**0.05**	0.01	1.92
GP	PH	0.63	0.24	-0.22	1.48
GP	PHA	0.26	0.90	-0.67	1.18
GP	POH	1.39	0.09	-0.13	2.90
GPA	PH	-0.33	0.87	-1.30	0.64
GPA	PHA	-0.70	0.33	-1.74	0.34
GPA	POH	0.42	0.90	-1.16	2.01
PH	PHA	-0.37	0.78	-1.31	0.57
PH	POH	0.75	0.62	-0.77	2.27
PHA	POH	1.13	0.27	-0.44	2.69
Tukey Test for CP4a by Job Position					
GP	GPA	-0.02	0.90	-0.86	0.82
GP	PH	0.56	0.23	-0.18	1.30
GP	PHA	-0.64	0.18	-1.43	1.16
GP	POH	0.61	0.67	-0.71	1.94
GPA	PH	0.58	0.32	-0.27	1.43
GPA	PHA	-0.61	0.32	-1.51	0.29
GPA	POH	0.64	0.68	-0.75	2.02
PH	**PHA**	-1.20	**0.00**	-2.01	-0.38
PH	POH	0.05	0.90	-1.28	1.39
PHA	POH	1.25	0.09	-0.11	2.61
Tukey Test for CP3_B by Job Position					
PH	**PHA**	-1.16	**0.01**	-2.02	-0.30

Table I.14 and I.15 show the Tukey Test results for Job Position. The significant differences for Job Position are the following: GP and PHA for A3, GP and PH for A3, GP and GPA for I2b, GP and PHA for I2b, GP and GPA for I4, PH and PHA for CP4a, and PH and PHA for CP3_B. Further noteworthy is the high number of pairs having a p-value of exactly 0.90.

Excluding Significant Pairs

Not all significant pairs are included for the analysis. Based on the following criteria: a *high-enough n-value* and *a usable category*, Table I.16 shows the excluded significant pairs.

Table I.16: Excluded Significant Pairs.

Statement:Category-Pair	Category 1	Category 2	Reason for Excluding
A1:Years of Experience	0 to 1 year [2.00, 1]	5 to 10 years [5.50, 12]	Only one data point for 0 to 1 year
CP4b_B:Years of Experience	1 to 2 years [3.00, 2]	10 or more [5.31, 32]	Only two data points for 1 to 2 years
CP4b_B:Years of Experience	1 to 2 years [3.00, 2]	2 to 5 years [5.43, 7]	Only two data points for 1 to 2 years
CP4c_B:Years of Experience	1 to 2 years [3.00, 2]	10 or more [5.18, 32]	Only two data points for 1 to 2 years
CP4c_B:Years of Experience	1 to 2 years [3.00, 2]	2 to 5 years [5.33, 7]	Only two data points for 1 to 2 years
CP3_A:Type of Practice	Duo Practice [4.64 ,17]	Other, namely: [3.29 ,7]	Uninterpretable category *Other, namely*
CP3_A:Type of Practice	Group Practice [4.92 ,12]	Other, namely: [3.29 ,7]	Uninterpretable category *Other, namely*
CP3_A:Type of Practice	Solo Practice [5.00 ,11]	Other, namely: [3.29 ,7]	Uninterpretable category *Other, namely*

I.2.2. Box Plots Included Significant Pairs

The box plots in Figure I.3, I.2, and I.4 show the median, mean, outliers and max and min of all the significant combinations of demographic variable and statement (17 pairs). The coloured boxes represent the interquartile interval, including 50% of the data points. The horizontal line in the box shows the median. The dot indicates the mean. The vertical line shows the minimum and maximum values in the data set. Finally, the outliers are represented by small dots outside of the box.

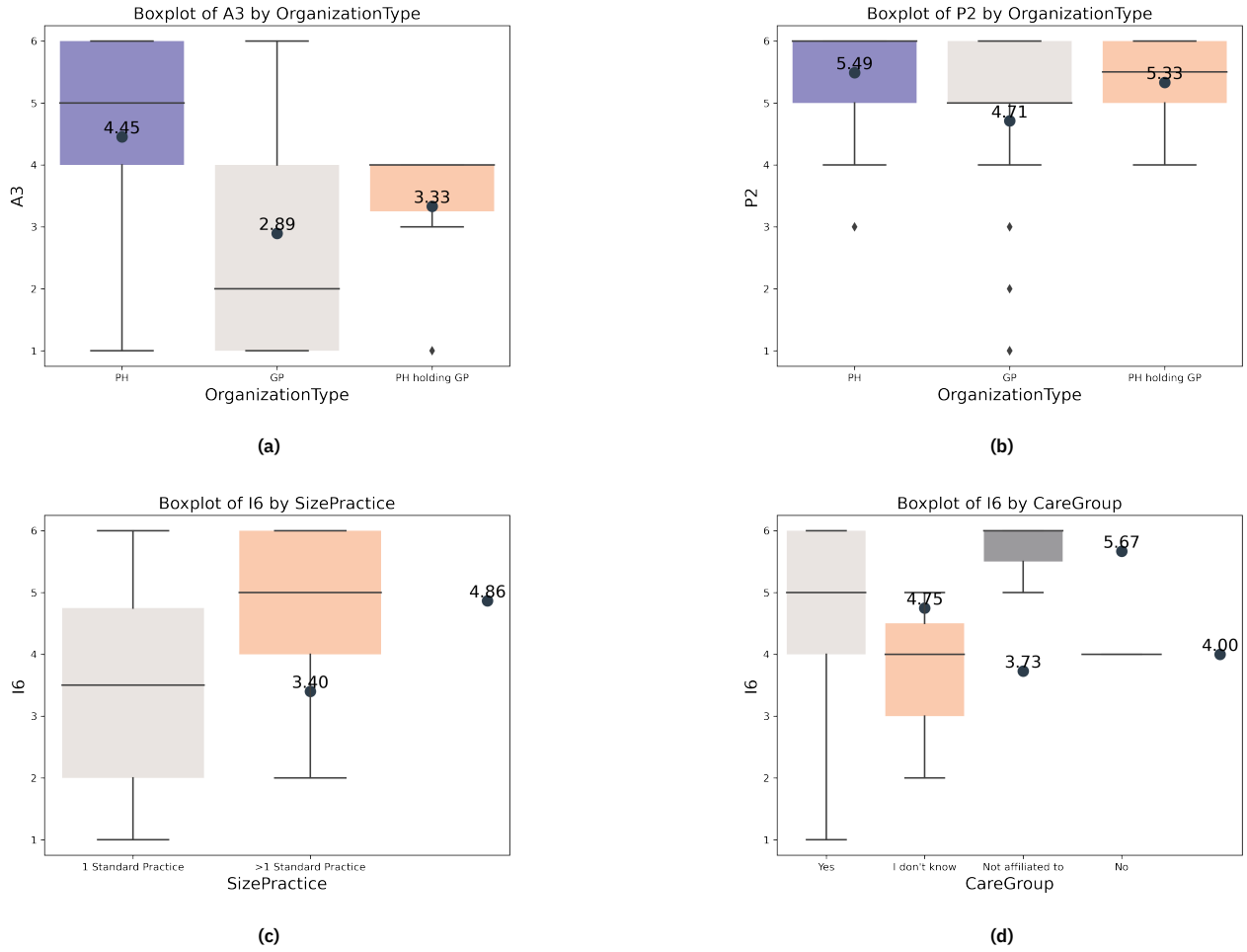


Figure I.2: Box Plots of Significant Effects by Organisation Type, Size of Practice and Care Group.

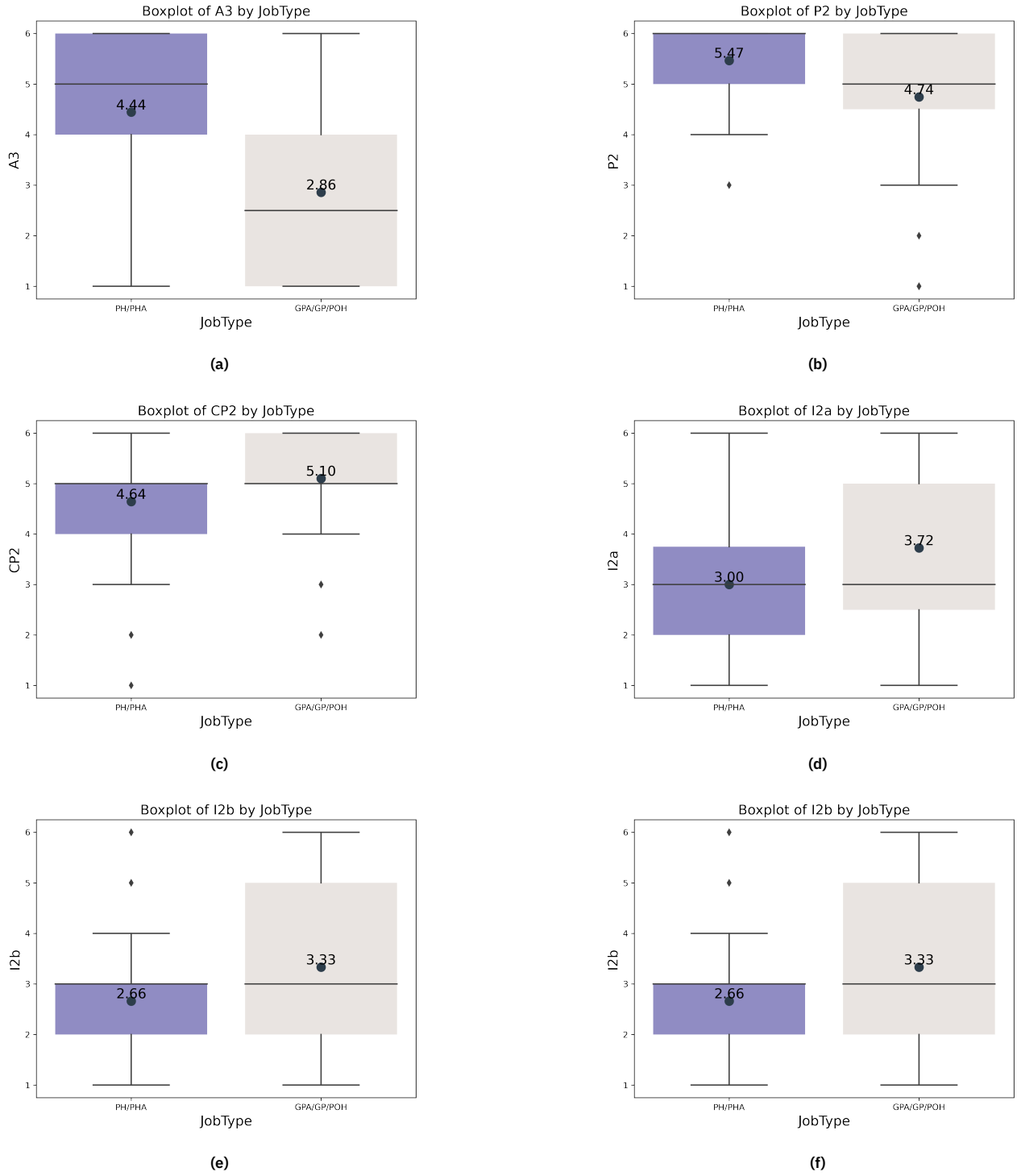


Figure I.3: Box Plots of Significant Effects by Job Type.

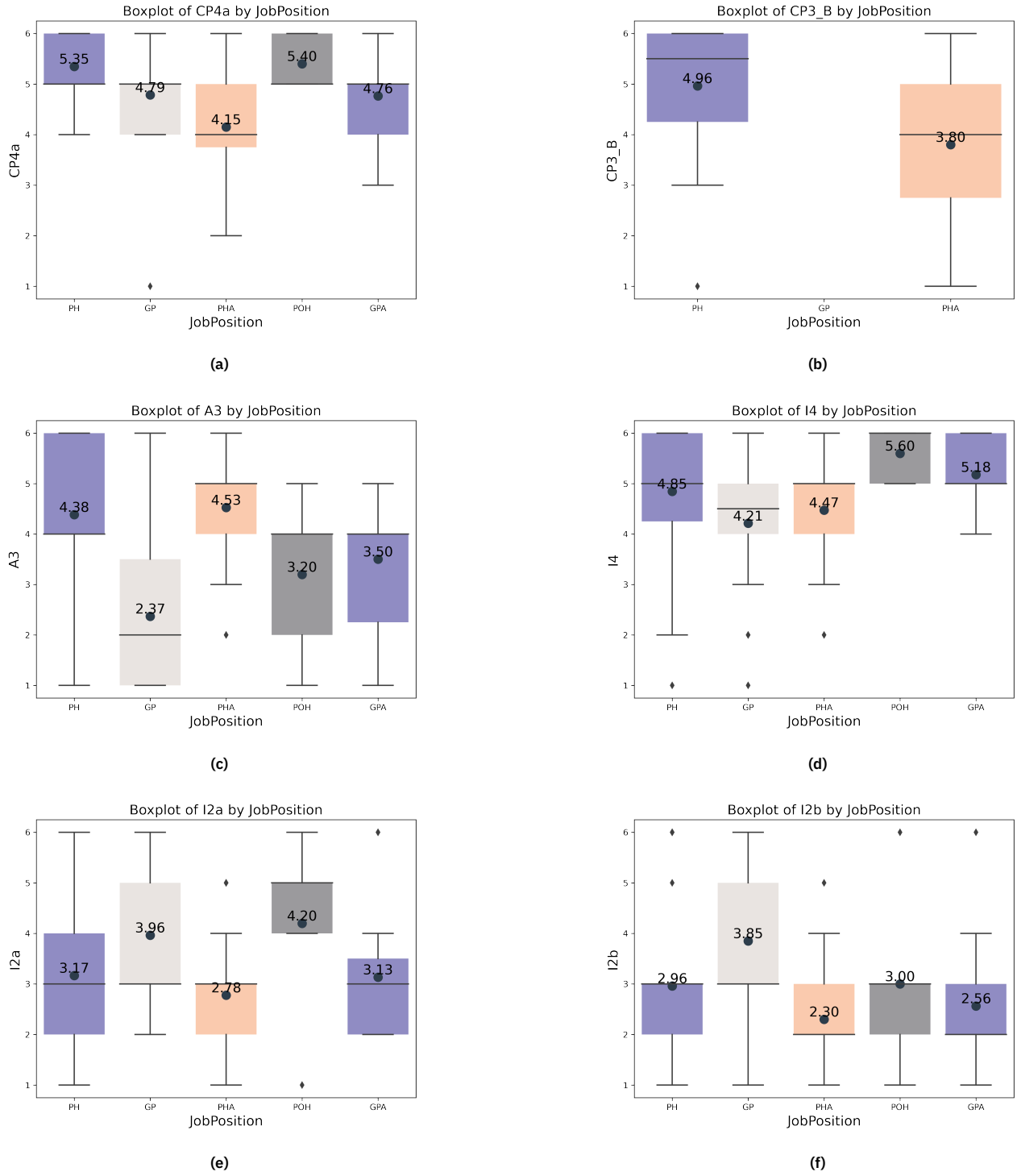


Figure I.4: Box Plots of Significant Effects by Job Position.

I.3. Overview of Qualitative Results

The cores for each statement or set of statements are shown in the following tables. The cores are separated based on a supporting/positive and critical clarification. Clarifications from positively assessed statements that still include some critical notes are seen as ”only if” clarifications.

Table I.17: Clarification Summary for Information Layer Statements.

Statement		Positive Cores	Critical Cores
I1	*I want the information exchanged about care around the medication process to be linked to certain codes.*	• Uniformity among healthcare professionals [6] • Efficient way of information exchange [6] • Effective way of information exchange [1] • Should be coupled to ICPC codes [5] • Is needed for automation [1]	• Only if the codes include the right information [3] • Afraid of a lot of documentation [4] • Only if the coupling between AIS and HIS is good [2] • Only if they are easy to find back [2] • Limited possibilities for communication [2] • *Respondent did not understand the statement [9]*
I2	*I want patient input on developments within his/her medication process* • *... (a) not always to be adopted.* • *... (b) not always to be adopted because the patient is not always trustworthy.*	• Yes, but always checks the input with other HCPs [8] • Yes, but use a healthy mind to process [2] • It mostly works as a signal function [3] • Especially Opiates/benzodiazepines [1] • Patient provides valuable information [5]	• Only if the relationship with the patient is good/ the patient is familiar [1] • Patient does have a different perspective [2] • Knowledge of patient is questionable [12] • - Especially older ones [1] • It depends on the medication [3] • Keep in mind that patients can be manipulative [2] • It depends on the state of the patient [1]
I3	*I would like to be able to decide whether communication notifications come in real-time in the system or not.*	• Also relevant for lab info [1] • Planning notifications would be nice [1] • Positively affects system contamination [3] • Would give control [2]	• I think direct is better, everyone should have that [3] • Only if responsibilities are clear [1] • It depends on the notification [3] • No need [2] • If they could be coupled in the system [1] • Don't understand the statement [3]
I4	*I would like to receive information from the patient about his/her personal developments regarding the medication process easier (medication change due to side effects/no result/other reason).*	• Up-to-date (timely) info is important [9] • This is the value from HCP [1] • Important for future consults [2] • Nice to directly process in the system [1]	• Personal contact is more clear [2] • Important to manage expectations for the patient [1] • More information would cause less overview [3] • First filer [1] • Patient does not have enough knowledge [2] • Already happening [10] (PGO, App, Portal, Desk, Mail, Tel, Website) • The communication to GP is the problem [1]
I5	*I want communication regarding care around the medication process to be available to the patient and those who have a treatment relationship with the patient.*	• Yes, information is essential [1] • Is part of MP9 [1] • Gives lots of chances [1] • Yes patient should decide what he/she can see [7] • Short lines [1] • Transparency [5]	• Internal communication is not relevant for the patient [4] • Patient is too fast involved [1] • Only if it's not a gush of information [2] • Statement is vague [2]
I6	*I want some communication regarding care around the medication process to be available only to healthcare professionals.*	• Only if the sender is clear [1] • Right interpretation by the patient is not guaranteed [5] • Privacy inter-professional is important [3] • It will prevent contamination of the system [1]	• Depends on the medication [3] • Patient should decide what he/she can see [6] • Transparency to the patient [5]

Table I.18: Clarification Summary for Application Layer Statements.

Statement	Positive Cores	Critical Cores
A1 *If a communication tool is going to be added for communication regarding care around the medication process, I want it in the same system we already work in.*	• Overview [4] • No double actions (especially logging) [7] • Content about the current system [1] • As much as possible in one system [21] • Efficient [1] • Decrease change on miscommunication [1]	• It should be clearly designed [1] • Only if there are limitations per discipline [1] • Only if other HCP cannot change/enter the system [1] • No communication, too busy [1] • Only coupled in the system if communication is finished/checked [2] • Not the same system, but a coupled system [1] • Only if it's also coupled with other specialists [1]
A2 *I prefer using as least as possible systems during my working day.*	• Less error-prone [2] • Decrease number of logins [2] • Time-related desires [2] • Simply agree [5]	• Only if it fits the process in the healthcare organisation [1]
A3 *I am quite willing to use an additional system for communication regarding care around the medication process if it would replace phone calls and mail contact.*	• Desire to get rid of phone [9] • Desire to get rid of email [5] • This is error-prone [1]	• Only if it could not be arranged differently [2] • Phones already clear communication [3] • Already arranged with Ncontrol [1] • Only if it is in line with the process [1] • Only if the system is easy to find/easily accessible [2] • Administrative concerns [7] • Only if it is coupled to the patient file [2] • Only if it will increase the spare time by a decrease of calls [6]

Table I.19: Clarification Summary for Policy Layer Statements and CP2.

Statement	Positive Cores	Critical Cores
P • *(1) I want to make national agreements on the communication regarding care around the medication process,* • *(2) I want to make regional agreements on the communication regarding care around the medication process.*	• National is safer [2] • National coding [2] • Locally fine-tuning [8] • Locally more bearing [1] • Locally gets off the ground faster [3] • National necessary [1]	• It should also include GGZ and transmural pharmacy [1] • National is not achievable [1] • Don't reinvent the wheel locally [3] • National won't cope with the differences in regional mentality [1]
CP2 *I want patients to be able to contact the GP practice and/or pharmacy directly about their own choices around the medication process.*	• Positive effect on therapy compliance [6] • Should always be possible [5] • The pharmacy could play a bigger role in minor ailments [1] • Already possible for repeat processes [1] • Already possible in patient portal [2] • Comment possibility would be nice [1] • Would improve the HCP perspective of the patient [2]	• Own initiative is not convenient [1] • They should arrange it by themselves [5] • The patient's question should go to the prescriber [2] • Only if the patients could choose their communication [2] • They can already call [2]

Table I.20: Clarification Summary for CP3 and CP4 for both Job Types.

Statement		Positive Cores	Critical Cores
CP3 GP/G-PA/POH	*I am quite willing to transfer more responsibilities to the pharmacist/assistant regarding care around the medication process due to digitisation.*	• Repeat recipes should be standardised [5] • GP doesn't give much attention to it [1] • Not good yet [1] • Pass-on digitally is good [1]	• Only if feedback is well arranged [10] • PH misses context [2] • Only chronicle medication [1] • GP will stay end-responsible [6] • Statement too vague [1]
CP3 PH/PHA	*I am quite willing to take over more responsibilities from the GP/GPA regarding care around the medication process due to digitisation.*	• We are capable and willing [7] • Digital verification [1] • Especially repeat recipes [2] • Also authority for lab values [1] • PH have a very complete AIS [1] • Especially chronicle and seasonal medication [2] • Also, for some tests [1]	• Only if responsibilities will be arranged sufficiently [1] • Only if funding will be arranged [3] • It's limited [1] • Only if GP is end-responsible [2] • We have no time [2] • No constant communication [1]
CP4 GP/G-PA/POH	*I am adequately involved in the care around the medication process,* • *... (a) so I want to process requests from the patient.* • *... (b) so I want to process requests from the PH.* • *... (c) so I want to process requests from the PHA.*	• Will result in a clear overview [1] • Medication overview should correspond with reality [2] (and who added/changed things) • Patient could go to pharmacy more often [1] • Working together for best result [1]	• Only if feedback is well arranged [3] • Responsibilities lie with the prescriber [2] • Requests from PH are always different. Uniformity should be guaranteed [1] • Trustworthiness of PHA is questionable [1] • Don't have time to handle requests [1] • GPA doesn't feel responsible [2] • PH shouldn't prescribe medication [2]
CP4 PH/PHA	*I am adequately involved in the care around the medication process,* • *... (a) so I want to process requests from the patient.* • *... (b) so I want to process requests from the GP.* • *... (c) so I want to process requests from the GPA.*	• Especially minor illness [1]	• Only if safety is guaranteed [1] • Only if authorisation/feedback is integrated [5] • GPA isn't that involved [2] • GP does decide [1]

Table I.21: Clarification Summary for CP1 for all Job Types.

Statement		Positive Cores	Critical Cores
CP1 GP	*In terms of care around the medication process, I would like to consult more easily with ...* • *... (a) PHA* • *... (b) GPA* • *... (c) PH*	• Yes, as long as it's not via the patient [1] • Especially PH [4] • Feedback is terrible [1] • Chat function instead of phone [5]	• Already have good communication [1] • No problems with own assistant [7]
CP1 GPA	*In terms of care around the medication process, I would like to consult more easily with ...* • *... (a) PHA* • *... (b) GP* • *... (c) PH*	• Especially with an assistant [2] • Especially for misuse of medication [1] • All disciplines should see changes [2] • Chat function instead of phone [2] • Short lines [3]	• Already good communication [2]
CP1 PH	*In terms of care around the medication process, I would like to consult more easily with ...* • *... (a) PHA* • *... (b) GPA* • *... (c) GP*	• It would increase PH's freedom [1] • Could be more efficient, digital [4] • GP is now badly reachable [2]	• Already good internal communication [6] • Assistants can communicate mutually [1]
CP1 PHA	*In terms of care around the medication process, I would like to consult more easily with ...* • *... (a) GP* • *... (b) GPA* • *... (c) PH*	• Passing something on can be done by the assistants [1] • Easier would be nice [1] • GP is unreachable [2]	• Depending on the medication [2] • Communication is already quite well [3] • Only if the communication is properly documented [1]
CP CP1 POH	*In terms of care around the medication process, I would like to consult more easily with ...* • *... (a) GP* • *... (b) PHA* • *... (c) GPA* • *... (d) PH*	• Would be good for everyone [1]	• Already have communication with assistants [1]

J

Appendix: Requirement Overview

Table J.1 show the requirements resulting from the clarifications. The requirement is supported by the number of respondents of which the clarification resulted in the requirement. This number is between brackets. An 'A:' or 'B:' indicates a distinction in Job Type. A represents GP/GPA/POH, while B represents PH/PHA. Table J.2 shows an overview of all requirements resulting from the statement assessment (structured by means and respondent group), and the requirement reference ('Ref'), used in the aggregation process. Both tables together include all constructed requirements based on the survey results.

Table J.1: Overview Additional Requirements resulting from Clarifications: showing Statement Code and Requirement Code.

Statement	ReqCode	Additional Requirement
I1		The design of codes supporting communication regarding care around the medication process ...
	I1.2	... should enable coupling between AIS and HIS. [2]
	I1.3	... should be well-documented. [1]
	I5.4	... should enable HCPs to easily find back the codes. [1]
	I5.5	... should include enough communication possibilities. [2]
	I5.6	... should include a link to ICPC codes. [5]
I2	I2.2	The design should enable HCPs to get feedback on patients' input from other HCPS. [8]
I3	I3.2	The design should couple communication notifications to the system. [1]
	I3.3	The design should provide HCP with planning opportunities regarding notifications. [1]
I4	I4.2	The design should manage patient expectations regarding communication regarding care around the medication process. [1]
	I4.3	The design should ensure the digital communication has a personal feeling. [2]
I5	I5.2	The design should enable HCPs to keep internal information only accessible internally. [3]
	I5.3	The design should ensure the communication regarding care around the medication process won't be a gush of information. [2]
I6	I6.2	The design should enable medication-based selection for communication transparency. [3]
A1	A1.2	The design should enable HCPs to decide on the regulations regarding saving communication. [2]
	A1.3	The design should couple other medical specialists to the communication regarding care around the medication process. [1]
	A1.4	The design should limit access to communication regarding care around the medication process based on disciplines. [1]
A3	A3.2	The design of an additional system enabling communication regarding care around the medication process should be easily accessible. [1]
	A3.3	The design of an additional system enabling the communication regarding cara around the medication process should increase the spare time by a decrease of calls. [6]
P1/P2	P1/P2.1	The design should include local agreements including GGZ and Transmural pharmacies. [1]
CP2	CP2.2	The design should enable patients to choose their own way of communication. [2]
	CP2.3	The design should ensure questions of the patient end up with the corresponding prescriber. [2]
CP3	CP3A.2	The design should include a feedback mechanism enabling PH/PHA to get feedback on choices regarding the care around the medication process. [A:10]
	CP3B.2	The design should ensure responsibilities within the care process are arranged sufficiently. [B:1]
	CP3B.3	The design should include a funding mechanism for taking over responsibilities. [B:3]
CP4	CP4.1	The design should include a feedback mechanism enabling HCP to obtain feedback on requests. [A:3][B:5]

Table J.2: Overview of Requirements resulting from Statement Assessment: showing the Statement Code, Mean, and Requirement Number.

Statement	Mean	Req	Requirement
General			
A2	5.26	A2.1	The design must limit the number of systems used by healthcare professionals.
A1	5.22	A1.1	The design must enable integration of the tool for communication regarding the care around the medication process in the current AIS and HIS systems.
P2	5.10	P2.1	The design must support local agreements on the communication regarding care around the medication process.
I5	4.96	I5.1	The design should make the communication regarding care around the medication process available for patients and healthcare professionals with a treatment relationship with that patient.
I1	4.91	I1.1	The design should integrate communication regarding care around the medication process based on certain codes.
CP2	4.88	CP2.1	The design should enable patients to contact GP practice and/or pharmacy *directly* about their own choices around the medication process.
CP4a	4.83	CP4a.1	The design should enable healthcare professionals to process requests from the patient.
P1	4.76	P1.1	The design should support national agreements on the communication regarding care around the medication process.
I4	4.68	I4.1	The design should enable healthcare professionals to receive personal developments regarding the medication process from the patients *easier*.
I3	4.66	I3.1	The design should enable healthcare professionals to decide which communication notifications enter the system in real time and which notifications do not.
I6	4.62	I6.1	The design should enable healthcare professionals to keep some communication regarding the care around the medication process between healthcare professionals.
A3	3.61	A3.1	The design could provide an additional system for communication regarding care around the medication process if it would replace phone calls and emails.
I2a	3.38	I2a.1	The design could implement a control mechanism to support the trustworthiness of patients' input.
I2b	3.01	I2b.1	The design could implement a control mechanism to support the trustworthiness of patients' input.
A			
GPA_CP1a	5.50	GPA_CP1a.1	The design must enable GPAs to consult more easily with PHAs.
GP_CP1c	5.46	GP_CP1c.1	The design must enable GPs to consult more easily with PHs.
POH_CP1d	5.20	POH_CP1d.1	The design must enable POHs to consult more easily with PHs.
POH_CP1a	5.20	POH_CP1a.1	The design must enable POHs to consult more easily with PHAs.
GPA_CP1b	5.06	GPA_CP1b.1	The design must enable GPAs to consult more easily with GPs.
GP_CP1a	5.00	GP_CP1a.1	The design must enable GPs to consult more easily with PHAs.
GPA_CP1c	4.94	GPA_CP1c.1	The design should enable GPAs to consult more easily with PHs.
GP_CP1b	4.78	GP_CP1b.1	The design should enable GPs to consult more easily with GPAs.
CP4b_A	4.76	CP4b_A.1	The design should support GP practice employees to process requests from PHs.
CP4c_A	4.69	CP4c_A.1	The design should support GP practice employees to process requests from PHAs.
CP3_A	4.60	CP3A.1	The design should enable GP practice employees to transfer some of the responsibilities regarding care around the medication process towards pharmacy employees.
POH_CP1b	4.00	POH_CP1b.1	The design should enable POHs to consult more easily with GPs.
POH_CP1c	4.00	POH_CP1c.1	The design should enable POHs to consult more easily with GPAs.
B			
PH_CP1c	5.27	PH_CP1c.1	The design must enable PHs to consult more easily with GPs.
CP4b_B	5.27	CP4b_B.1	The design must support pharmacy employees to process requests from GPs.
CP4c_B	5.11	CP4c_B.1	The design must support pharmacy employees to process requests from GPAs.
PH_CP1b	5.04	PH_CP1b.1	The design must enable PHs to consult more easily with GPAs.
PHA_CP1c	4.70	PHA_CP1c.1	The design should enable PHAs to consult more easily with PHs.
PHA_CP1b	4.55	PHA_CP1b.1	The design should enable PHAs to consult more easily with GPAs.
PHA_CP1a	4.53	PHA_CP1a.1	The design should enable PHAs to consult more easily with GPs.
CP3_B	4.46	CP3B.1	The design should enable pharmacy employees to take over some of the responsibilities regarding care around the medication process from GP practice employees.
PH_CP1a	4.32	PH_CP1a.1	The design should enable PHs to consult more easily with PHAs.

K

Appendix: Semi-Structured Interviews for Requirement Structure Discussion

This section provides an overview of the interviews with PO1, PO2 and PO3. The goal of the interview was to keep it short, but still obtain proper insights into the usability of the requirements. The main goal was to find the overall opinion of the requirement structure considering usability and clarity. Not all interviewees discussed all questions, the questions were asked following the conversation with the interviewee.

K.1. Interview Results Interviewee PO1

What is your first impression of the requirement structure?
I definitely recognise the work breakdown structure (WBS). Even in my work, we break down large tasks into smaller chunks. I can see the similarities between this process of breaking things down into smaller pieces and the concept of a WBS.

At what point do you involve developers with the requirements?
It depends on the subject matter and how technical it is. The level of detail can vary based on the specific needs and requirements at any given moment.

How do you approach this requirements structure?
If you hand over this requirements structure to a development team, you'll receive something completely different. For that purpose, it should be specified more.

How do you make decisions regarding task prioritisation and scope selection?
In the grand scheme of things, choices must be made. It's not possible to do everything, so decisions are made to meet as many interests as possible.

How do you divide the responsibilities around the design of platform components?
I don't have expertise in that area, so I prefer to leave it to others who do have the experience.

Do you or did you experience any similar ideas on communication regarding the care around the medication process?
Visibility of messages and restricting access to certain people is not currently possible. It wasn't considered in the internal communication system of ASP. It's a component of the medical record for correspondence. Within a GP practice, there are different roles. The POH (Practice Nurse) only needs to see relevant information. Is it a significant issue? Not really, but it would be convenient. This applies to all roles and also depends on the patient. The difference among healthcare professionals is evident. Linking communication to codes was also mentioned. Research is needed to categorise all types of communication into specific codes. Communication is valuable because it deals with special or complex matters. Documenting complex things can be challenging. There's a limit to how complex it can be. Communication is always about something and always within a certain context. PO1 had provided an example regarding the communication notifications as well, specifically mentioning that in the VDF system, an urgent notification message remains visible. If it is not urgent, the notification briefly appears and then disappears. This functionality exists for internal communication between assistants and the doctors in the VDF system. However, when considering external communication, receiving a notification for every message could be bothersome. In such cases, there would need to be a system for indicating urgency, where only messages requiring immediate action would trigger a notification.

K.2. Interview Results Interviewee PO2

What is your first impression of the requirement structure?
As a product owner, you are familiar with the concept of a work breakdown structure (WBS). It serves as a valuable tool for organising and managing the various tasks and deliverables of a project. However, you can take it a step further by delving into the WBS in more detail, tailoring it specifically for your own use.

At what point do you involve developers with the requirements?
Once I start creating user stories, I consult with the developers to understand what is feasible and what we already have in place. They help refine the criteria for the stories. We then discuss the stories together, ensuring that everyone is aligned in their understanding. When it comes to communication, what is the desired outcome? Is it about signalling issues or ensuring proper documentation in the patient's record?

How do you approach this requirements structure?
The high-level goals you want to achieve are features that need to be broken down into smaller increments for development teams. Handling them as large blocks takes much longer and becomes highly complex for the development teams. They don't know where to start without a clear start and endpoint. When they receive a large block, they struggle to determine the starting point. To reduce complexity and increase predictability, you need to provide more detailed specifications to guide them through the development process and clarify the scope.

How do you divide the responsibilities around the design of platform components?
The definition of done refers to the criteria that must be met by the development team for a product backlog item to be considered complete. It outlines the specific conditions and requirements that need to be fulfilled in order to deliver a high-quality, functional increment. The definition of done helps ensure that the team maintains consistent standards and that all necessary tasks and aspects of development are addressed. While it is important to meet the defined criteria, it is also essential to strike a balance and avoid getting caught up in excessive detail that may hinder productivity.

Do you think the requirements are clearly described?
Upon reviewing the scanned information, it was noticed that the term "HCP" (Healthcare Professional) was unclear. It is important to ensure that everyone is speaking the same language and using consistent terminology. When examining section 1.2.1, the question arises of what should and should not be included. For example, one may not want to clutter their medical record with unnecessary information. There are still many underlying questions that need to be addressed. If the communication needs to be recorded, where should it be stored? Is there a need for a signalling function associated with that communication?

How do you handle trade-offs between multiple clients using your system?
You have to find something like the right direction. And make sure it's balanced. You can never please everyone.

What does a story look like? Is there a standard structure?
We use a way of formulating the use case in a short sentence. Using: As a... I want... so that... For example: As a pharmacist, I want to contact GPs in a chat so that I don't need to call them anymore. This way the situation is sketched in a uniform way for each story.

Do you or did you experience any similar ideas on communication regarding the care around the medication process?
Second-line example: Request functionality was built for inter-professional consultations. The request appeared in a task list for the physician or department, allowing multiple people to take it into account. This was for internal communication. Sometimes care pathways were integrated as well. There is integration with the patient portal, such as requesting tests or asking questions. It's not documented in the medical record. It goes to the personal worklist of the physician. But if they find something important, they can copy and paste it. There's a workaround field. In ASP, there's an "overlegmodule" (consultation module) that allows you to see it in relation to a patient, but it's not really part of the medical record. Creating a sub-encounter will copy the text into the SOEP report. It's a cumbersome way of doing it. The "overlegmodule" is only used by GPA (General Practitioner Assistant) but it should be available for everyone to communicate with each other, not just from a specific role. You want to be able to send it to a specific role. Provide a chat module.

K.3. Interview Results Interviewee PO3

What is your first impression of the requirement structure?
Patient participation is undoubtedly crucial, but it can also be a goal. What solutions can we devise for this? For example, when it comes to communication, there are various methods like integrating an app, such as WhatsApp. Eventually, we reach a point where we consider WhatsApp to be a viable idea. How is that determined? Through a value analysis and cost-benefit analysis. We identify the needs, spot trends, evaluate the potential for usage, and assess its potential benefits for the company, such as attracting more customers. We develop a business case to weigh the pros and cons. Let's say we decide to proceed with WhatsApp, which may require a month of development work. What will be the outcome? Ultimately, it needs to be balanced.

The development process involves creating a business case, determining the impact, and conducting a cost-benefit analysis. Once we receive the green light, we move on to detailed elaboration. We start by creating Epics, which provide a semi-concrete framework. Then, we delve into the specifics, considering factors such as who wants this, whether it's intended for a specific customer group, how it will be monitored, what integration is required, and what criteria it must meet. Do we need to be available at all times? Are developers involved in the process? This is where an information analyst comes into play. They can gather specifications and determine the effort required. What are the requirements? An architect is involved to address security requirements, while someone from the development team considers the technical impact. We refine the details until we reach a point where even a simple integration with WhatsApp can bring about a significant structure. The actual implementation may not be as structured as this description, but the Epics are broken down into user stories, which are integral parts of a whole. The process applies

to both F and A. Within each user story, choices need to be made. Regarding security, we can choose to make it highly secure or more relaxed. These decisions are based on thorough analysis. As we continue to dissect the project, even more details emerge. Patient participation is undoubtedly crucial, but it can also be a goal. What solutions can we devise for this? For example, when it comes to communication, there are various methods like integrating an app, such as WhatsApp. Eventually, we reach a point where we consider WhatsApp to be a viable idea. How is that determined? Through a value analysis and cost-benefit analysis. We identify the needs, spot trends, evaluate the potential for usage, and assess its potential benefits for the company, such as attracting more customers. We develop a business case to weigh the pros and cons. Let's say we decide to proceed with WhatsApp, which may require a month of development work. What will be the outcome? Ultimately, it needs to be balanced.

At what point do you involve developers with the requirements?
What you need to do is explicitly clarify what you aim to achieve. If we consider a patient's preferred communication methods, which options are available? Do they all need to be supported? How will you document this information? Where will it be recorded? Who will have access to it? Should the patient indicate their preferences themselves? Does it impact existing logic? If the preferred method is SMS or email, does it involve integration with other platforms? You need to translate these requirements into concrete implications for the impact on your system/application. You must work on it until the developer understands what happens when a specific button is clicked. What will be the system's behaviour? Do you want it to be flexible?

How do you approach this requirements structure?
While it's beneficial to have a general idea of how things should be, there is still a significant translation process between this conceptualisation and what is needed for the development team to actually start building. It's valuable to have a detailed breakdown of the requirements through a needs analysis, considering what customers or target audiences would want in terms of communication. This analysis can be properly categorised and prioritised. Typically, we assess what is most important and where the greatest benefits lie, such as improving customer satisfaction, reducing inquiries to the service desk, or considering future prospects. The value isn't solely monetary but can encompass various aspects beyond financial gains.

How do you make decisions regarding task prioritisation and scope selection?
Breaking things down into smaller components, even at a lower level (including this level), is necessary. You simply cannot do everything. The development team cannot handle everything either, so choices have to be made.

How do you divide the responsibilities around the design of platform components?
Based on certain architectural principles and best practices, it is preferable not to interfere too much with the technical design. It can also be beneficial for the team to be involved in making certain choices. We define acceptance criteria for stories, which outline the specific requirements that we believe the product should meet. These criteria are measurable and testable, and they are managed by the information analyst. The story can be seen as a contract between the information analyst as the client and the development team as the contractor. The information analyst serves as the primary approver, and the tester creates scenarios and tests them accordingly. If the information analyst approves the work, there may still be a consultation with the product owner to align their perspectives, as their opinions may differ.

Do you think the requirements are clearly described?
PO3 refers to a specific aspect or requirement within the context being discussed. Without further context, it is not possible to determine the exact meaning or origin of PO3. Similarly, the term "Communication Notification System" refers to a system or mechanism that notifies individuals about communication-related events or updates. The underlying need or purpose behind such a system may vary depending on the specific situation or context. It is important to understand the underlying needs and reasons for considering or implementing such systems to ensure clarity and alignment with user requirements. The specific details and importance of these aspects can be further clarified and filled in through discussions, analysis, and gathering more information from the relevant stakeholders.

How do you handle trade-offs between multiple clients using your system?
You always have to make choices, and there will always be happy and less happy people. That's the case with everything you do. The key is to find commonalities that are relevant to everyone. If we can justify our choices well, we can sell them to other clients. It's about how you explain why you make certain choices, and they may have their own opinions. It's an interesting challenge because customers want everything adjustable, but from a development perspective, making everything adjustable is not feasible. It's detrimental to the maintainability of the product. There needs to be a lot of communication and testing becomes challenging as well because you have to test all scenarios. The goal is to make it as generic as possible and minimise settings per healthcare professional.

What does a story look like? Is there a standard structure?
We often use best practices for uniformity. A user story typically follows a certain semantic structure. Who is the stakeholder, what do they want, and why? For example, when describing system behaviour, there is also a specific structure. BPMN... Give... when... then... It depends on what you want to achieve together. How you fill in a story depends on the specific requirements. If you want an integration, you need to create a good API description. If you want to create a workflow, you need to focus more on system behaviour and use diagrams. Let's say you want to make an appointment. Making the appointment is the end goal, but there are intermediate steps. It can have different statuses that can be easily modelled. Each aspect needs to be modelled separately. There are different types of requirements and stories, and you have to choose the format that fits each situation.

Do you or did you experience any similar ideas on communication regarding the care around the medication process?
It is definitely an area where we have insufficient understanding. I directly think about the information structure for this communication. For example, labels in an email inbox or specific side effects of certain medications. Labelling based on medications and patient-specific information, following therapy derived from an episode of drug treatment. Would you like to link them to different labels? There's no concrete plan to use Teams or WhatsApp. That can take various forms and is yet to be determined. Sanday is positioned as a healthcare information platform, aiming to bring together various communication flows and forms logically for multidisciplinary collaboration.

It is once again mentioned that GP practices are lagging behind. They have advanced registration systems but not really modern or adaptable ones. There's not a lot of money to spend. How much does a general practice allocate for this? General practitioners have limited resources. It all costs money, and that's more with pharmacists, no, now with insurers and hospitals. Many new startups are introducing systems. Sanday can start a new cycle with many great new opportunities, but wanting more means having to pay more. It can't be free.

L

Appendix: System Requirement Structure

The full SRS is shown in Figure L.1, for which the readability was neglected. The aim of this figure is to illustrate how the structure is composed. Figures L.2, L.3 and L.4 show the zoomed-in SRS branches. It includes the updated version after the discussion interviews as discussed in Chapter 5.

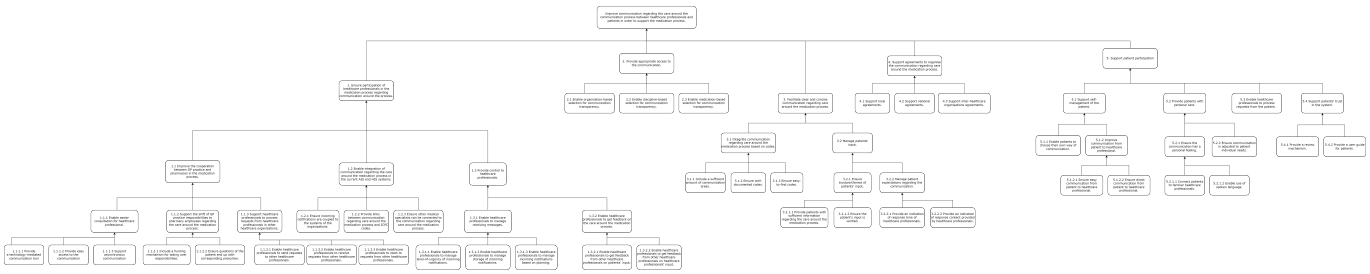


Figure L.1: Full Overview of the SRS.

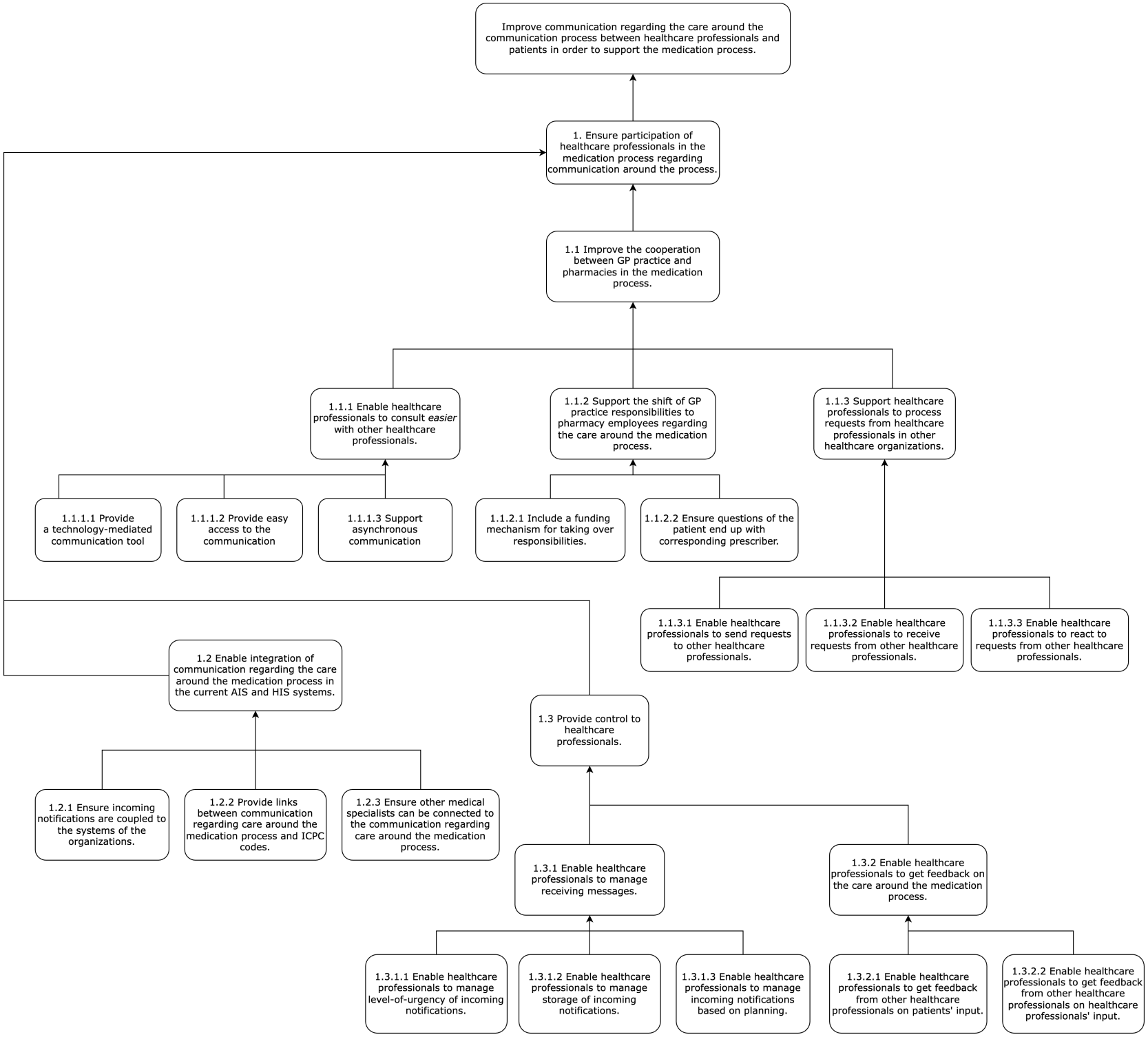


Figure L.2: SRS (1/3)

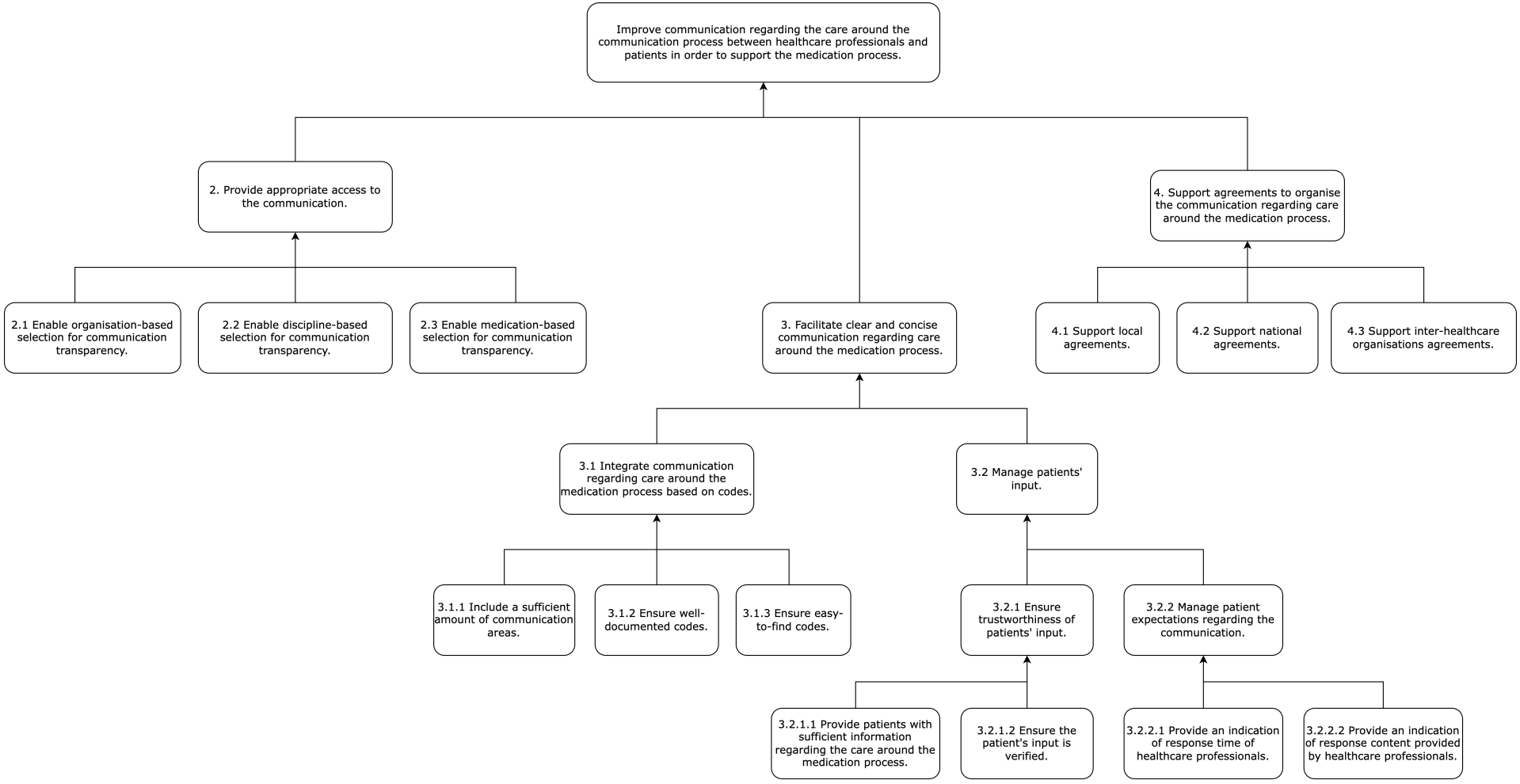


Figure L.3: SRS (2/3)

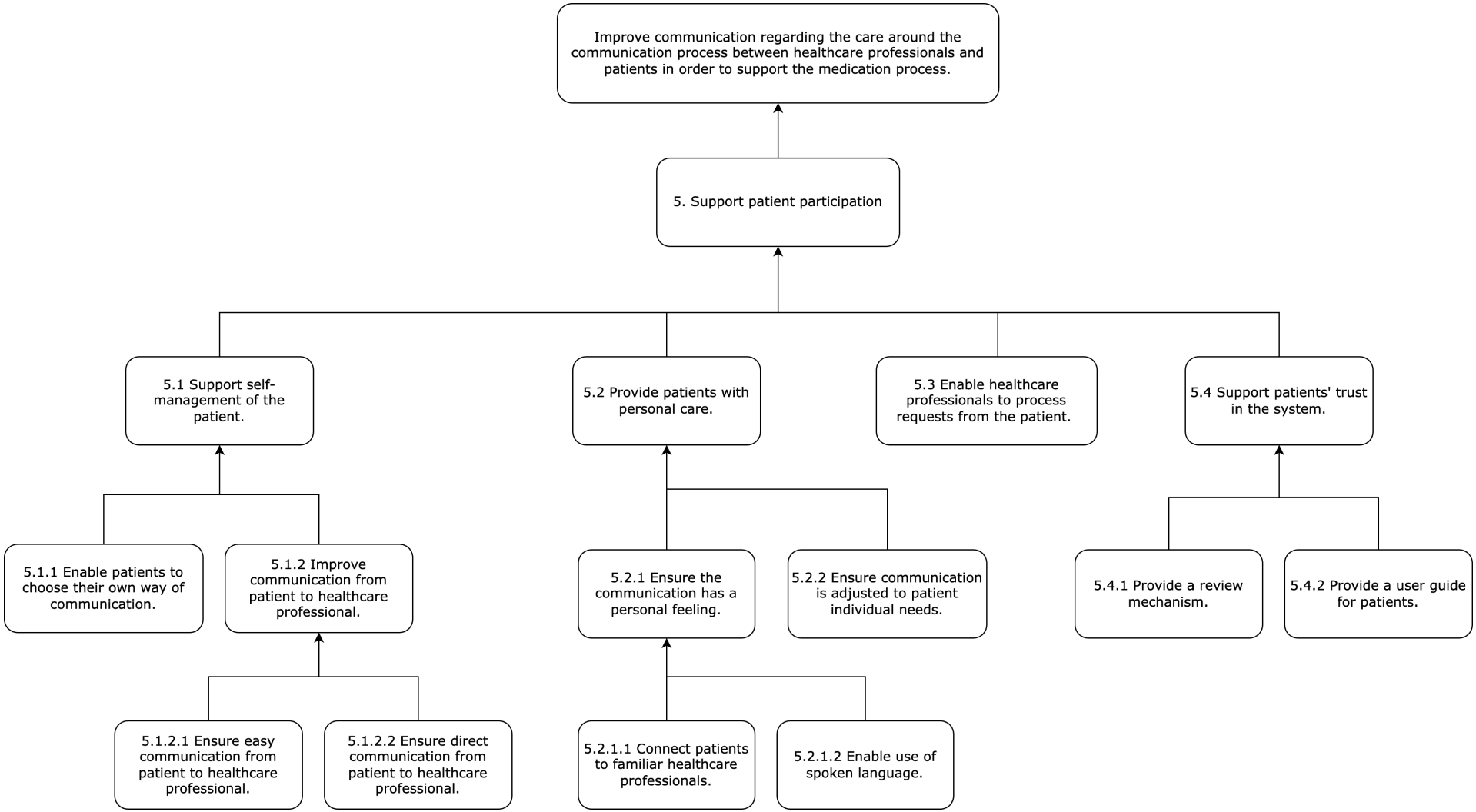


Figure L.4: SRS (3/3)

M

Appendix: Semi-Structured Interviews for Platform Design Evaluation

This appendix shows an overview of the discussion between the researcher and the interviewees. Slides were shown to the interviewees beforehand (and during the interviews as well) to support their knowledge. The discussion also raised questions both to the researcher and the interviewees - which are also mentioned in this Appendix.

Considering the requirement validation Sections - discussing whether the platform components can realise the requirements linked to it - only the points indicating a discussion are mentioned extensively. The not-mentioned requirements and corresponding platform components are valid.

M.1. Insights Interview PA1: Platform Architect within Healthcare Organisation

During the interview with interviewee PA1, there was not enough time to discuss the validity of the components vs requirements.

M.1.1. General Insights on the Platform Architecture Design

First Impression
Components in the draft cannot yet exist because no legal agreements have been made for them. Mainly the financial transfer between the platform and the healthcare organisation. This is now only within pharmacy and GP. There is no transfer of responsibilities for reimbursement yet. PA1 is surprised by the desire from GP and pharmacists. Now, communication around the medication process mainly consists of the medication and the reason for prescribing. If the design will be implemented, PA2 expects pharmacies to take on many responsibilities because they have more time.

Currently, pharmacies yearly receive a financial reward to research the medication process of the patient, resulting in a yearly recurring process where the pharmacist checks the medication and adjusts the medication based on insights and best practices considering health and business. This supports, even more, the importance of financial reward since this would occur frequently due to the platform enabling patients to discuss their medication process more efficiently with healthcare professionals. For how long will this financial system be integrated into the healthcare domain?

The preferences of patients are currently not that much considered in the medication process. If the communication would also support patients to ensure they will receive medication based on their preferences, this would indicate a shift in responsibilities and would need governance interventions.

Discussion External Components
The financial system as proposed is questioned by PA2. PA2 outlines that there is yet no financial system connected to healthcare organisations rather than insurance companies. Every financial transaction is connected to the insurance of the patient and thus regulated via the insurance companies. The declaration is sent from the healthcare organisations to the insurance companies. Theoretically, it could be handled by a financial system, but this will need a new institutional intervention. The gateway could be a declaration module. PA2 uses Vecozo to regulate the declarations to insurance companies. The insurance companies now also return the declaration when there is any missing information or the patient does not have insurance covering the time spent by the healthcare professional.

Furthermore, PA2 outlined the bigger picture of the proposed information standard databases. The ICPC codes are part of all tables discussed by NHG in the NHG tables. All these master tables facilitated by NHG should be considered when coupling information provided by platform complementors. Considering the MP9 Information Database, PA2 notified that this belongs to the overarching G-standard (Dutch: *Geneesmiddelen-Standaard*) as proposed by KNMG. The G-standard is a database consisting of all relevant information on medical products available in the Dutch healthcare system.

Information Flow/Storage
The design is quite complex due to the use of lots of connections. These connections indicate information flows. The storage of the communication is yet unclear. If the communication is stored insight each of the HCP system complementors involved in the communication, this results in privacy issues. If the communication will be connected to the medication overview - which is desirable due to the overview of the communication - this will need further research in information storage. The medication overview is stored insight the HCP systems and is not always up-to-date related to the actual situation. Adjustments that are communicated through a phone call or face-to-face meeting will not be stored correctly. To tackle this information asymmetry the information regarding changes in medication which is transferred on the communication platform should be coupled with the medication overview. The system should then ensure communication is labelled and sent to the HCP systems storing a medication overview of that unique patient. PA2 argues the great value of resolving this.

FHIR as Message Broker
PA1 argued the need for implementing the FHIR standard since the FHIR standard is the standard for directing messages from one system to another. The FHIR broker can be designed by the platform owner or could be bought from suppliers. FHIR consists of Zibs (Dutch: *zorginformatie bouwstenen*) - all designed to fulfil different functionalities. The Zibs needed within the FHIR broker can be designed by the platform developer if they do not yet exist. This would be the case for managing the direction of messages. The FHIR broker needs to know what to do in any case occurring in the system. This should be defined by the platform developer. PA1 pinpoints that diving into FHIR technically would not be relevant for this level of abstraction.

Communication Storage
PA1 stated that communication storage equals the disability of care. The privacy flag goes up, and yup there is the delay. Central storage of patients' sensitive healthcare data will not be possible according to PA1. No central patient file will be stored, which is what is already stated during the process of designing LSP. Also, considering the systems on the patient side, are yet not allowed to store any patient file. Especially keeping in mind for example an app used by patients to access their data. Using an application on a mobile phone where the file is stored is unsafe. In the case of currently existing PGOs, this is not happening, but PA1 also don't know how this will be regulated considering the storage. This would need further research. The information is currently stored in the source system (which is now the HCO system). PGOs are not yet there in development.

Furthermore, PA1 notes the DVZA (Dutch: *dienstverlener zorgaanbieder*) is currently between the PGO and the AIS/HIS. The DVZA could be used to transfer the information stored in AIS and HIS to your PGO, without saving the information on the PGO - and thus result in a decrease in safety.

Also, the AMO (Dutch: *Actueel Medicatieoverzicht*) is mentioned as part of the relevance of this system. An AMO is an overview of all the medication the patient is taking presently. AMOs currently are not yet fully symmetric, meaning not all HCO systems have an up-to-date version of the AMO of the patient. A connection to the messaging system can improve the accuracy of the AMOs. When a message is coupled to a medication in the AMO, a notification could be sent to the systems that have an AMO of that patient. The healthcare professional would then integrate the information in the AMO (or this is done automatically). Should this be added?

Review Statistics System
Comparison with the review system of a restaurant - which is currently mostly loosely coupled to the restaurant website, but integrated together in Google Review. PA1 supports the idea that it would be valuable to choose a specific healthcare organisation based on your condition. Technically speaking, the review statistics system would be possible. Information on the response time could be defined and sent to a review statistics system by an API. There would be many opportunities for information to send from the HCO API to the review statistics system. The response time could be linked to the HCP, the HCO, the discipline, the matter discussed, etc. Would need further research to define what information is most valuable to the patient. But, it does need a change in the system (where patients decide based on their conditions and preferences which HCO they contact/visit) - which needs change management.

PA1 pinpoints the possibility of using FHIR Zibs to regulate this statistics system. PA1 also directly argues that this will take years and gives the example of a lab result Zib. If Zibs would be created to support functionalities in this system, Nictiz would be involved in the process. Official Zibs must be understandable for everyone. The infrastructure is separated from this information systems design.

User Guide
PA1 supports the importance of supporting the user in using the system. But questions the role of the platform in this case. The PGO/patient system should take the role of providing the patient with an easy-to-use interface, and thus also with a user guide that belongs to this interface. The decision must be made on where to draw the line of responsibilities. Do PGOs get the freedom to decide on the user interface, or does the platform owner decides on the user interface? Or does it provides specific standards for the interface?

The importance of providing additional information to the patient is outlined by an example in lab values. When lab values differ significantly from the average results, they are marked red in LSP. To a patient, this can result in direct concerns about their health. However, looking closer at the situation from a health perspective, it can be the expected value considering the condition of the patient. Then it should not be an alarming value. Considering the communication system it should be decided where the translation should be made. Is it in the platform? Or do PGOs get the responsibility of translating the information to something

patient-friendly? In case the PGO will have full responsibility for this, user-friendliness will differ significantly for each PGO. In case the message is already translated (if necessary) on the platform, the PGOs will differ less considering the translated information - but there are still other aspects on which the PGO can innovate (for example the layout of the message, or the availability of the multiplicity of languages provided). The trade-off is something essential to consider for the information layer - and the governance supporting the responsibilities within this layer. A trade-off between innovation and value-based (and patient-centred) design.

M.1.2. Discussion Platform Criteria

Simplicity
The design is presented as too complex for the primary goal of the design. PA1 experienced difficulties in following all the lines in the design. Lots of interactions are visualised, which results in PA1 draining in the lines.

Resilience
If it will be too complex, it will always hurt somewhere.

Maintainability
The use of modules supports the maintainability of the design. Dividing ensures that the system will keep working, even when one part is under maintenance. Easy to get components in and out.

Evolvability
It can already be seen that it is evolvable, since for example the review system is something that could be added after the system is already working for a while. If the complexity would be contracted, the evolvability would increase.

M.2. Insights Interview PA2: Platform Architect within Field of Education Institutes

M.2.1. General Insights on the Platform Architecture Design

Functionality and Clarity of the Case
Functionally, PA2 experienced difficulties in understanding. This had to be supported by the researcher. Furthermore, some modules overlap. PA2 advises carefully considering the life cycle of one module. Within PA2's work, the platform management - agreements, procedures and monitoring - would be placed vertically in the diagram.

Structured vs Unstructured Data
The division between structured and unstructured data is made long ago. Structured data includes data directly inserted based on a block-based approach. An example of structured data is the Dutch tax authority, where individuals can only insert data based on drop-downs or structured answer fields. Considering a case handled by the municipality - where a legal expert and architect are involved and asked for feedback - and giving it back to the individual is an example of unstructured data. In this design, PA2 questions what is leading: unstructured or structured data?

Document Management Module
Document management within the domain of software architecture is different from what is meant in this design. In software development, this will indicate for example that all citizens have a personal case in which all documents belonging to that citizen will be stored. Document *management* then includes setting up the system correctly so that all of the citizen's documents end up in the proper case. The decision for document management is thus somewhat confusing.

However, PA2 thinks the intention is interesting. PA2 also experience the idea of code-based labelling in the domain of education. The case PA2 introduced: *The education domain wants to be more flexible by standardising education goals. A number of codes will be linked to a specific course. To obtain a diploma, the student should obtain a defined list of codes - connected to those education goals.* PA2 directly outlines some difficulties with outliers - students with personally different situations - for which the unstructured information in study guides must be considered. Therefore, they are striving to combine the codes with the unstructured data belonging to it.

Platform Management in terms of Agreements and APIs
PA2 argues the importance of managing agreements for each different type of API - do not only consider the technical aspect of connecting the API. The APIs are constructed for different types of complementors and thus need different agreements and settings. Under what conditions do parties join as complementor? what are they allowed to do? What will they receive? What can they send? These questions should be handled in a contract or agreement - for each complementor. This could be automatically arranged - enabling parties to simply agree with the conditions proposed. However, if the contract includes a clause for yearly control on information management, this should be checked - and thus linked to for example a team responsible for managing the agreements/API. Furthermore, the implementation support should be considered. Would there be a team helping the platform complementors to implement? Would there be a legal expert to discuss complex legal complications?

The coupling layer should include agreements with all complementor groups. These different agreement systems should be designed to achieve a ready-to-be-implemented design. Next to the agreements between the platform and the platform complementors, there will also be agreements included made regionally and nationally on the communication.

In the education domain, PA2 (and PA2's colleagues) interpret the coupling layer not only technical but also institutional. The target groups are mentioned, in their case: universities, colleges, national sector partners, municipalities, etc. For all, they include a different agreement framework, including connection conditions.

Access Management Module
Essential to consider who will decide on the identity of the user - and connected party. Who will grant the role? Who will decide on the identity? The BIG registration module can be implemented through an external connection. But, not all the employees of healthcare organisations are BIG registered. Therefore, this system would need a new institutional identity-deciding system. Also, considering the patients' identities it's essential to define who is responsible for the identification: the platform or the patient system? Or an external system?

The medication-based access would be a different case. It would be only available for healthcare professionals, but it would be interesting not only to the HCP with a treatment relationship with the patient. If the medication-based access should also be available for any other registered healthcare professional - yet to be decided who - the communication should be anonymous. And who will be responsible for that? If it is a platform functionality - would it be the platform owner? Or would it be the complementor experienced in making information anonymous? How safe would that be?

Who will be the owner of the patient on the platform? Is it the reacting healthcare professional? Or is it the general practitioner - who is responsible for managing the episode? What will be the flow of the message? Or will it be multiple flows next to each other?

Distinction HTTP/REST
PA2 questions the indication of displaying the distinction between HTTP and REST, since it is instead the technical standards used (overarching the platform). PA2 notes the importance of indicating communication patterns rather than HTTP/REST. The communication pattern would be a three-way handshake, not fire and forget since the functionality of the platform would decrease if the destination would not receive the messages.

M.2.2. Requirement Validation

Requirement 1.1.1.1
The technology-mediated communication tool raises questions with PA2. Namely, how this will evolve over time, looking at the technological developments in communication currently - speech through home speakers, audio messages, and video messages (all unstructured data from nature). Nobody knows what is yet to come, resulting in difficulties considering the user interfaces. Considering the complexity of the platform it is a good thing that the user interface is within the connected parties - currently mainly at the patient side. Ensuring the communication on the platform is adjusted to the preference of speech on the receiving side would resolve this issue in the platform design itself. Thus, structuring the data from a user interface within the complemntors' system would be suitable according to PA2, ensuring the generic form of the data on the platform itself.

Requirement 1.1.1.2
PA2 argues easy access is always a tricky one. The access would definitely be managed in the API. Access to communication can also be something for system suppliers in order to excel. PA2 outlines an essential means of accessibility nowadays. The Self-Sovereign Identity (SSI) wallet. The SSI wallet can be used by citizens to save their credentials - such as marital status, birthplace, email address, and other personal data regularly requested in legal connections with organisations. By saving the data in their SSI wallet, they are able to access the information directly and mostly they are able to convert the information into the answer fields in the form. The emergence of this SSI wallet at the same time results in changing interaction patterns and a shift of responsibilities considering data storage. Is the information in the wallet? Is the information at the University? Do universities exchange your credentials with other universities? Reflecting this on the communication on the platform: Is the message encrypted? When it is not accepted yet by the other complementor, is it stored on the platform? Is it still in the sending complementor? Does the FHIR broker wait with directing the message to the receiver until the complementor is available? A future-proof platform would need a proper debate on the interaction patterns and how they change due to new technologies being part of the platform.

Requirement 1.1.2.2, and 1.1.3.1 until 1.1.3.3
The user catalogue must include a process functionality to achieve this requirement. It should be able to connect patients to HCPs, or the connection between HCP and patient should be delivered by the prescriber on the platform. The responsibilities in supplying the information should be assigned.

Requirement 1.2.1
PA2 mentions the possibility of arranging notifications in a separate notification centre.

Requirement 1.3.1.3
The choice of agreements catalog to manage notifications is questioned by PA2. The agreements catalog could consist of agreements made regionally (to what extent the notifications may be postponed). The settings for incoming notifications can be handled by the complementors' system suppliers. This is still a trade-off to be made.

Requirement 3.2.1.2
Verifying would need process functionality and business logic (for example: this input conflicts with the other input). Verifying the information could also be done by a person or automatically in a system - would be the responsibility of the patient systems.

Requirement 5.1.1
The communication should also be administrated on the patient's side. A use case would be: *a patient calling with a question to the pharmacist. The pharmacist notes the question in the communication system. Then the message should also be directed to the patient (if connected to a patient system)*.

Requirement 5.2.1.1
PA2 argues the complexity of this requirement. Who can see what? How will you regulate this? How do you know the connected HCPs? How to obtain privacy regarding this issue? The treatment relationships will need to be stored on the platform - how will this be arranged to safeguard the data?

Requirement 4.1 until 4.3
The agreements catalog alone won't be sufficient. Probably the platform would need to capture the agreements in a structured way. These agreements can be automatically monitored.

M.2.3. Discussion Platform Criteria

Simplicity
The interaction pattern is not yet clear enough to understand from this overview. PA2 states that for all big commercial platforms, the core interaction is very clear and basal, which makes it attractive for complementors. Functionalities on a platform are added to these core interactions, which furthermore needs clarity of the core interaction. Where is the value creation for all involved parties connecting to the platform? What is the value chain?

Resilience
PA2 mentions the importance of enabling the replacement of functionalities by manual processes. If a component experiences a failure, and the system moves on to the manual process, it should be possible for the actors to add the information to the system retroactively. Especially the system in which the HCP or patient accesses the communication must still work if the communication platform experiences a failure. This would be the responsibility of the complementors' system supplier. Resilience is even more critical due to the national vision of the platform effects. The business continuity plan needs to be created to score better on resilience.

Maintainability
Comparable with resilience: taking one part out should be possible by managing the business continuity. Inside a platform module, the output should be scoped and safeguarded. If new releases from a system are planned, the output of the module/API should still be the same while stabilising the API. When one target group API is changed - do the other APIs stay stable? PA2 mentions furthermore the variety of aspects affecting the maintainability. Questions to be answered to assess maintainability: Is the documentation acceptable? Is there logging on the platform? Is there monitoring? Monitoring should be able to detect suspicious behaviour on the platform. Furthermore, the business process, team management, team responsibility, and more are relevant to assessing the maintainability of the platform.

Evolvability
The fact that the platform is headless is significant for its evolvability. Headless indicates the platform not having a user interface. Fast changes within user interfaces (from web pages to mobile applications to speech options and AI) can be arranged by the complementors' system suppliers. Deciding on suitable separations will realise a proper decoupled system and thus improve possibilities for future developments. Furthermore, a detailed and precise description of the core interaction would support the evolvability. It would not be easier to develop, which could result in system suppliers' resistance, but they now know how to maintain the core interaction. PA2 supports this finding by pinpointing the example of 50 years-old bank systems, being very old and log, but due to the strong core interaction, it did already last for 50 years. PA2 hopes this will also be the case regarding platforms - preferably even longer.

A future-proof strategy would also include a modern API strategy. The API could be adjusted if new information exchange methods become current. The future-proofness of the platform would profit from a strategy enabling this change. Choosing specifically for REST in APIs could have consequences if REST best practices change or other standards become a better choice. Before developing the system, this should be strategically chosen. Choosing standards is an excellent means to come along with the best practices, because standards keep innovating, and the platform must go along with the standards.

M.3. Insights Interview PA3: Platform Architect within Healthcare Organisation

M.3.1. General Insights on the Platform Architecture Design

Clarity of Diagram
Too many lines, not readable enough. PA3 does create complex diagrams, but I had a hard time reading the diagram due to the many lines. PA3 suggests leaving out the systems with [...] and indicating the multiplicity of complementors differently for better readability. Also, the use of the same line for different purposed was experienced negatively by PA3.

Consistency of Terminology
PA3 argues the inconsistency of terminology. The terms module, system, components, catalog, etc., result in confusion about the nature of the described thing.

Also, the name document management module is confusing. In the world of software and IT, document management is interpreted differently. PA3 proposes something like catalog management module.

Process of Module Defining
To PA3, it was unclear where the modules resulted from - which was also not reported in the slides shared with the interviewee. What do you see as a module? The entire life cycle of a module should be defined. The input and output of a module are relevant when using modules to define the platform design. PA3 states that this should be clarified more specifically - from a platform module perspective.

Furthermore, PA3 mentioned using use cases in deciding on the functionalities and platform modules. The use cases could support the understanding of the life cycle of the platform module - where does it begin, and where does it end? PA3 provides an example based on the document management module, as defined by the researcher. The document management module can be interpreted as a black box - consisting of several functionalities. The module will always be a collection of similar activities. Modules are being realised by technologies building the module (systems and applications). Each high-level module should be specified detailed by the components in the module - in the case of the document management module the agreement catalog and the communication code catalog. Each module should consist of (1) the goal of the module, (2) the performance indicators of the module, and (3) the necessary systems of the module.

PA3 criticise the granularity used in the platform modules since they now result in functionalities necessary for multiple modules. Supported by the example: the user catalog, which will be needed by the FHIR broker even as the financial gateway.

The switch from modules to specific coding does need more guidance. PA3 advises to get a proper overview of the modules. Starting with the modules - without details (describing the standards etc, would be good). Then define which information is exchanged between those modules. Example with the user catalog (PA3 advises a new name = identity provider): incoming information consists of the willingness to login, and outgoing information consists of a claim. This claim is a security means for logging in.

Abstraction Level
The abstraction level should be based on the goal of the diagram. To the participant, is was unclear what the goal of the diagram was. This was due to the mixed approach of layers. To increase the clarity of the diagram and the decision for any abstraction level, this goal should be more clearly described.

The distinction between HTTP and REST is not applicable at this abstraction level. This would be determined based on the technical layer. This abstraction level mainly focuses on the information and business layer - no need for HTTP/REST distinction. Also, PA3 mention the fact that HTTP is essentially a REST API, but follows a protocol. The distinction was originally made due to the use of FHIR - which is a standard based on HTTP. The modules primarily focus on the information layer, while the platform design also tries to touch upon IT. The connection between the described modules describes the information. It's an excellent choice to mention the communication protocols, but they don't belong in this diagram according to PA3. PA3 suggest an information layer approach - connecting the modules and looking into these information layers in more detail considering the technology.

Differences in abstraction are present in the Archimate language and would be a good idea to integrate them into the design - despite the fact that the Archimate language is hardly understandable to less-technology-focused people. The layers can provide a clear overview and connection to the modules - underlying components - and the business interaction. Mainly the first two layers of Archimate would be relevant. PA3 argues that the bottom layer won't be reached with the abstraction in which modules are constructed now. This bottom layer will always be possible due to the multiplicity of options to obtain the desired connections. The complexity in the top layers does make it more complex - which indicates the relevance of clearly defining the user interaction in the top layers.

Use of FHIR and User Catalog
The FHIR broker does not exist, this needs to be made during the platform development. The FHIR broker will handle the message. But what does handle mean? That needs to be designed. Questions arise considering the task list of a FHIR building block. Does FHIR send the message directly to the receiver? Does FHIR send a confirmation message to the sender directly? Or does FHIR wait until FHIR receives a confirmation from the receiver before sending the confirmation to the sender? All these procedures should be decided on and defined during the platform development. Also, defining the destination is a set of procedures to be defined. To whom will the message be sent? Will it be directly to the complementor? How to address the right complementor? Or does it need to be sent to a queue? For how long will it be there? What type of connection does FHIR need to create with the receiver? Fire and forget? Three-way-handshake?

It is, however, possible to use already existing FHIR building blocks, for example, HealthProfessional - an existing information building block with the aim of documenting the identity of people providing healthcare (for example, based on UZI or AGB number). The HealthProfessional block can be connected to the user catalog in this platform to arrange to direct the message to a particular HCP. The functionality of redirecting is part of the FHIR broker, but the address book should be a separate system. There is already an address book available from VZVZ (Dutch: *Vereniging van Zorgaanbieders voor Zorgcommunicatie*). If the address book

is created in the platform development itself, it should also be maintained by the platform owner/responsible for that part - which PA3 sees as undesirable.

The researcher brings up the not-yet-identified HCPs that will need access to this system (such as practice employees - who will be able to answer some practical questions). In case the communication should also be possible to be received by assistants (which is expected in this case), there is a need for an additional registration system for those not already BIG registered. If the sender is deciding to who the message is to be sent - the list of possible receivers should be available to the sender. If this would be the use case, the platform should include a clause in the agreements which states that the complementor is obliged to update the user catalog automatically when new employees start working in the organisation.

Considering the task list of FHIR, the following is also mentioned by PA3. What does FHIR do when it receives a message? If only "put it on a queue" is defined, then that final destination is also the performance indicator seen by FHIR. The performance indicator should be defined correctly - according to the user interaction use cases. For example: *if the message is on the queue, send a confirmation message to the sender*. Or do you want to send an additional confirmation notification when any AIS/HIS adopts the message?

Considering the use of FHIR for response statistics, the following was discussed. FHIR receiving the message and passing it through is, however, not capable of also saving the time needed for answering the message. Giving signs to a sub-system in the platform can be a task given to the FHIR broker (which should also be developed by the platform owner/another party). The signs should be shared with a separate system aggregating this information into usable statistics for the user awareness system. Other systems could then plug in as well.

Defining Roles and Rights
The roles and rights of each individual or organisation connected to the platform should be integrated into the design. Now, the user catalog seems to tackle it all: users, address book, roles, etc. But it can increase overview if this information is regulated separately. Technically speaking, all this information could be in one information system. However, since multiple applications would need to access the roles and rights, the address book, or the users separately - it can be beneficial to developers in terms of clarity and maintainability.

Failure Management
The platform design needs further research or descriptions of use cases. Use cases provide insights into how the system responds to different types of situations, expected and unexpected. What if a message is directed to a GP, but the user catalog doesn't provide that GP anymore? What if that colleague is just fired and thus deleted from the system? Should fire HCPs stay in the system for a while? How would you communicate the absence of an HCP to those that wanted to contact that HCP? Where is the message being stored in these cases? What are the requirements when the HIS or AIS is offline? What if the platform is offline? Should the FHIR broker still accept messages from the sender?

Failure management needs a new managing module - for monitoring and sending back messages. Using a *queue* to drop the message before directly sending it to the receiving party would be a good means for handling the failure process.

Putting Messages on a Queue
The queue is not only proper as a means to handle the failure processes of the receiving party. The queue enables temporarily saving messages, which is a means for sending the message to multiple HCPs (in case the patient provides multiple destination HCPs). In that case, PA3 mentions the importance of regulating privacy. When a patient sends a picture/question to multiple HCPs using different systems, and they directly receive the message, this would cause problems. What about the patient's privacy when messages are stored in all HIS/AIS? What happens when two HCPs are handling the message at the same time? What about the financial reward if two HCPs declare the same message? It could be possible to notify other HCP systems if one HCP is already handling the matter based on a notification sent by the system of the HCP handling it. But this would increase the number of notifications, which is undesirable. This interaction must be foolproof.

The message could be stored on the queue/or another lock-in means, while a notification with metadata about the message is sent to all destination HCPs notifying the HCP about the 'waiting' message. When one HCP wants to handle the message - they can access the queue. Then the other HCPs will be notified that another HCP is already handling the message - the metadata could be adjusted based on that. The following questions should be answered when saving these messages on a queue for this purpose. How long will it be stored in the queue? Who can access the message on the queue? What notifications are sent to update the other HCPs? What information is already sent to the HCP in the notification stating that the message is waiting? Do you mention how many HCPs are receiving the message? What if no HCP handles the message in a defined amount of time? How long do you want to wait? How to ensure the privacy of the message in this queue/lock-in?

Auditing
PA3 mentioned the importance of auditing in the platform, especially when multiple HCPs receive the message. According to NEN5710, patients must be able to know who entered their information, so auditing is a mandatory platform management functionality. Who entered what file at what moment? PA3 knows pharmacists do not care intrinsically for this auditing, but this does not mean it's not mandatory. The traceability of a message should be fundamentally arranged. A cross-cutting concern of the platform.

Structured vs Unstructured Data
The distinction between structured and unstructured is crucial, according to PA3. The platform does not work when only unstructured data is transferred through the platform. Metadata is always needed when sending a message from one system to another. The message will include metadata based on numbers (unique user IDs, etc.) to ensure anonymous metadata. The APIs of the platform would also need to oblige that to the platform complementors - handing in the message structured with the correct metadata.

Unstructured data would be possible, for example, speech-to-text in case the sender wants to record the message. However, the translation should be regulated somewhere - and it can be difficult. For example, considering the naming of specific HCPs: if the sender records a name to which the message should be sent, how do you ensure that the correct receiver will be addressed? How accurate is the translation? Will there be feedback from the complemntors' system? There are still some failures in this process nowadays (when Siri does misinterpret the message). However, according to PA3, this is clearly outside of the platform - with the complementors. However, the information needs to have generic nature - accepted by the platform.

M.3.2. Requirement Validation

PA3 supports the idea that technically regulating connections between information systems would always be possible.

Requirement 1.2.3
Adding other medical specialists need additional rights and roles. How do you announce that other medical specialists enter the system? Do you send an update through a notification? Wouldn't that increase the pollution of an information system (as also indicated from the HCP perspective)?

Requirements 1.3.1.1 until 1.3.1.3
Do you want to incorporate that into your platform? The API is part of the platform. The platform owner provides the API to which complementors can connect. In an API, it is regulated that the complementor is allowed to send things to the platform, and the platform sends things to the complementor - following agreements. If the platform is connected to the APIs of the complementors, this would be annoying since every complementor has different APIs. Furthermore, it is far from efficient if the platform handles the notification regulation. A supporting example: *A HCP is away from 10:00 to 12:00 and wants to switch off the notifications during this time slot. If the platform regulated this, this would mean that the platform should have additional information, for example, on the time zone. The platform should check for every notification if it is possible.* PA3 advises to leave that out of the platform, and send everything.

Requirements 1.3.2.1 and 1.3.2.2
Interactions within these feedback requirements are complex. Obtaining complete anonymous information is a study on its own. How do you ensure anonymity if a patient sends a picture from a head? How do you ensure anonymity when a patient accidentally drops a phone number in an unstructured message? Do you incorporate this within the platform? Or do you leave this to the HCP who wants to obtain feedback on a specific situation? Leaving the responsibility with them would enable them to create an anonymous and meaningful (since they are asking for feedback) message, which they can send to other HCPs. They know what is relevant for other HCPs to give feedback, which makes it sufficient to leave that to them.

Requirement 3.2.1.2
How to verify this on the platform? It is possible to set expectations or requirements for certain information, but the user interface in the patient systems would be the better party to do that. It would also be beneficial to connect the communication system to the list of medications available on a patient's portal. Then the communication would be directly linked to the medication, and metadata can be easily added.

Requirements 3.2.2.1 and 3.2.2.2
The response statistics considering time and content would not be possible to regulate only by the FHIR broker. The FHIR broker could give a sign to another system when receiving and sending messages - but it cannot store or aggregate any information. The signs should then activate the FHIR broker to send a sign to a separate system. This separate system then aggregates the data to an overview per HCP/HCO on the response statistics. The signs and notifications must be linked to the same unique ID - to ensure the data ends up in the suitable aggregation.

Requirements 2.1 until 2.3
The FHIR broker won't be enough to handle these requirements. It also needs the user catalog including the roles, addresses, etc. PA3 sees access management more as destination selection - enabling directing the message. The access is already arranged within separate systems. The sender would get a drop-down menu to specify the receiving party (or parties).

Requirement 1.1.2.1
PA3 argues the complexity of the financial system. Who decides on the financial reward? It would need additional research. PA3 also mentions the insurance companies and how declarations currently work. Declaring something for a patient with which the HCP does not have a treatment relationship is complicated. A patient's insurance information should be gathered to construct the declaration (insurance policy number). Gathering this data is possible through COV (Dutch: *Controle op Verzekeringsgegevens*), but needs the BSN of the patient - which is difficult regarding privacy.

Requirement 5.2.1.2, 5.2.2, 5.4.2
PA3 supports the idea of separating user awareness. Again, the question arises: should this be part of the platform? Is your platform headless? Or does it include a user interface? No, then it should be the responsibility of the platform competitors. If the unstructured speech message should be available for the receiving party - instead of a translated structured version - then the platform should support transferring this unstructured message. Unstructured messages in healthcare is a study on its own, especially when considering X-rays (could be 100 Megabytes). How do you arrange this? Do you want the receiving party to also listen to the speech message? How will the validation be done? To what extent do you want to accept all this information?

Requirement 5.1.1
HCPs want asynchronous communication, but patients want to choose their communication (calling). PA3 raises questions about the storage of communication. Do you want a phone call to be stored? Is that part of the idea? Does this mean the system should store the communication endlessly? PA3 argues for deleting the communication after the matter was assessed as answered by the sender. Then, the responsibilities for storage would be within the storage system.

M.3.3. Platform Criteria

PA3 has a critical perspective on using these platform criteria due to the difficulties in assessing the criteria on this abstraction level. The information layer could have additional blocks connected. However, it could be that the functionalities of the application and infrastructure change - and thus affect the platform criteria even more. A firm statement can be made if also this layer is fully present in the design.

Simplicity
High-level abstraction is apparent to PA3. Interactions regarding the information would support clarity, for example, in an activity diagram. The use cases - discussed in this interview - can support the clarity of interactions. These use cases are more complex and need further insights.

Resilience
Interaction patterns do belong to resilience. How to regulate communication? What if something is not working? Which interactions do work? Which ones don't? What does a PGO do? Would they need temporary storage? Or do you accept that a subsystem can always drop a message on the platform, which is then temporarily stored on the platform? How are you sufficiently available to connected parties? To be able to elaborate on this continuity plan, more insights are needed. Also, non-functional requirements are involved then.

Maintainability
Hard to assess. PA3 mentions the importance of availability for this criterion. How do you ensure the platform is always available? This would need more insights in the architecture/application layer, including many additional connections. For example, to divide the load on different servers. PA3 supports the idea of using APIs. But mentions the question: How do you ensure changing one API would not cause the other API to stop working? The use of FHIR is suitable for maintainability since it is versioned.

Evolvability
Yes, APIs are easy to expand. FHIR is also easy to expand. Market standards are good for evolvability since they evolve by themselves. Keeping up with these market standards supports evolvability.

M.4. Insights Interview PA4: Platform Architect within Production Domain

M.4.1. General Insights

Clarity
PA4 assesses the architecture as comprehensible. The architecture was easily understandable - supported by the introduction of the researcher. Only the researcher proposes to add labels to every arrow in the system since PA4 learned that this is necessary when building an architecture.

Defining Layer Approach
PA4 pinpoints the importance of describing the layered approach by defining the purpose of each role. The interaction layer could be the business, while the business layer could be the business processes. The platform could then add the business layer (grey layout). Why these layers? What is the responsibility of the layers? PA4 thinks people insufficiently realise the stability of choosing a layered architecture approach. The more you go down in the architecture, the more the architecture is expected (or should be) to be stable. A layered approach has a specific dependency character - meaning that the top layer depends on the layer underneath. This would indicate, again, that the bottom layer should be the most stable. Is it?

The technology layer, in this case, misses lots of components. Only the most critical technologies - directly supporting the system's functionality are presented in the architecture design. Since the technology layer is not covering all technologies needed to support the information layer, it is questioned during the evaluation how to follow the layered approach, while currently, the technology layer is not the most stable. PA4 states: if the technology is an enabler - as in this architecture - you could think of the following. Is it the lowest layer of your solution? Or do you abstract from the technology layer using well-defined APIs to my information layer? Resulting in resilience to new technologies. Ideally, for every component, there should be an additional API. Concluding, PA4 is proposed to prevent the wrinkle effect, meaning changes in a lower layer needs adjustment on a higher layer.

M.4.2. Requirement Validation

PA4 asks for the prioritisation of the requirements. The researcher discussed that the prioritisation was done but neglected in the case of the platform design. There was no time to discuss all of the requirements independently.

M.4.3. Platform Criteria

The description of maintainability is close to evolvability according to PA4, which is a little confusing.

Simplicity
PA4 understands the architecture design after an explanation of 5 minutes and thus assesses simplicity as good. According to PA4, the semantics of the arrows should be defined explicitly. The responsibilities of a component in the solutions should be clear.

Resilience
To improve the system's resilience, scenario development could be added to the architecture design description. PA4 mentions the term graceful degradation. Graceful degradation is described as the ability to maintain limited functionality, even when a large proportion of the system fails (resilience in the system).

Multiple possibilities to improve resilience. First, considering the technology components, they must be executed redundantly, meaning multiple times. If something goes wrong, then it should still be working. This part is not visible, looking at the architecture. Secondly, do other systems still work if parts of the system fail? For connected users, the system does not work if it fails. PA4 proposes substitutes for every system to answer the question: what if system A is not working?

Maintainability
PA4 outlines the duality in maintainability. First, preventive maintainability, and second, corrective maintainability. Platform management processes positively affect the maintainability of the system.

Evolvability
Using the APIs between the technology and information layer would be an improvement considering the evolvability of the architecture. Furthermore, again, scenario development will be helpful. Scenario development considering new functionalities is needed to assess the evolvability. Should a new component be added? Or should the existing component be adjusted?

N

Platform Design Iterations

This Appendix shows the different iterations of the platform design. The design choices considering these versions are also shortly addressed.

Figure N.2 shows the first version of the platform design, discussed with PA1. The first design did not include the Archimate language or a layered approach because it was expected to be out of the scope for achieving the design goal: the platform architecture design should be clear for everyone at a high abstraction level. The first design was based on the following literature.

Communication
The benefits of asynchronous communication were identified by participants in this research and the literature. Jhala and Menon (2021) researched their platform enabling asynchronous communication within hospital operations and found a statistically significant difference in time for average task completion between using- and not-using Medic Bleep, a solution for communication challenges. Medic Bleep is an example of an internal communication tool where colleagues can discuss easily and asynchronously with each other. The message protocol should include multiple endpoints since one sender can send the message to multiple actors. In IoT applications/platforms, messaging protocols is an essential part of the platform. Messaging protocols support IoT platforms in terms of real-time communication between users.

IoT and UDP/TCP
Frank (2023) described some practical possibilities for creating communication between users in a system. IoT enables communication between devices, applications, and the cloud. An IoT ecosystem could be described using the ISO layers. The role of the transport layer is to support end-to-end communication in a network. The protocol used in IoT is TCP/IP or internet protocol. This protocol includes two types of traffic: User Datagram Protocol (UDP) and Transmission Control Protocol (TCP), of which TCP would be the most suitable for communication within healthcare systems since UDP is not intended to guarantee delivering the message to the sender. Examples for which UDP is used are real-life television or radio connections. On the other hand, TCP is based on a three-way handshake connection between two nodes in the network and can, therefore, guarantee the delivery of the message (Kumar & Rai, 2012). The three-way handshake uses message acknowledgement and re-transmissions in case packages are lost.

UDP does provide a more suitable solution for time-sensitive situations. Of course, it would be beneficial if messages do not take a decade to arrive at the destination, but it's not a time-sensitive communication. Additionally, the communication tool is intended to support asynchronous communication since real-time communication (call) is insufficient due to planning issues within healthcare organisations.

A disadvantage of TCP is the high power consumption within the system. This is due to the three-way handshake ensuring the packages are delivered. The three-way handshake does support reliability and handles congestion control. TCP transmits the segments to the destination in the order they were sent. TCP can order the messages correctly if they arrive differently due to network performance. The idea of a network (as the internet) would be that there are so many connections between different nodes there is always another path to transmit any message or connection. This would also result in messages entering at different moments. To categorise all the messages in the correct order, it is necessary that the messages are sorted in the correct order (Kumar & Rai, 2012).

AMQP
V1 of the platform design still included an AMQP broker as a message broker. A couple of criteria are relevant to decide on the messaging protocol. This is privacy and security, compatibility and scalability, performance, implementation and reliability. In this case, messaging in healthcare-related content would need high privacy and security means.

- Privacy and security: since sensitive information will be shared among the users, this is a critical criterion for deciding on the messaging protocol. A messaging protocol with end-to-end encryption is therefore necessary.
- Compatibility and Scalability: The communication must be compatible with multiple devices. To improve the availability and access to communication, communication should be also available on patients' mobile devices, healthcare professionals' mobile devices, and information systems (mostly running on computers within a healthcare organisation).

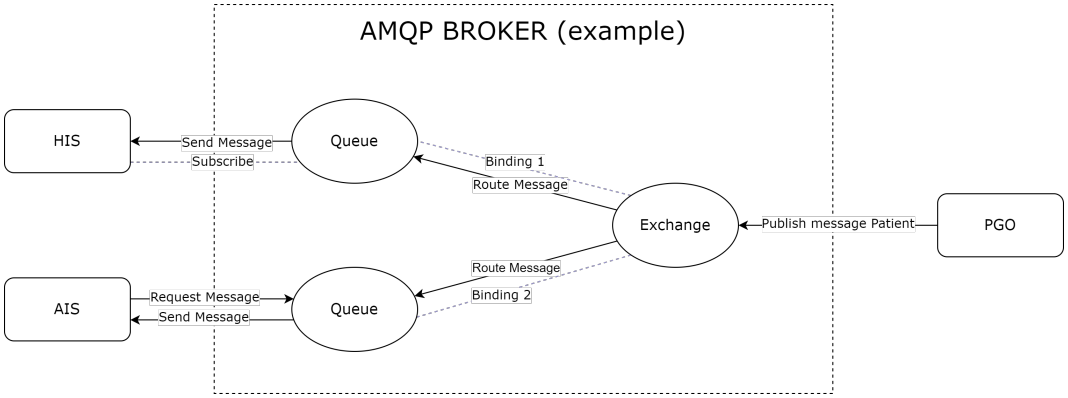


Figure N.1: Proposed AMQP Working on the Platform

- Performance: real-time performance of an enormous amount of messages is not the case within the thesis scope. Since the communication tool would substitute for patient visits, calls or emails, or calls/meetings between healthcare professionals, none of those communication means (except for the conversation itself (disregarding the time-consuming process of looking for that person)) enable real-time information exchange. Furthermore, the availability issues of healthcare professionals (they are in meetings, etc.) indicate that there won't be any need for real-time information exchange considering questions for the care process. The questions can wait a little for an answer.
- Implementation and Reliability: However, implementation and reliability are essential to motivate software/system suppliers/providers of involved platform actors. The communication should be integrated into currently existing systems, and the earlier mentioned platform modules do need integration - and thus adjustments in the current code-base. Choosing a messaging protocol that is easily compatible with the rest of the system would be beneficial. Furthermore, it would affect the system's effectiveness/entire idea if the message would not arrive at the destination. Therefore, reliability is critical.
- Concluding: The most important criteria for the messaging protocol are privacy and security, compatibility, scalability, reliability and implementation.

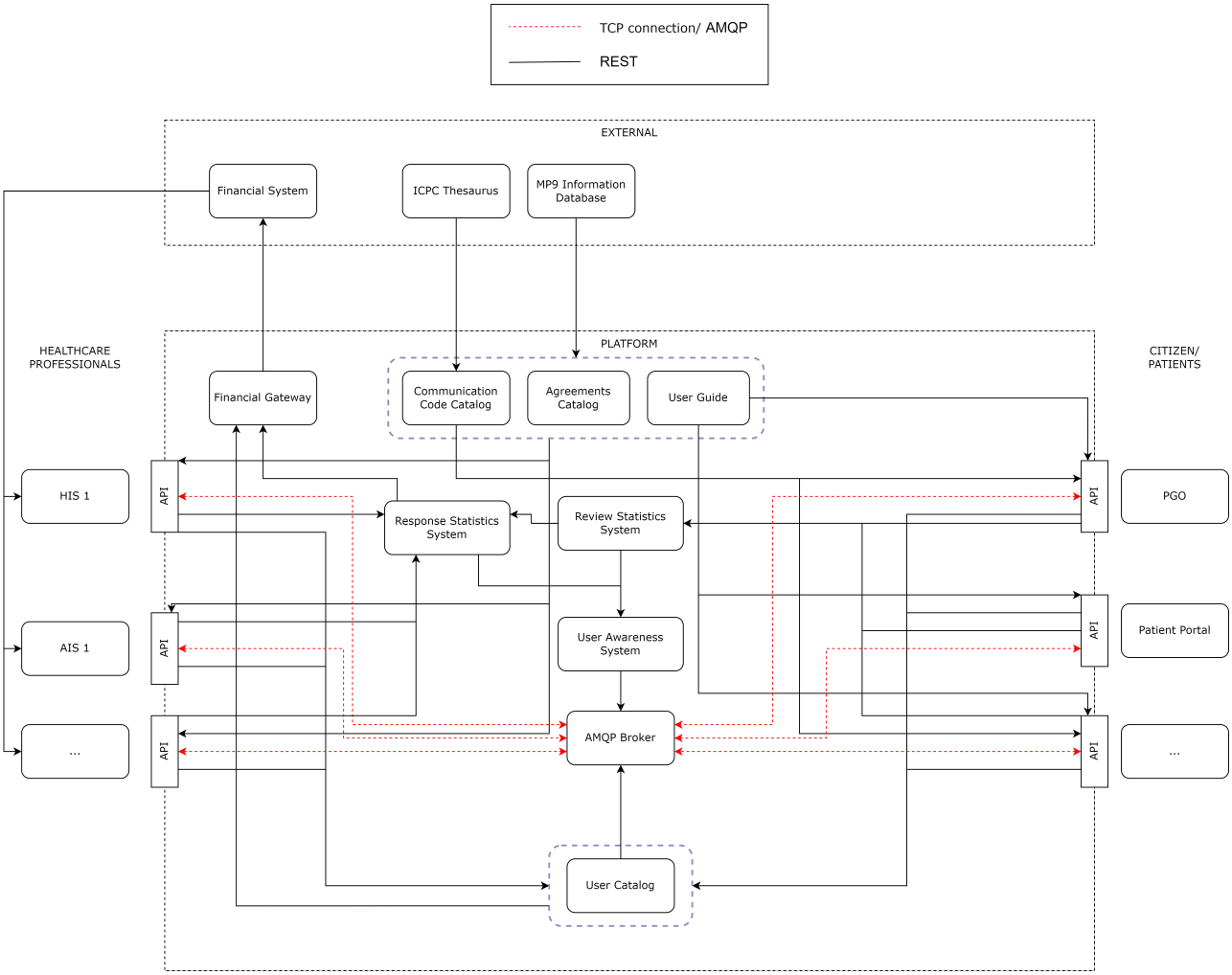


Figure N.2: Design Platform Architecture V1

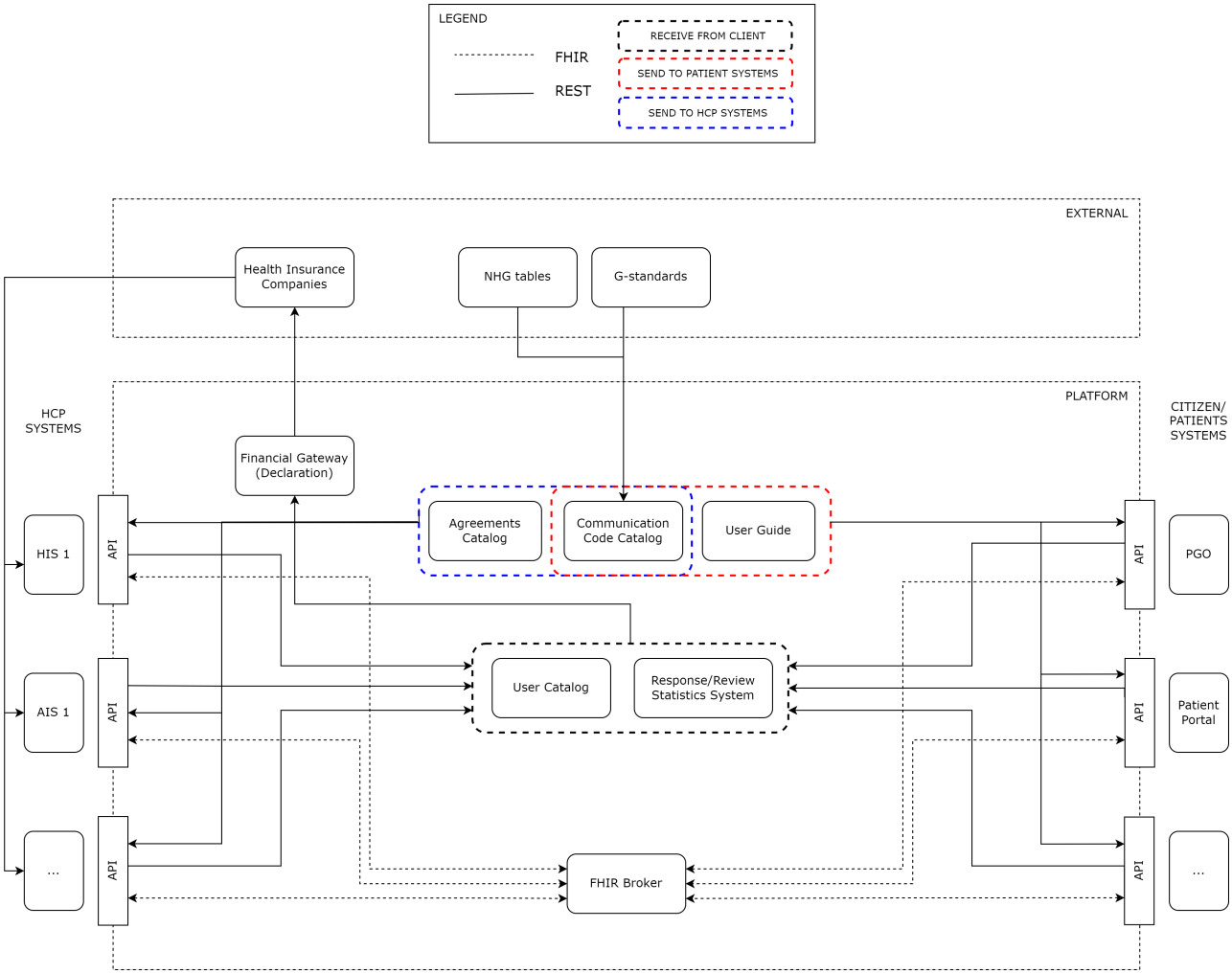


Figure N.3: Design Platform Architecture V2

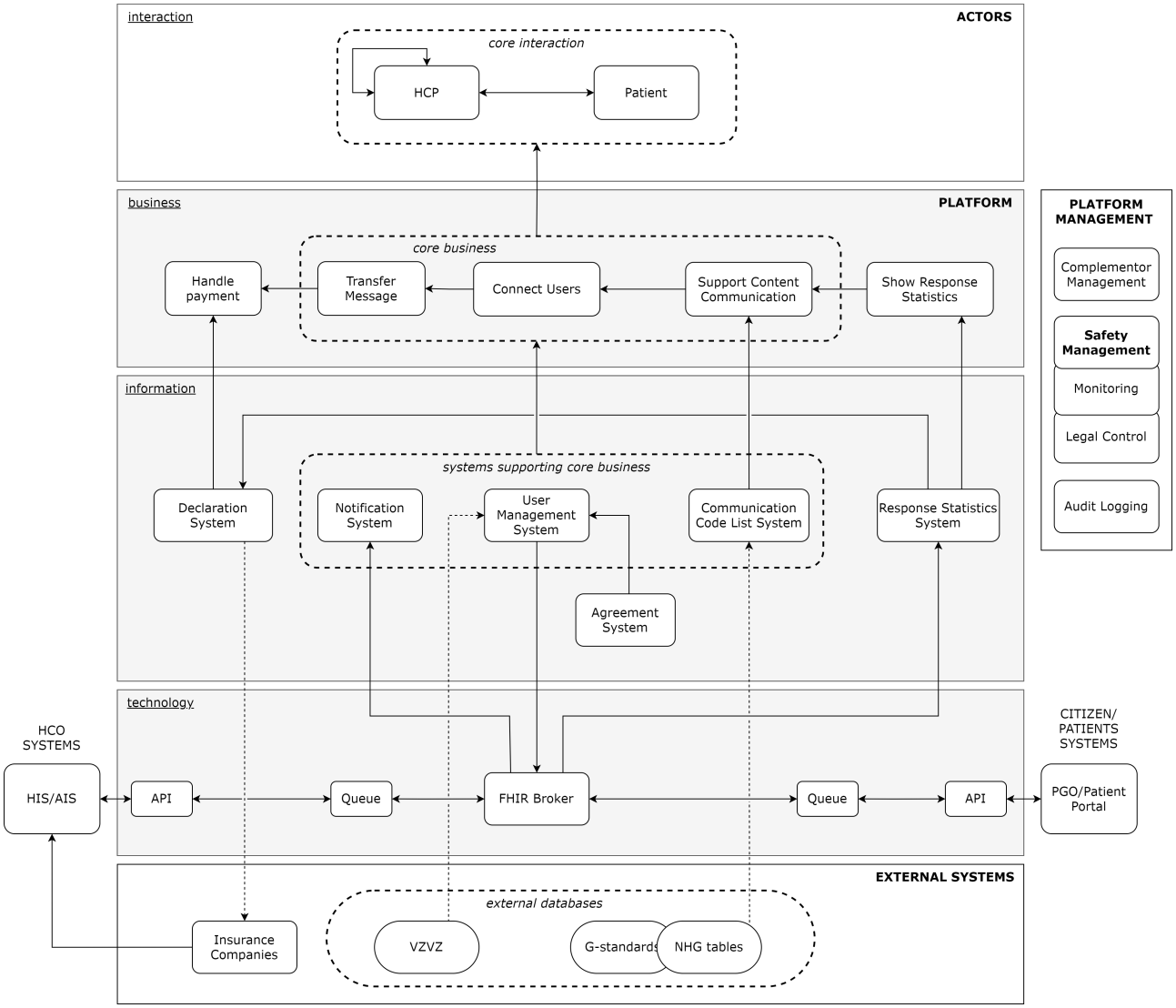


Figure N.4: Design Platform Architecture V3