Smarter prehospital triage

Integrating user needs into workflow design for the SMART Triage platform

Graduation report
MSc Strategic Product Design
February 2025

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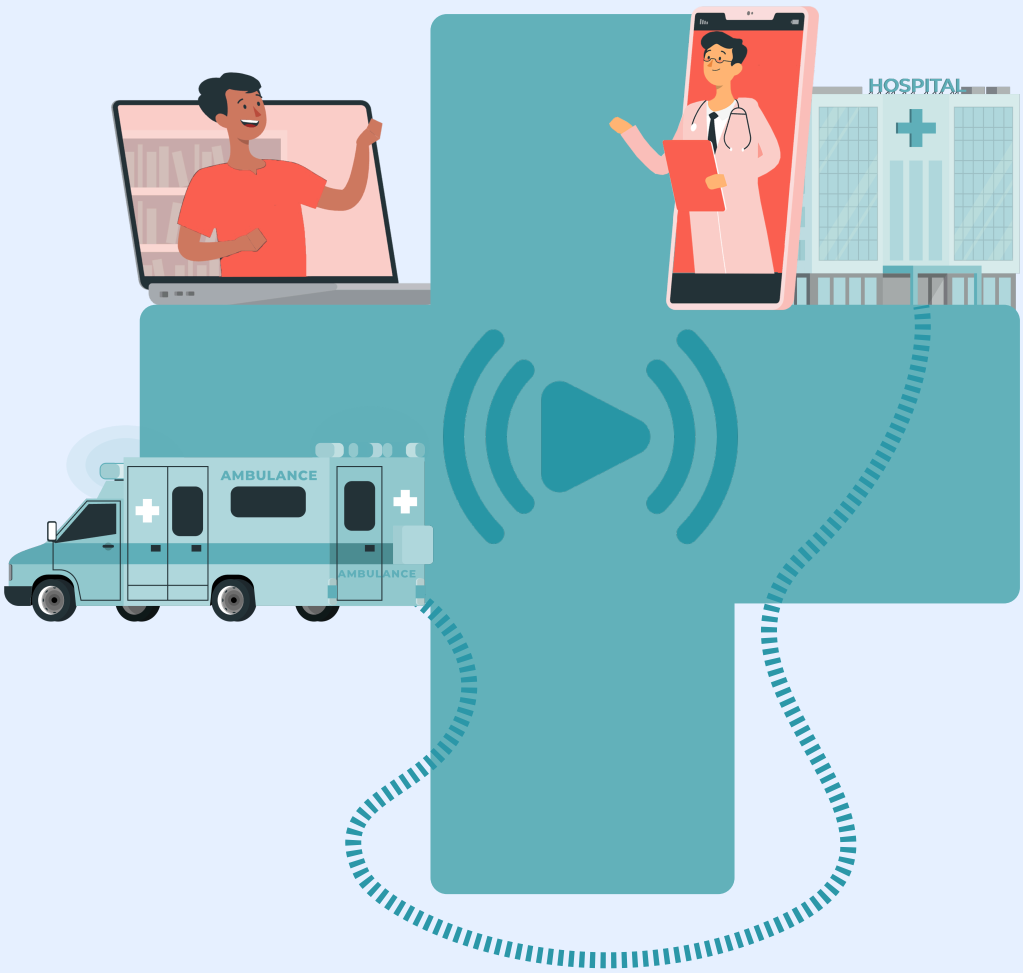
Industrial Design Engineering



TU Delft

LUMC Leids Universitair Medisch Centrum

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Master Thesis

MSc Strategic Product Design

Faculty of Industrial Design Engineering

Delft University of Technology

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February 2025

Foreword

My interest in combining design with healthcare led me to start this project in September 2024. I have always enjoyed working on initiatives that contribute to society in a meaningful way, and when this opportunity came along—with the possibility of the results being implemented in real-world practice—I was immediately excited to take on the challenge. The idea of contributing to tangible improvements in Dutch healthcare kept me motivated, even during the six intense months of hard work on this thesis.

Throughout this project, I had the unique chance to meet many inspiring people, including physicians, ambulance personnel, and other people working on similar teleconsultation initiatives. I would like to thank Sophia and Meys, my supervisors at LUMC, for putting me in contact with these people and for believing in my contribution to this project. Your insights and tips, particularly regarding medical terminology and healthcare practices, were invaluable in navigating a field that was largely new to me.

I would also like to thank Valeria and Fredrik, my supervisors from TU Delft, for their invaluable feedback and support. Your expertise in healthcare design not only helped me stay on track but also encouraged me to reflect more deeply on my own work - a skill that became an important learning point during this project. I really appreciated our discussions and the mix of encouragement and constructive advice. A special thanks to Fredrik for dedicating time every week to schedule a meeting with me and review my work carefully—it made such a difference in keeping my project moving forward.

Lastly, I want to thank my family, friends, and boyfriend for all the support and fun times throughout my student years. It's a big chapter I'm closing now, but I'm looking forward to starting the next chapter in my career!

Enjoy reading this thesis, and feel free to contact me if you ever want to discuss on the topic!

Executive summary

Acute care in the Netherlands is under significant pressure due to increasing demand, growing complexity, staff shortages, and rising costs (Kingma & Roukens, 2023). Adjustments to the acute healthcare system will be necessary in the coming years to maintain high-quality care and reduce the pressure on the system (Ministerie van Volksgezondheid, Welzijn en Sport, 2022).

In response, the Leiden University Medical Center (LUMC), in collaboration with other hospitals and healthcare institutions across the Hollands Midden region, initiated the SMART Triage project (SMART Medical Applications for Regional Triage Use). This project aims to enable real-time visual and audio communication between ambulance personnel and physicians during pre-hospital triage.

While the rationale and objectives of the SMART Triage project are clearly defined – *Why*: to improve acute care during pre-hospital triage, and *What*: a platform facilitating communication between ambulance personnel and physicians – the definition of '*How*' the platform's design will look and *'How'* it will integrate into user's daily workflows still requires further exploration. Critical questions include how the platform will be integrated into existing working routines and how users will interact with the new technology. Defining these elements is crucial for ensuring the platform is functional and user-centered.

As a service designer, I will address the "*how*" to work with SMART Triage, focusing on designing and integrating the platform into daily workflows.

To determine the design and integration of the SMART Triage platform, thorough research was conducted. Chapter 2, *Research*, outlines the necessary knowledge of pre-hospital care and ambulance workflows. Additionally, (international) teleconsultation initiatives were studied to learn from their experiences. User research in the form of interviews was conducted to gain insights into the needs and expectations of the SMART Triage platform.

With these insights, the Design Phase in Chapter 3 could begin. Findings from Chapter 2 were used to map the platform's functionalities and user values. Collaboration with the IT department helped distinguish between functionalities for Phase 1 (2025-2027) and Phase 2 (>2027), resulting in Service Blueprints (SBs) for each phase. To complement these, application interface designs were created to define specific interactions between the user and the technology.

Chapter 4 focuses on validating and refining the SB and interface designs. The SBs for Phases 1 and 2 were reviewed with the IT department to assess the feasibility of the platforms' functionalities and then validated with end-users to increase the desirability of the platform. Interface designs played a key role in the validation sessions, offering a visual, tangible way to test and adjust the design of the platform. Based on user feedback, both the blueprints and interface designs were iteratively improved, resulting in a finalized design ready for service development in 2025. Chapter 4 concludes with a refined SB and interface designs.

To strengthen the future vision of the SMART Triage platform, a tactical roadmap was created in Chapter 5. This roadmap offers a high-level overview of the implementation scale and the technology rollout for the platform. It ensures that functionalities are introduced at the right time and serves as a communication tool for all stakeholders involved in the SMART Triage project.

Finally, Chapter 6 discusses potential risks that could affect the platform's implementation, outlines unaddressed research directions, and provides future recommendations to guide its continued development and deployment. This chapter concludes with a reflection on the use of service design in the context of SMART Triage and the project's contribution to advancing digital health implementation.

Abbreviations & Glossary

BSN	BurgerServiceNummer (Citizen Service Number)
ED	Emergency Department
EPD	Elektronisch Patiënten Dossier (Online Patient File) - This is a local file in which hospitals maintain patient records.
EHH	Eerste Hart Hulp (First Heart Aid)
GHZ	Groene Hart Ziekenhuis (Groene Hart Hospital)
GP	General Practitioner
Hartc1.0	Hollands-midden Acute Regionale Triage Cardiologie - audio consultation system connecting ambulance nurses with cardiologists, implemented in the Hollands Midden region.
LUMC	Leiden University Medical Center
NAZW	Netwerk Acute Zorg West
PreVis	Prehospital Video i Samhandling project - a teleconsultation initiative in Norway
RAV	Regionale Ambulance Voorziening (Regional Ambulance Services)
SB	Service Blueprint
SMART Triage	Smart Medical Applications for Regional Triage Use
VPD	Value Proposition Design

Ambulance care professional	A reference commonly used at RAV Hollands Midden for ambulance personnel, including both the ambulance nurse and the ambulance driver. This term reflects the higher level of training compared to a paramedic in the Dutch context.
Ride urgencies	Urgent = A1 ride, the ambulance arrives within 15 minutes. Less urgent = A2 rides, the ambulance arrives within 30 minutes. Non-emergency = B rides, ambulance arrives within 1 hour.
Triage	Triage involves assessing the urgency of a patient’s need for care, meaning the triage professional determines how quickly a patient requires examination and treatment. Subsequently, the triage professional decides on the most appropriate treatment. Triage occurs at multiple stages, including by ambulance personnel, ED staff, and physicians.

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01 Introduction.

1.0 Introduction

To introduce the project brief, it is essential to understand what the SMART Triage platform is and why its implementation is desired. This chapter provides background information and outlines the goals that need to be achieved by the SMART Triage platform. Furthermore, this chapter highlights the expected impact the platform will have in the years following its implementation. The chapter concludes with a description of the assignment for this thesis.

1.1 Introducing the SMART-Triage project

1.1.1 Rationale for SMART-Triage

Where ambulance care was once primarily focused on acute and life-threatening situations, numerous factors now influence its evolving nature. Demographic shifts, such as an aging population, significantly impact the growing demand for care (Ministerie van Volksgezondheid, Welzijn en Sport, 2022). Simultaneously, the threshold for calling 112 has lowered, leading to more frequent calls for ambulance assistance (NAZW, 2023). Additionally, General Practitioners (GP) are increasingly assisted by ambulance personnel, and patients' expectations for service and care quality have risen in the last years (A2, interviews).

All these factors result in ambulance personnel increasingly being dispatched to situations that do not involve acute emergencies where the necessary care can be quickly determined. This creates additional challenges for ambulance nurses in making on-site diagnoses independently. As a result, patients in such cases are often transported to the emergency department (ED).

Projections show a sharp increase in ambulance rides and ED visits in the Hollands Midden region over the coming years. By 2040, the number of Regional Ambulance Services (RAV) rides is expected to rise by 31% compared to 2023, and ED visits are predicted to grow by 25% (Sneijder, 2024) (see figure 1). Important to note is that not all ambulance rides result in ED visits (think about interhospital transfers), explaining the difference between these numbers. The predicted growth builds upon an already elevated level of ED visits in 2022, which were 19% higher than in 2015 (NAZW, 2023).

Another pressing concern in healthcare is the shortage of health personnel. Current forecasts suggest that this shortage will continue over the next decades. By 2029, the healthcare sector is expected to reach a critical limit, as one in six workers will be employed in healthcare (NAZW, 2023). This level is considered unsustainable. Reducing the demand for labor is therefore a significant challenge, and SMART Triage can play a role in addressing this.

Given the challenges posed by an aging population, the increasing complexity of care, and a shortage of qualified staff, new agreements and initiatives are urgently needed to maintain accessible, high-quality acute care.

1.1.2 The goal of SMART-Triage

Before the start of this thesis, the objective of the SMART Triage project had already been defined. The information in this subsection is therefore derived from internal project team documentation like the tender application submitted to health insurers.

The goal of the SMART Triage platform is to allow ambulance personnel to have a remote consultation with a physician in cases where there is uncertainty about whether a patient should be transported to the hospital or can safely remain at home. Currently, when in doubt, patients are always taken to the hospital, which results in many patients transported to the ED who do not necessarily need to be there.

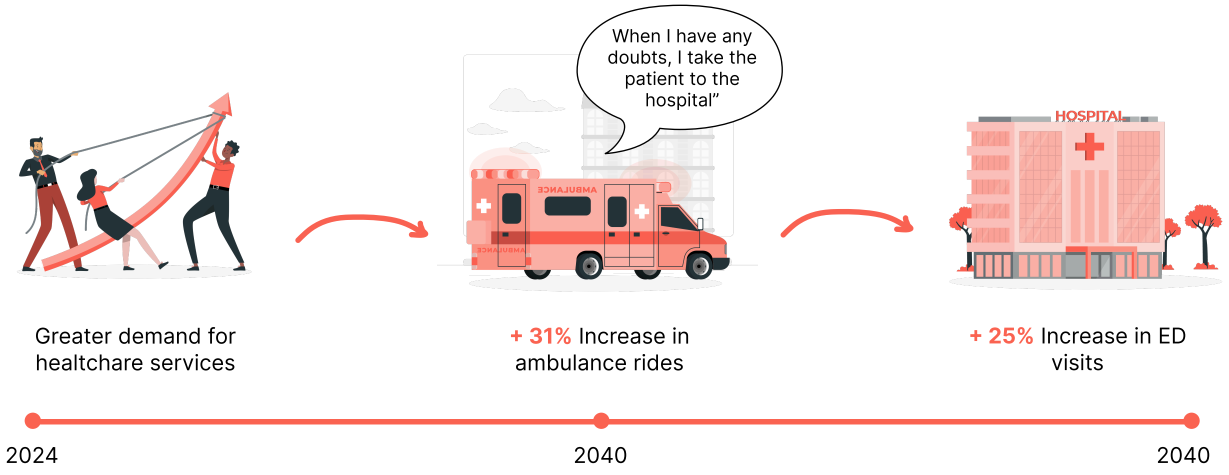


Figure 1: Changes in acute healthcare without new initiatives like SMART Triage

A more effective form of triage, aided by remote consultation in and around the ambulance, can help ensure that more patients can remain safely at home.

Additionally, if hospital care is required, the platform will provide better insights into where the patient should be taken, reducing inter-hospital transfers.

Both of these functionalities help to reduce the pressure on ambulance services and EDs, contributing to the main goal of **providing the right care in the right place.**

The project has four sub-goals:

1. Shifting acute care: For unclear cases, aim to establish the diagnosis in the prehospital phase rather than transporting the patient to the hospital.
2. Enhancing collaboration between healthcare providers in acute care: Currently, everyone works in their own "silo" under intense pressure, where quick decisions are required. Given the constantly changing teams, effective collaboration is essential.
3. Optimizing limited capacity by replacing physical contact with digital communication.
4. Leveraging innovative technology to deliver the right care.

To achieve these goals, the SMART Triage platform must support three key functions: (1) Displaying real-time patient data (such as vital signs and visual indicators), (2) Sharing this real-time data with the physician, and (3) Facilitating communication between ambulance personnel and the physician for information exchange and advice.

One major innovation within these core functions is establishing a video connection to transmit visual information, which allows physicians to better assess a patient's condition. For neurologists, for example, it can be essential for evaluating a potential stroke. Video can convey critical visual cues that audio alone cannot, such as when a neurologist conducts an eye test to determine if a stroke has occurred (Quadflieg et al., 2020). Early recognition of stroke symptoms during prehospital triage can facilitate faster transport to the right treatment facility. Especially for suspected stroke patients this is crucial, as stroke is a time-critical condition with a direct correlation between time to treatment and treatment outcomes (Candefjord et al., 2024).

In short, the SMART Triage platform aims to make patient data, such as vital signs and video images, accessible to physicians during remote consultations. This allows ambulance nurses to receive support during prehospital triage and enables patients to be directed more swiftly to the appropriate place of treatment. The core structure of the SMART Triage platform is visually represented in Figure 2.

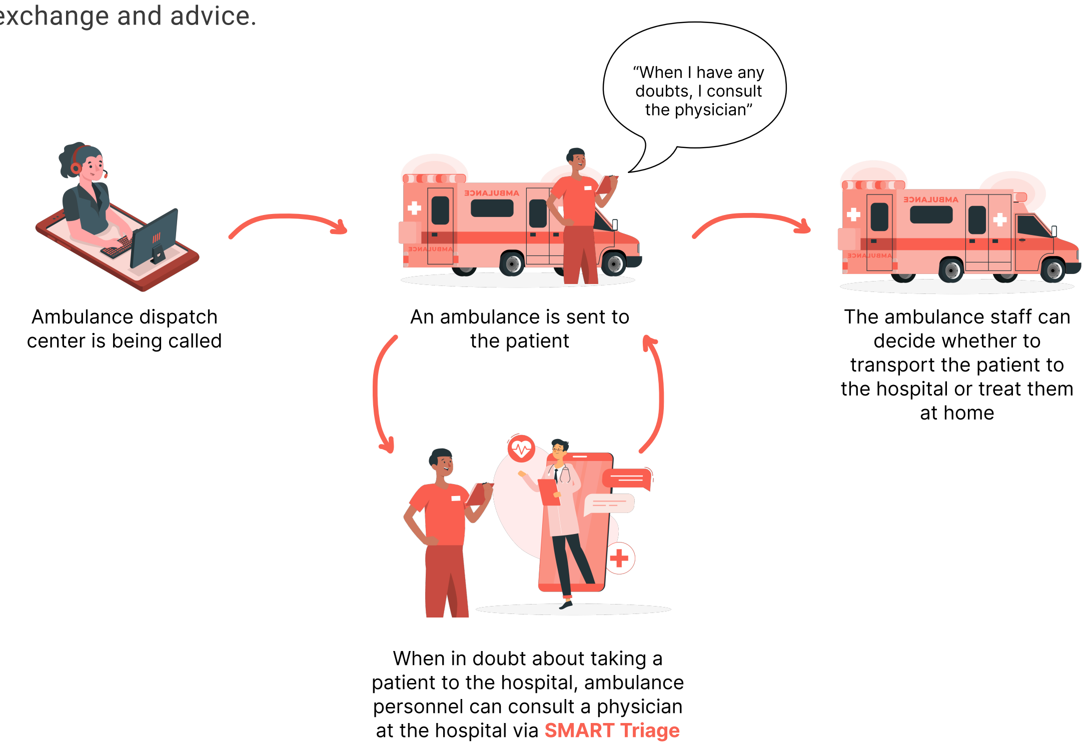


Figure 2: Simplified visualization of SMART Triage

1.1.3 The scope of SMART-Triage

Ambulance services are regionally structured across 25 Regional Ambulance Services (RAVs) (Ambulancezorg Nederland, z.d.). While expansion to more regions is certainly possible in the future, this research is focused on region Hollands Midden (nr. 16).

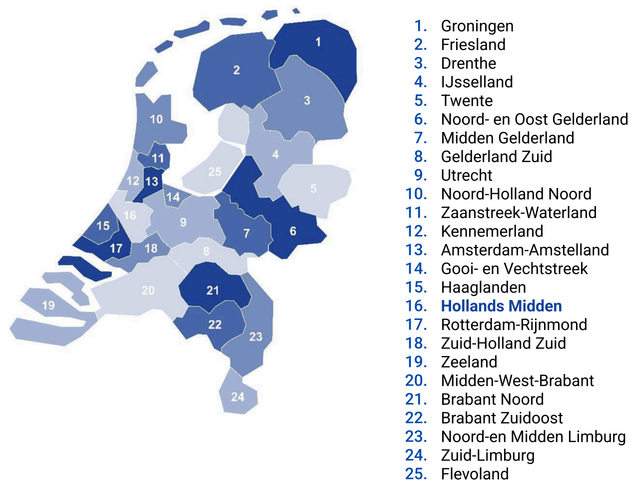


Figure 3: The 25 RAV regions (Ambulancezorg Nederland, z.d.)

The Hollands Midden region currently has a population of over 800 thousand people, with a projected population growth of 27% from 2017 to 2050 (NAZW, 2023). To meet the healthcare needs of this population, 40 ambulances are operational daily across the region (RAV Hollands Midden, 2024).

Last year, LUMC, in collaboration with other healthcare providers in the Hollands Midden region – including Groene Hart Hospital (GHZ), Alrijne Hospital, RAV Hollands Midden, and the NAZW Network), began developing the SMART Triage platform. These five healthcare institutions are shown in Figure 4.

Figure 4: Collaborating SMART Triage parties

At the start of the project, several physicians from the three hospitals became involved in the development of the SMART Triage project. Neurologists and cardiologists themselves have shown a strong interest in contributing to the platform's development. Additionally, a previous survey conducted among ambulance nurses also highlighted a strong demand for video consultations with pediatricians. The specific reasons for involving these physicians are as follows:

The numbers mentioned below are derived from internal documentation of the LUMC.

1. Neurologists

Neurologists are currently especially interested in using video consultations for patients suspected of having a stroke.

In the Hollands Midden region, ambulances were dispatched 2,475 times in 2022 for patients with possible stroke symptoms. Of these, 85% were transported to the ED with an A-priority ride (explained in the glossary). However, research revealed that 38% of these patients did not have a stroke. Given that the use of video communication in ambulances to improve stroke triage has already proven effective in countries like Sweden (Johansson et al., 2019). Neurologists in the Hollands Midden region are eager to implement video consultations as well.

2. Cardiologists

Cardiac issues are one of the most common reasons for ambulance calls and ED visits. However, the majority of patients with such symptoms are sent home after acute cardiovascular conditions are ruled out. In the Hollands Midden region, ambulances were dispatched 3.686 times in 2022 for patients with chest pain, 91% of whom were transported to an ED. Since the implementation of HARTc1.0 (explained in chapter 2.2.2), the number of patients who could safely stay at home has doubled. Cardiologists aim to further expand the HARTc1.0 system within SMART Triage to create a standardized consultation process and enhance the data shared with physicians. These improvements could allow even more patients to be safely treated at home.

3. Pediatricians

The number of children transported to the ED by ambulance increased significantly in 2022 compared to 2021. In the Hollands Midden region, ambulances responded to over a thousand emergency calls involving children. Many of these cases involved shortness of breath or febrile seizures, with 46% of the children being taken to the hospital. More than half of this group was discharged home after an average hospital stay of 2.5 hours. Ambulance professionals indicate that a lack of experience with pediatric cases may influence the decision to transport children to the ED. Therefore, ambulance nurses themselves have expressed a strong desire to be able to consult with pediatricians.

It is important to note that the platform is currently being designed for the common situations mentioned above. However, this does not mean that the platform cannot be expanded later to accommodate other scenarios and different users.

1.1.4 Expected outcomes of SMART Triage

The implementation of the SMART Triage platform is expected to deliver significant positive outcomes across multiple domains, serving as the key drivers for this project. Its introduction will benefit patients, healthcare professionals, stakeholders across the care chain, and contribute to sustainability and cost efficiency. The specific impacts are detailed in the list below.

This information is derived partly from internal documentation and partly from firsthand project experience.

For patients

- Avoidance of unnecessary visits and prolonged stays in EDs
- Improved patient flow when ED visits are necessary
- Faster diagnosis both at home and in the ED
- Enhanced self-reliance, fostering confidence in managing care at home rather than in a hospital setting

For healthcare professionals

- Reduced pressure on EDs through care delivered in the right place
- Fewer unnecessary ambulance trips
- Better integration between ambulance personnel and ED staff, promoting collaboration
- A positive learning curve for healthcare providers due to shared knowledge
- Decision-making becomes a shared process through the consultation function
- Centralized access to essential information for informed decision-making

For care chain partners

- Investment in strengthening collaboration
- Expanded diagnostic capabilities through technical support, diagnostic tools, and targeted training
- Fewer ambulance transports to EDs
- Fewer unnecessary hospital admissions
- Reduced inter-hospital ambulance transfers
- Cost savings; projections indicate that SMART Triage will save €3.1 million during the transformation period (2025-2027), with further impact expected as the platform is scaled to additional applications and regions.

1.2 Project brief

1.2.1 My assignment

The What – a platform facilitating communication between ambulance personnel and physicians – and the Why – to improve acute care during pre-hospital triage – are clearly defined for all stakeholders. But, defining the How – will the design of the platform look like, and how will it integrate into the users' daily workflows? – still requires further exploration and will be the subject of this thesis.

Bringing together the various needs of the stakeholders and translating them into how the service should be designed to meet these needs is a big challenge. In addition to conceptualizing the platform, there are also challenges regarding funding and legal aspects, which fall outside the scope of my project.

Furthermore, the SMART Triage project offers substantial opportunities for future expansion. Beyond scaling the platform to more users, there are also many possibilities for adding functionalities, such as data storage, data training, and AI integration. In this thesis, the minimum functional requirements and potential future expansion opportunities will be separated to clarify the phased implementation approach for the platform.

Summarized in one sentence, my assignment is as follows:

"Design a Service Blueprint (SB) that illustrates how ambulance care professionals can be assisted by a physician during prehospital triage using the SMART Triage platform, ensuring that the platform effectively addresses user needs to support successful integration into daily workflows."

1.2.2 Project approach

Within this graduation project, a triple diamond design thinking approach has been followed (Marin-Garcia et al., 2020). The method has been slightly adapted to suit this project; the explanation of these adjustments is provided below. It comprises three main stages: Research, Design, and Validate & Finalize. The chapters of the thesis will also be presented in this order (see Figure 5). The figure should be read from left to right.

The first diamond, Research, focuses on understanding the context through desk research, exploring existing alternatives, and conducting user interviews. Certain insights generated during the research phase influenced subsequent research, which is why the arrow from 'insights' points back toward the research stage. The key findings from all the research were structured and served as the foundation for the design phase. The orange block at the end of the design phase symbolizes a closing moment. After the transition to the design phase, only minimal additional research was conducted.

In the second diamond, Design, a Phase 1 and Phase 2 Service Blueprint (SB) were developed, along with a strategic roadmap and platform application interfaces. During the ideation and prototyping stages, several iterations were conducted to ensure alignment between the three design deliverables: the SB, interface designs, and the roadmap.

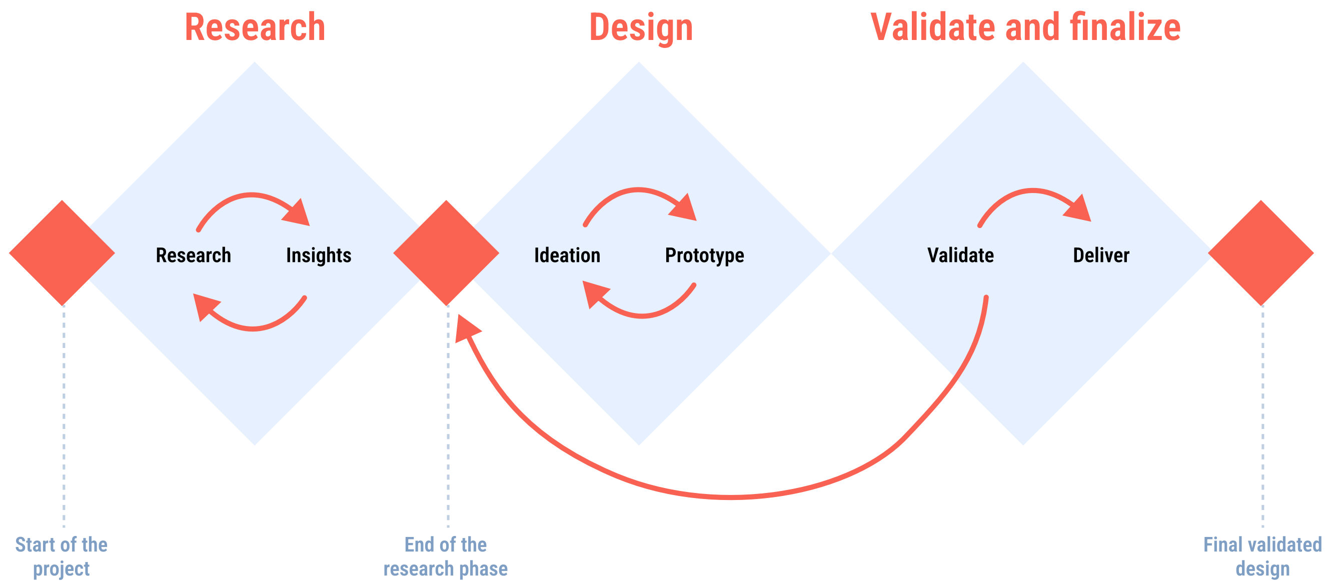


Figure 5: Triple diamond design approach

The final diamond, Validate & Finalize, focuses on testing the blueprints and interface designs with stakeholders to evaluate their desirability, feasibility, and viability. Following each validation session, the concept was adjusted during the design phase where necessary, based on the feedback obtained. This iterative process, moving back and forth between the third and second diamonds, occurred after each validation session.

After all the validation sessions, the insights were consolidated in the delivery phase into a refined SB, supporting application interface designs, and a tactical roadmap.

1.2.3 Project Team

The SMART Triage project involves a range of people, each with their specific competencies and responsibilities. During the writing of this thesis, I collaborated with many colleagues from the LUMC, RAV, and Hecht. There are four individuals I would like to further introduce.

Sophia Kingma has been the project lead of SMART Triage since the beginning. She manages all the contacts and is ultimately responsible for getting in the tender, handling the legal aspects, overseeing the financial framework, and keeping everyone engaged in the project.

Meys Cohen is the head of the ED at LUMC. Since patients transported by ambulance are brought to the ED, she has a big interest in the SMART Triage platform. Therefore, she works closely with Sophia and serves as my internship supervisor during my graduation project.

Additionally, the ICT team, consisting of Milan and Sandra, is actively involved in this project, overseeing the technical implementation of the platform's backend. The ICT team is part of Hecht, the umbrella organization of the RAV Hollands Midden. They focus primarily on the technical implementation of the platform, including both the software and hardware requirements. They play a key role in deciding which company will ultimately develop the platform.

During my graduation, I worked closely with Meys, Sophia, Milan, and Sandra, and in this thesis, I will sometimes refer to us as the "project team".

02
Research.

2.0 Research

At the start of this project, a stronger understanding of prehospital healthcare was necessary for me. This was achieved by spending a day with an ambulance team, conducting extensive reading, and engaging with staff at the RAV. Additionally, I was interested in exploring similar initiatives both within and outside the Netherlands to identify potential lessons that could be applied to this project. The research into these initiatives drew on both academic and non-academic sources.

Additionally, research was conducted into how service design can contribute to the development of a successful and sustainable SMART Triage platform. Central to this process is user research, which is detailed at the end of Chapter 2.

2.1 Context analysis

2.1.1 Introducing prehospital healthcare

Every call to the dispatch center is unique, requiring a tailored approach to each case by ambulance nurses. Additionally, each ambulance nurse has developed their own working methods. However, to ensure consistent care, protocols guide how healthcare professionals should act during the prehospital phase. To provide a clear picture of prehospital care, a journey has been mapped out from pre-arrival to arrival at the ED (see Figure 6). This overview was developed through a combination of online research and in-depth discussions with staff at the RAV office. After the 'day with the ambulance', described in the next section, I was able to review and refine the overview.

In figure 6, the stakeholders involved are displayed on the left. Interactions between different stakeholders are visualized with vertical lines. The total process is explained below, following the 10 numbered steps which are shown in the journey.

1. **Notification received**: The dispatch center receives an alert via the 112 line, a healthcare provider, a fire department, or the police.
2. **Processing notification**: The dispatch center identifies the destination and confirms a contact number, then dispatches the ambulance.
3. **Ambulance on the way**: While driving, the dispatch center can provide the ambulance nurse and driver with extra information. The dispatch center provides the caller with instructions to stabilize the situation until the ambulance arrives.
4. **Arrival at scene**: For urgent cases (A1 rides), the ambulance arrives within 15 minutes; for less urgent cases (A2 rides), within 30 minutes. Non-emergency transport (B rides) arrives within one hour.
5. **On-site care**: At the scene, the ambulance nurse and driver assess the situation and follow the protocols.
6. **Consultation**: Ambulance staff may consult physicians when they need advice. However, the current practice of contacting physicians is unsustainable, partly due to privacy issues, as the phone connection is not 'officially' secured. Additionally, physicians currently lack access to real-time patient data during these consultations This highlights the need for secure consultation, as planned in the SMART Triage project.
7. **Leaving patient home/informing GP**: Ambulance staff may choose to leave the patient at home and inform their GP if necessary.

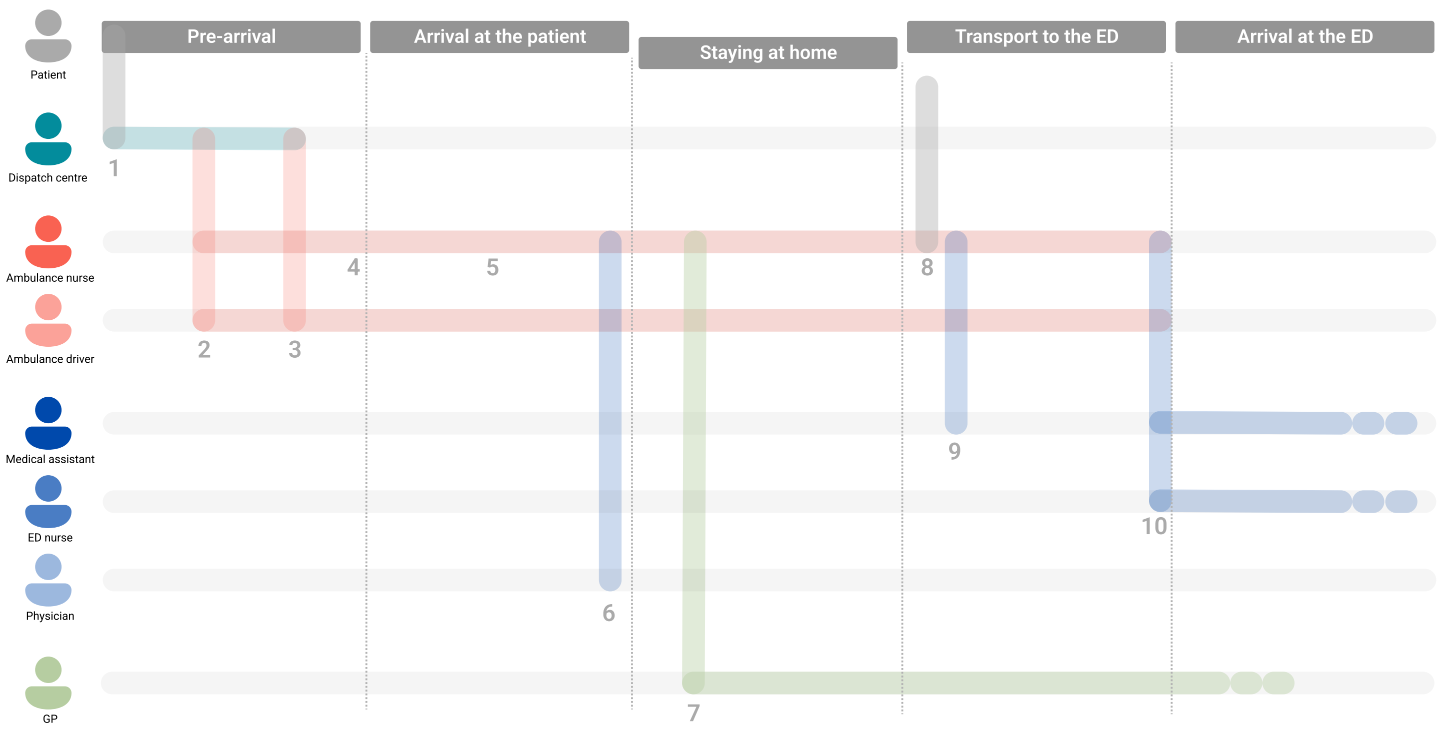


Figure 6: Stakeholder involvement in the prehospital care process (author's own illustration)

8. **Destination discussion**: If treatment at home is not possible and the patient needs to be transported to the ED, ambulance personnel face a second decision: which ED is most appropriate? When possible, the ambulance nurse discusses with the patient hospital preference, while considering medical needs, urgency, and bed capacity.
9. **Prepare notification**: The ambulance nurse informs the hospital's medical assistant of the patient's situation and notifies them of the expected arrival, allowing the hospital to prepare accordingly. After, medical assistants support ED triage nurses in the ED.
10. **Patient handover to ED**: The patient is handed over to the ED triage nurse, with relevant information about the condition and the actions taken by the ambulance care professionals.

2.1.2 Day in the ambulance

On September 26, I had the opportunity to join Marcel (ambulance nurse) and Vince (ambulance driver) for a full morning shift on the ambulance, from 7:00 to 15:00. Throughout the day, we had three rides: one patient was transported to the hospital, another referred to a GP, and a third was left at home due to suspected psychological delusions. This experience provided me with a clearer understanding of the daily routine of ambulance personnel and the range of (technical) equipment they use.

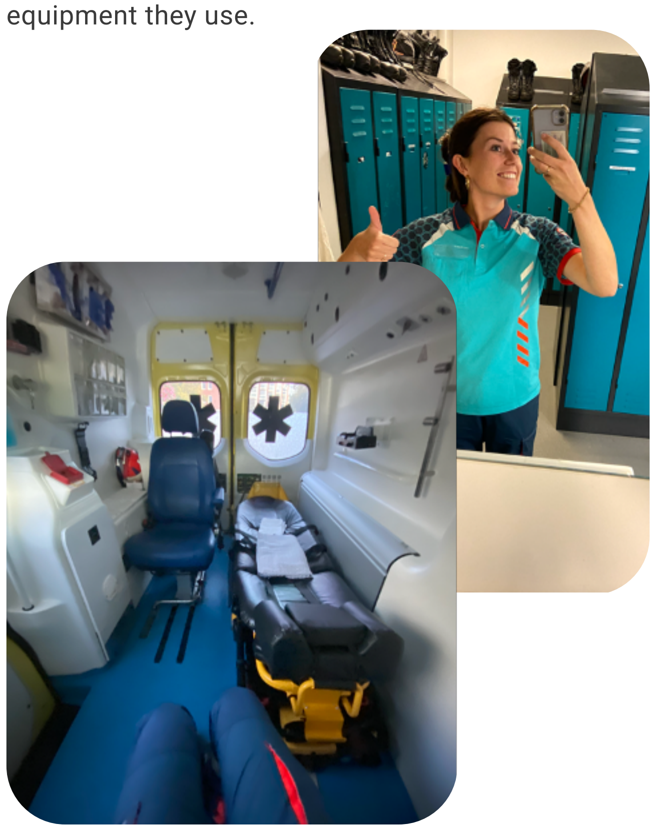


Figure 7: Pictures from the day on the ambulance

The following observations stood out to me during the day:

1. **Context plays a crucial role in the work of an ambulance nurse.**

On our way to the second patient of the day, Marcel, based on the information displayed on the ambulance's dashboard, already suspected that it might be a case of psychological delusion. Upon arrival, the patient was able to open the door for us, and after checking the patient's eyes and assessing the home environment, Marcel quickly determined that it was a case of psychogenic epilepsy.

"It's all about small contextual cues that lead to a final decision; that's why it's so important to look at the entire context from the start"

2. **Narratives in healthcare can be subjective.**

The subjectivity of a story begins at the dispatch center, making it essential to assess all the situations yourself from the beginning.

"Sometimes we receive a dispatch message stating 'the blood gushes out', but upon arrival, we find it to be a minor injury with minimal blood loss."

3. **Bias can't play a role in healthcare.**

When Marcel got the feeling that the second patient might be experiencing psychogenic epilepsy, he decided not to look at the previous call history to avoid any bias.

"Experience allows you to trust intuition at times, but it's essential to be cautious so that intuition doesn't introduce bias"

4. **There is significant variation in the practices of ambulance nurses.**

Ambulance nurses differ in their experiences and interpretations of context, leading to different decisions despite established protocols.

"In cases of doubt, we always transport someone to the hospital, but there are colleagues who doubt more often and almost always transport patients. This insecurity can be stimulated by traumas from wrong previous decisions.

5. **Ambulance work is changing as the threshold to call 112 lowered, leading to more cases of uncertainty.**

"People are calling 112 more frequently, making it increasingly difficult to determine which patients need to be transported and which can remain at home"

6. **Working on the ambulance is truly a two-person job**

Currently there are little opportunities to consult with other colleagues or healthcare professionals directly. In some cases, they might consult a colleague with particular expertise, such as burn injuries, by sharing a photo. Due to their limited experience with children, they may seek advice from a pediatrician. However, since they can only describe the situation over the phone, the pediatrician often insists on referring the patient to the hospital.

"Although, as an ambulance nurse, you always have final responsibility, it's very helpful to consult someone in uncertain situations, as it makes you feel more confident in your decisions."

7. **HARTc1.0 (explained in chapter 2.2.2) is an initial innovation in remote consultations, which is highly appreciated by the ambulance personnel**

Unfortunately, I didn't experience a HARTc1.0 consultation during this shift, but I had the time to talk with Marcel and Vince about their experience with the consultation system.

"Interpreting an ECG involves a degree of interpretation, so it's very helpful that cardiologists can monitor it in real time."

Conclusion day in the ambulance

This day provided me with a clear understanding of the steps ambulance care professionals take with each patient. Additionally, I gained insight into the technical tools used in and around the ambulance and when these tools are applied. This is valuable background information, which is crucial for implementing the SMART Triage platform.

2.1.3 Used technology inside the ambulance

The SMART Triage platform must be able to integrate seamlessly into existing work routines while also connecting to the technology currently in use within ambulances. Therefore, an explanation of this used technology is provided here. Additionally, each section title includes a reference number indicating where the technology is used in the journey visualized in Figure 6.

DRF (5,7,9)

The Digital Ride Form (DRF) is a digital medical record created for the patient during the ambulance service. This record includes details such as the timing of ambulance care, treatments performed, measurement results, and any medication given to the patient.

The DRF is accessible on an iPad and is filled out by the ambulance nurse during the patient visit or the ride. After entering the patient's citizen service number (BSN), previous ride forms for that patient can also be viewed. Once the ride is complete, the DRF is sent to the chosen hospital or the patient's GP.

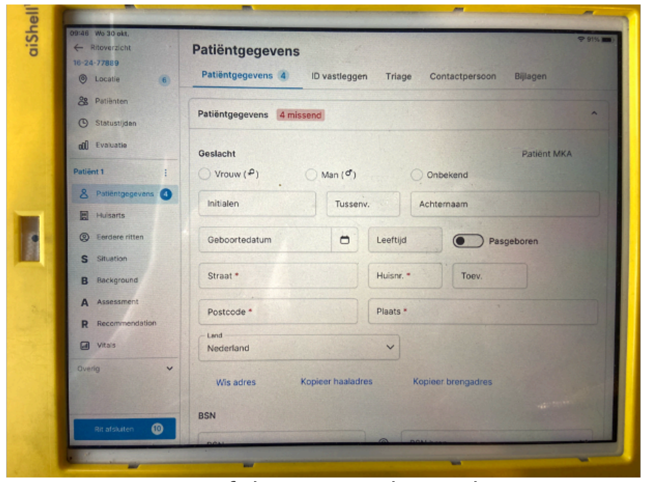


Figure 8: Picture of the DRF on the Ipad

Tempus Pro monitor (5-6)

All ambulances in region Hollands Midden are equipped with a Tempus Pro Monitor, allowing for the recording of a 12-lead ECG and real-time monitoring of essential patient vitals, including heart rate, blood pressure, and oxygen saturation levels. This device can display trends in these measurements and transfer the data via a service to the DRF (once the ride number is filled in), ensuring that all the data is recorded within the patient record. The Tempus Pro Monitor is shown in Figure 9 (Philips, 2024). Because the Tempus Pro is connected to the internet, the real-time measured parameters can be monitored on distance.


Figure 9: Philips Tempus Pro Monitor installed in the ambulance

Service phone (Zebra-phone) (6-7-9)

The Zebra is the service phone assigned to the ambulance. With this phone, the ambulance nurse can call other healthcare professionals, such as physicians or the patient's GP.

Pager (2)

The ambulance waits at a designated post until a call comes through on the pager worn on their belt. When the pager goes off, the ambulance care professionals can see if the call is classified as A1, A2, or B. They then step into the ambulance.

Tablet on dashboard (3)

After receiving an alert on their pager, the ambulance personnel see a detailed description of the call, the location, and the contact details of the caller on the ambulance dashboard screen. If there is any additional information provided by the dispatch center, then it will appear on this screen as well.

Measuring equipment (5)

The ambulance is equipped with several tools to use when assessing a patient's condition, like a blood pressure monitor and a finger-prick device that can measure various blood values. Some of these values are automatically sent to the DRF (via specific software), while others must be manually entered into the DRF.

Further details about the software used to transmit live measurements from the measuring equipment to the DRF are provided in Chapter 3.2.5, titled '*Terminology Data Streams*'.

2.2: Digital health solutions

SMART-Triage is one of many digital health solutions. Digital health refers to instruments and services that employ information and communication technologies (ICTs) to enhance and optimize health and lifestyle management, as well as play a role in the prevention, diagnosis, and treatment of diseases (Mumtaz et al., 2023). Digital health technologies have the potential to revolutionize the way healthcare is delivered, with the ability to facilitate remote monitoring, improve disease management, and provide more personalized care (Mumtaz et al., 2023). These technologies include telemedicine, mobile applications, wearable devices, and artificial intelligence (Karlsson et al., 2024).

This research focuses on telemedicine, examining how this form of e-health contributes to improved care and the implementation challenges it faces.

2.2.1 Defining telemedicine

A big development in digital health is telemedicine, defined as the use of advanced communication technologies, that deliver care across distances (Turner, 2003). Early implementations of telemedicine primarily involved audio communication, but currently, patient information is increasingly transmitted through a combination of audio and video technologies (Winburn et al., 2017). Video communication enables a more thorough assessment of a patient's condition, which can enhance decision-making accuracy and ensure that more patients receive the most appropriate care (Vicente et al., 2021)

Telemedicine (including video) can be used in a variety of ways. According to Su (2023), it can be divided into three main categories:

1. **Teleconsultation**: This type of telemedicine facilitates interaction between two healthcare professionals. It is often used for obtaining second opinions, consulting specialists, and accelerating the delivery of appropriate care to patients.
2. **Telemonitoring**: Involves the remote tracking and monitoring of patients. In pre-hospital care, telemonitoring can share critical patient data with the hospital, enabling them to prepare the necessary treatment before the patient's arrival.
3. **Tele-education**: Allows healthcare professionals to train or instruct one another remotely. This is frequently used in emergency settings, such as within ambulances, and is used mostly during high-risk, low-frequency procedures where ambulance staff may need real-time guidance from physicians.

Although the SMART-Triage platform may potentially be expanded in the future for broader purposes, such as telemonitoring, this research primarily focuses on how teleconsultation can be implemented within the SMART-Triage platform.

2.2.2 Studied teleconsultation initiatives

To gain further insights into the current use of teleconsultation within pre-hospital emergency care, various initiatives have been examined, including a local audio consultation system at LUMC named HARTc1.0, and a similar video consultation system in Norway (PreVis project). Scientific papers about the use of teleconsultation in Europe were also reviewed to explore user experiences of teleconsultation. The types of sources used, along with the reasoning for reviewing these initiatives, are:

1. **Scientific papers about the use of video teleconsultation in ambulance triage** - *Comparable projects, other European countries*
   In Europe Extensive research has been conducted on the experiences of users of similar prehospital teleconsultation systems. These studies provide valuable insights into user experiences from which can be learned.
2. **Previs project** - *Comparable implemented project, Norway*
   Norway already has years of experience with the PreVis (Prehospital Video i Samhandling) project, which utilizes a similar video connection. Given its established usage, there is much we can learn from this initiative.
3. **HARTc1.0** – *Implemented audio teleconsultation system at LUMC, Groene Hart Hospital, and Alrijne hospital*
   The HARTc1.0 system was implemented in 2019 across three hospitals in the Hollands Midden region, enabling ambulance personnel to establish audio contact with cardiologists. This new communication technology has been in use for several years and I am eager to understand what aspects of this communication are effective and what improvements can still be made.

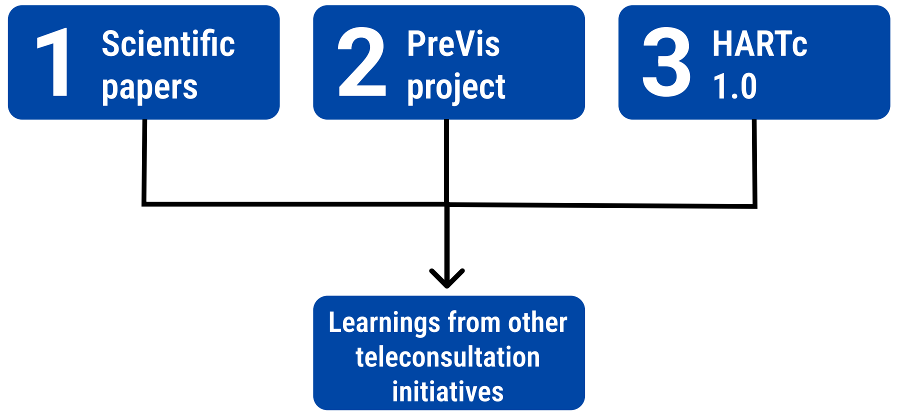


Figure 10: Examined other teleconsultation initiatives

The following subsections will dive deeper into the initiatives and discuss notable findings.

1 Scientific papers

SMART Triage is not the only initiative in the Netherlands focused on developing live video connections between ambulances and EDs. In recent years, similar projects have gained attention in the media.

One such initiative is "Spoedzorg Connect," led by UMC (Universitair Medisch Centrum) Amsterdam, which plans to deploy ambulances equipped with video technology starting in early 2025 (Amsterdam UMC, 2024). This innovative system aims to enhance communication and collaboration between ambulance teams and ED staff in life-threatening situations. The live video connection allows the ambulance team to share real-time video images with the ED team during transport, enabling better preparation and faster transitions of care. If the patient's condition changes during transport, hospital staff are instantly updated via video.

The overarching goal of Spoedzorg Connect, "*a seamless transfer from ambulance to ED*," differs from the main objective of SMART Triage, which is "*to enable ambulance personnel to consult a physician remotely when uncertain about hospital transport or safe home care*".

Despite these differing objectives, it is valuable to remain informed about similar initiatives. This awareness allows for potential knowledge sharing and, in the future, the possibility of integrating these systems for greater synergy.

Outside the Netherlands, numerous video teleconsultation initiatives with nearly the same purpose have already been implemented, and there is greater insight into user experiences with these initiatives. Unfortunately, due to significant national differences in healthcare systems, these initiatives cannot be directly replicated.

However, to explore potential learnings, a selection of these initiatives will be examined.

One of these studies was done in southern Sweden. In the study by Vicente et al. (2021), both physicians and emergency care professionals shared their experiences about real-time video consultations. The findings showed that video communication improved patient involvement and increased confidence in the medical assessment. Ambulance nurses felt more confident in making decisions, which led to a greater sense of patient safety. Additionally, better collaboration improved the quality of the assessments.

However, in the study of Vicente et al. (2021), both the physicians and ambulance staff had concerns about the technology of the device. The nurses experienced connectivity issues and found it challenging to set up the system. These technical difficulties hindered the system's usability and made the process more time-consuming.

A study conducted in Germany by (Bergrath et al., 2012) focused on the feasibility of prehospital teleconsultation for acute strokes. The aim was to assess how well a teleconsultation system with real-time video and audio could function between an ambulance and a physician (see Figure 11). The results showed that the video quality was good in general. In Pre (compared to only using audio), especially when evaluating neurological symptoms such as facial asymmetry or specific movements. In terms of communication, the remote consult was also positively received; in 17 out of 18 cases, continuous two-way audio communication was maintained (via video or phone), enabling effective collaboration between ambulance personnel and physicians.

Figure 11: Interior of the tele medically equipped ambulance (Bergrath et al., 2012)

However, in 3 out of 18 cases, technical issues such as video or picture transmission failures occurred, reducing trust in the system among both ambulance personnel and physicians. A similar study in Sweden noted that the reliability of the system for ambulance personnel also depends on how physicians interact with it (Johansson et al., 2019). Therefore, it's crucial to consider both the ambulance personnel's and physicians' perspectives to ensure reliable and successful implementation.

For this reason, a study by (Vicente et al., 2020) explored physicians' experiences with using video communication during ambulance triage. While the physicians agreed that video triage improved communication and diagnostic accuracy, they also highlighted some concerns. Technically, the device was sometimes slow and had a short battery life. From a patient perspective, physicians worried that patients might see this system as an easy way to request home consultations with a physician or lose confidence in the ambulance staff, preferring to always consult with a physician directly.

To provide a comprehensive overview of both the positive aspects and challenges surrounding ambulance video triage, two more studies were examined. The research by Jaeger et al. (2023) focused on how effectively such a system can support neurological symptoms such as facial asymmetry.

From a 12-week pilot, during which seven successful video consultations took place, barriers to implementation for physicians, patients, and technology were identified. The physicians primarily struggled with mastering the new workflow and using the new technology correctly. Additionally, a major concern arose that patients might assume that a 112 call would easily lead to an online home visit from a physician (Jaeger et al., 2023).

The last study by Omran et al. (2024) aims to explore the impact of video support on remote interprofessional collaboration and teamwork during simulated stroke scenarios within the prehospital context. In this study, one of the main concerns of the ambulance personnel was performing examinations while simultaneously communicating with a physician. One of the main concerns of the physicians was the practical implementation and what to do if they are unavailable to answer the phone for a consultation. Figure 12 shows the video images that the neurologist saw during the study.

Figure 12: The Neurologist view during the consultation (Omran et al., 2024)

All positive experiences as well as the barriers to implementation from the five European studies discussed are presented in Figure 13.

	POSITIVE EXPERIENCES OF AMBULANCE VIDEO TRIAGE IMPLEMENTATION	NEGATIVE EXPERIENCES OF AMBULANCE VIDEO TRIAGE IMPLEMENTATION
PHYSICIAN	• Better collaboration and knowledge exchange between physicians and ambulance personnel (Bergrath et al. 2012), (Vincente et al. 2020) • Good assessment of facial and body expressions (Bergrath et al. 2012) • Improved data transfer (Bergrath et al. 2012)	• Challenge with new workflow (Jaeger et al., 2023) • Discouragement with technological issues (Jaeger et al., 2023) • Liability concerns (Jaeger et al., 2023) • Practical implementation; what will happen when they are not available to pick up the phone (Omran et al., 2024)
AMBULANCE PERSONNEL	• Improved decision-making (Vincente et al. 2021) • Increased confidence (Vincente et al. 2021) • Better uniform assessment of different patients (Johansson et al. 2019)	• Video calling, and setting up the video system, is more time-consuming (Vincente et al. 2021) • Assessment of the patient is completely dependent on the way of the physician's way of working with the system (Johansson et al., 2019) • Trust issues due to technical failure (Bergrath et al. 2012), (Vicente et al., 2020), (Vicente et al., 2021) • Performing examinations while simultaneously communicating with a physician (Omran et al., 2024) • Network variability (Jaeger et al., 2023) • Battery charging issues (Jaeger et al., 2023)
PATIENT	• Increased participation (Vincente et al. 2021) • Increased patient safety (Johansson et al. 2019)	• Expectations that a 112 call would result in an easy online physician 'home visit' (Vicente et al., 2020) (Jaeger et al., 2023) • Will lose trust in ambulance staff (Vicente et al., 2020)

Figure 13: Positive and negative user experiences with teleconsultation initiatives

2 PreVis project demo days

In the Innlandet region of Norway, ambulance services and hospitals have been gaining experience over the past few years with integrating video technology into prehospital care. One of these projects is the PreViS (Prehospital Video i Samhandling) project, which enables ambulance personnel to establish real-time contact with specialists in the hospital to improve decision-making during emergencies (PreVis, 2024).

I connected with Kari Bjerke Gjaerde, a PhD candidate at Innlandet Hospital. She is working on the PreVis project and could provide me with more insights into the functionality of the video system. Additionally, she scheduled an online demo where the operation and experiences with the head camera were shared.

A simple overview of how the consultation between the ambulance nurse and physician currently works with the PreViS camera setup is as follows:

1. The ambulance personnel contacts the physician in the hospital by making a call with the service phone and puts on the headcam
2. Through a shared link, the physician can connect with the headcam of the ambulance nurse.
3. On a screen, the physician can see what the ambulance nurse sees
4. Using the microphone and speakers in the headcam, the ambulance nurse and physician can talk with each other
5. The ambulance nurse can control the camera with voice commands, such as saying "zoom-zoom" to zoom in or "light" to put the flashlight in the head camera on

As mentioned above, a head camera is used in the PreVis project. For the testing phase of the project, the head camera is currently installed in 20 ambulances in the Innlandet region.

While the use of the camera has not yet become standard practice and not all ambulance personnel are utilizing the head camera consistently, the system has been tested. This testing phase allowed the project to meet its objectives in terms of identifying user needs, spreading research findings, and successfully completing the technical implementation.

Application interface

On October 2 and November 11, 2024, my project team and I received an online demo of 1.5 hours. During this demo, the PreViS team showcased the technology they use, their working methods, the lessons they've learned over the past few years, the challenges they still face, and how ambulance personnel, physicians, and patients assess their experiences with the system. Additionally, they shared their future plans for the PreVis project. During the second demo day, several future users of the SMART Triage platform were present and had the opportunity to ask questions. For my research, this was particularly valuable, as it allowed users to gain a clearer understanding of an existing initiative before participating in the concept validation sessions with me.

It is important to mention that, in addition to the head camera, the PreViS team is currently working on the development of cameras inside the ambulance. Since cameras may potentially be installed in ambulances for SMART Triage in the future, these insights have also been included. The insights are grouped by theme:

Time and complexity

- For each scenario or situation in the ambulance, a corresponding on-call or consulting healthcare provider must be involved. This complexity makes implementation more difficult.
- Getting used to new technology takes time, so platform users should not feel discouraged by the new way of working and the initial learning curve. The PreVis team also suggested leveraging enthusiastic users to motivate other users.

Head camera

- The voice control feature allows the ambulance nurse to zoom in, zoom out, or add extra lighting. This function works very well, is not overly sensitive while talking, and allows the ambulance nurse to keep their hands free.
- To maintain ease of use, it's important to not install too many functions and buttons on the head camera itself.
- Currently, initial contact is made by phone, after which the video connection can be established. They are still working on enabling the video connection to start in a single step.
- The ambulance personnel cannot currently see the physician. While this was not perceived as problematic by the ambulance staff, for patients, it could add a more personal touch.

Control panel in the ambulance:

- The control panel has the following functions: (1) Turning the cameras on, (2) selecting which physician to contact remotely, (3) local selection of camera views and angles, and (4) ending the call
- The display screen inside the ambulance must always show the images being transmitted to the physician to prevent any misinterpretation.

Camera in the ambulance

- For psychiatric patients, the appearance of a camera (especially in the ambulance) can be intimidating. Therefore, the camera should not be too notable.

Network coverage

- The ambulance is also equipped with a 5G system (via satellite) for connectivity in areas with no network coverage.

In addition to these technical insights, I also asked them about their biggest challenge in implementation. Their response was:

"The hardest thing with implementation is definitely that all the users of the technology only see their own benefits, so you need strict guidelines for when and how to use it"

This highlights the importance of not only developing an effective system but also establishing clear usage guidelines, ensuring that all users operate consistently.

Additionally, the PreVis team advised involving ambulance care professionals and physicians in the process by asking how they would prefer to use the system, rather than designing a system that forces them to adjust their daily workflows. It was encouraging to hear this, as it directly aligns with the approach I am taking in this thesis.

Lastly, we received a valuable suggestion to start by experimenting and testing with existing device cameras instead of immediately investing in a headcam system.

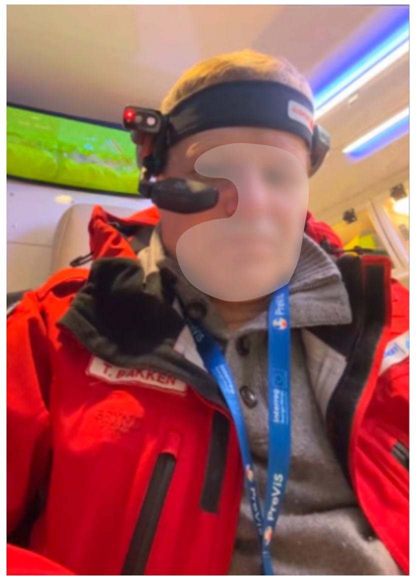


Figure 14: Headcam of the ambulance nurse

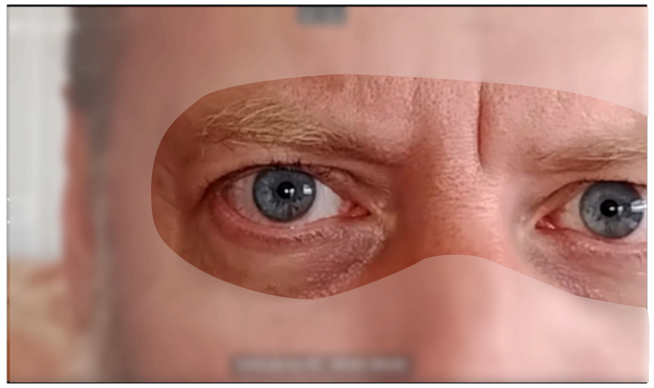


Figure 15: Picture of the patient's eyes after the "zoom-zoom" function

Figure 16: Picture of the ambulance without "zoom-zoom" function

3

The SMART Triage initiative builds on previous communication systems developed in the Hollands Midden region, notably during the COVID-19 pandemic when various systems were implemented to facilitate data exchange between healthcare institutions (HARTc, z.d.). To improve prehospital triage for patients with cardiac complaints in the entire chain of acute cardiac care, a comprehensive triage method entitled Hollands-Midden Acute Regional Triage-Cardiology (HARTc) was developed (De Koning et al., 2021).

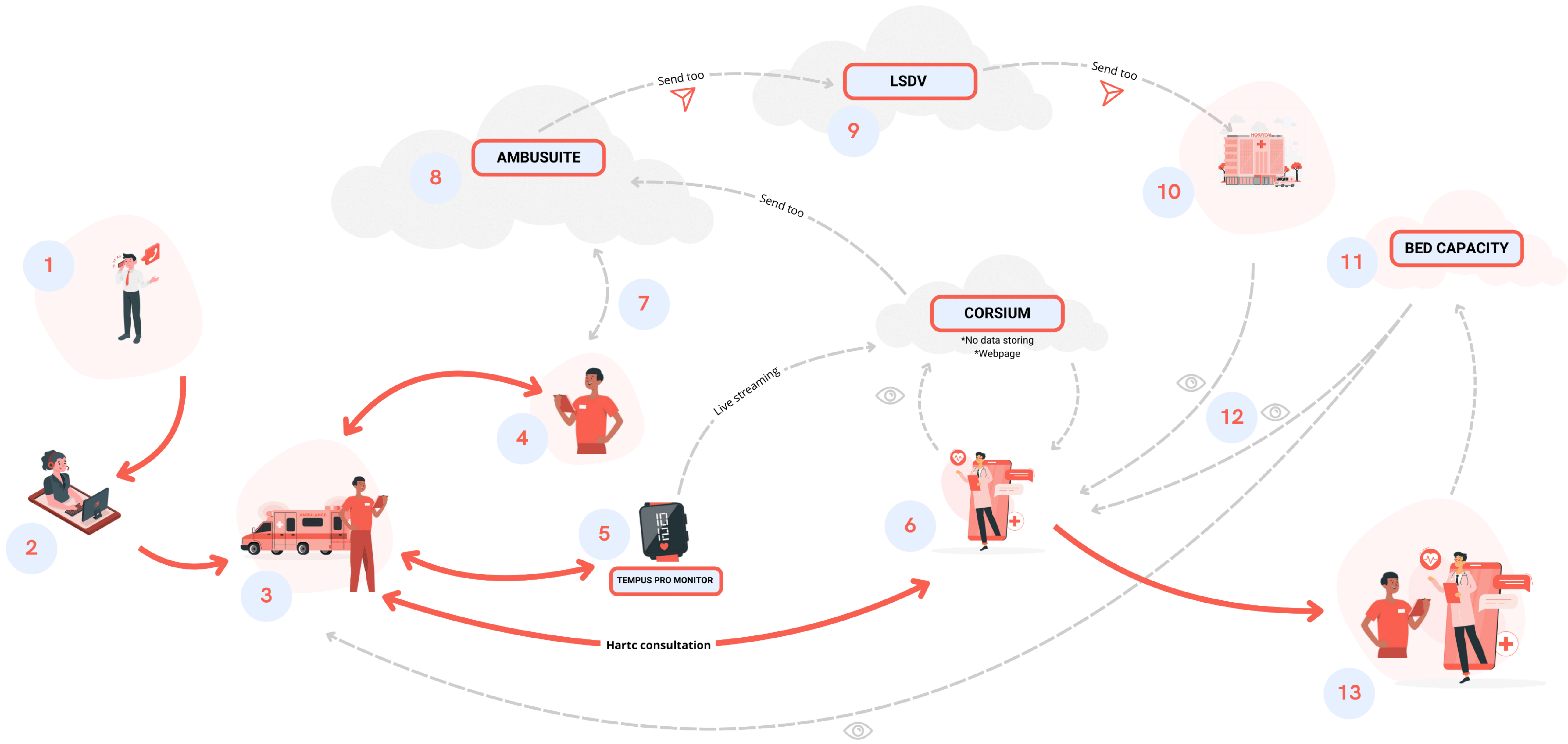
Before the implementation of HARTc1.0, cardiologists in the Netherlands had no access to a patient's real-time records and the actual hospital bed availability. This lack of information often made it difficult for cardiologists to make fully informed advice on whether to leave a patient at home or not. In the Netherlands, around 95% of patients with cardiac complaints are transported to a hospital after an ambulance nurse assessment (De Koning et al., 2021). However, given the number of unnecessary ED visits, there is a large cohort of low-risk patients in whom ED presentation could be prevented with better prehospital triage processes.

The HARTc1.0 system was designed to address this issue. It enables cardiologists to communicate directly with ambulance personnel via audio while receiving real-time vital signs of the patient such as the ECG, oxygen levels, and blood pressure. With this real-time data, cardiologists can advise whether a patient should be referred to the hospital or can safely remain at home. Additionally, the system provides real-time insights into the bed capacity of the three hospitals in the Hollands-Midden region, eliminating the need for phone calls to check availability and speeding up patient transfers to the appropriate hospital. The bed capacity is a relatively simple system, with a table accessible to cardiologists, ambulance nurses, and assistants via a secure online login. The clinic assistant maintains real-time updates on bed capacity. When a patient arrives, departs, or is expected, the assistant adjusts the count. Cardiologists can also update the bed capacity, as they sometimes have more insight into patient arrivals and departures.

A visual representation of the working principle of HARTc1.0 is shown in Figure 17. The data systems 'Topicus', 'Corsium', and 'LSDV' are explained later in chapter 3.2.5, '*Terminology data*'.

According to the article by De Koning et al. (2021), the results of HARTc1.0 are positive. In the first year after its implementation in 2019, 20.7% of patients triaged with HARTc1.0 were able to remain at home. This is 5.4% more than the year before when HARTc1.0 wasn't yet in use.

Additionally, the unplanned transfers between hospitals decreased by approximately 26%, leading to an estimated cost savings of €350.000



1.112 call, GP call, Fire brigade call, Police call
2. Dispatch center does first triage and sends an ambulance to the specified location
3. Patient receives care
4. Patient data is filled in into the DRF (Digital Ride File).
5. The parameters of the patient are determined
6. The on-call triage cardiologist securely logs into Corsium, connecting digitally with the ambulance's Tempus Pro Monitor to view real-time vitals and ECG.
7. The DRF data is continuously updated with Ambusuite, allowing Tempus Pro monitor data to be visible on the DRF.
8. All data from the DRF and Tempus pro monitor is stored in Ambusuite, a secure external database
9. LSDV facilitates the exchange of patient information between ambulance services, hospitals, and GPs on a national level
10. Each hospital, GP post, or doctor can open their own "portal" to access data from LSDV.
11. Real-time bed capacity is continuously updated by nursing staff
12. The on call physician can see the bed capacity online
13. The ambulance nurse and the physician together make a decision over the phone whether to take a patient to the hospital or leave the patient at home.

Figure 17: Working principle of HARTc1.0

Chapter 2.4 of this thesis explains how interviews were conducted with the future users of the SMART Triage platform. During the interviews with the cardiologists, their experiences with HARTc1.0 were also explored. Several key lessons and areas for improvement were mentioned:

Positive experiences with HARTc1.0:

- Audio consultations are currently done using the work phone. After picking up the phone, the cardiologist accesses the patient's real-time data on their computer. **This allows the physician to conduct the consultation from any location** in the hospital while still viewing the data on a larger screen.
- One person is on call across the three hospitals. They handle this alongside other duties, and the **availability** of the cardiologists is good most of the time.
- The use of the **bed capacity app** is easy to integrate across three hospitals and saves a lot of time, as you only need to notify one hospital that you are coming via HARTc1.0 instead of calling multiple to find available space.

Areas for improvement for HARTc1.0

- **Integrate patient records across hospitals:** Providing access to patient records from other hospitals would enable more informed and accurate decision-making for on-call cardiologists.
- **Troponin data accessibility:** Make it possible to measure troponin level in the ambulance so that the complete HEART score (explained in chapter 3.2.5), inclusive of the troponin level, can be determined. Measuring the HEART score in patients presenting with chest pain allows for a quick and reliable assessment of their risk for major cardiac events, enabling efficient decision-making for discharge or further intervention (HEART, z.d.)
- **Unified platform for all data**: Having all the information in one app/website/device would be better than using two devices (one for the real-time patient data inside the ambulance and another one for looking at the bed capacity or patient history)
- **No 'waiting' time for ambulance care professionals**: The on-call cardiologist for HARTc1.0 doesn't schedule any 'urgent' interventions. However, if such a situation arises, ambulance personnel sometimes have to wait until the cardiologist becomes available.
- **Larger screen for data display**: A screen the size of a computer or an iPad is needed to get a clear and comprehensive view of patient data.
- **Address GP concerns**: Engage with GPs, to address concerns about shifts in patient flows and their potential impact. Ensure that patients who are no longer transported to the ED are properly managed, and clarify how these changes will affect GPs' responsibilities.

2.2.3 Conclusion learnings previous initiatives

Key insights from the literature, PreVis, and Hartc1.0 project that may impact the implementation of SMART Triage are summarized in Figure 18. These factors are organized using Ross et al. (2016) systematic review, which categorizes digital health implementation elements under the Consolidated Framework for Implementation Research (CFIR).

An additional 'Technology' category was added to the 'Inner Setting' group to address the many technology-related factors identified.

The groups presented in Figure 18 highlight the multi-level complexity of e-health implementation and are explained below:

1. Innovation Characteristics:
   - **Adaptability**: Technology that can be tailored to local contexts enhances acceptance and adoption.
   - **Complexity**: Easy-to-use systems are more likely to be adopted, while high complexity can hinder implementation.
   - **Cost**: Both start-up and ongoing costs significantly impact the decision to adopt e-health systems.

2. Outer Setting:
   - **External Policy and Incentives:** Supportive legislation and recognized standards can either facilitate or hinder implementation efforts.

3. Inner Setting:
   - **Implementation Climate**: Successful integration depends on the system's compatibility with existing workflows and organizational culture.
   - **Available Resources**: Necessary infrastructure, time, and training are crucial for effective implementation.
   - **Technology:** The performance and user interaction with the technology significantly impact satisfaction.

4. Characteristics of Individuals:
   - **Knowledge and Beliefs**: Positive attitudes toward e-health systems enhance acceptance, while negative perceptions can obstruct implementation.

5. Process
   - **Planning**: Strategic planning, including clear role assignments and stakeholder engagement, is vital for success
   - **Engaging**: Involving key stakeholders and champions fosters ownership and smooth implementation.

Presenting the key factors as shown in figure 18 provided greater insight into the contextual elements influencing implementation.

These factors, combined with the end-user interviews, form the foundation for designing the SB.

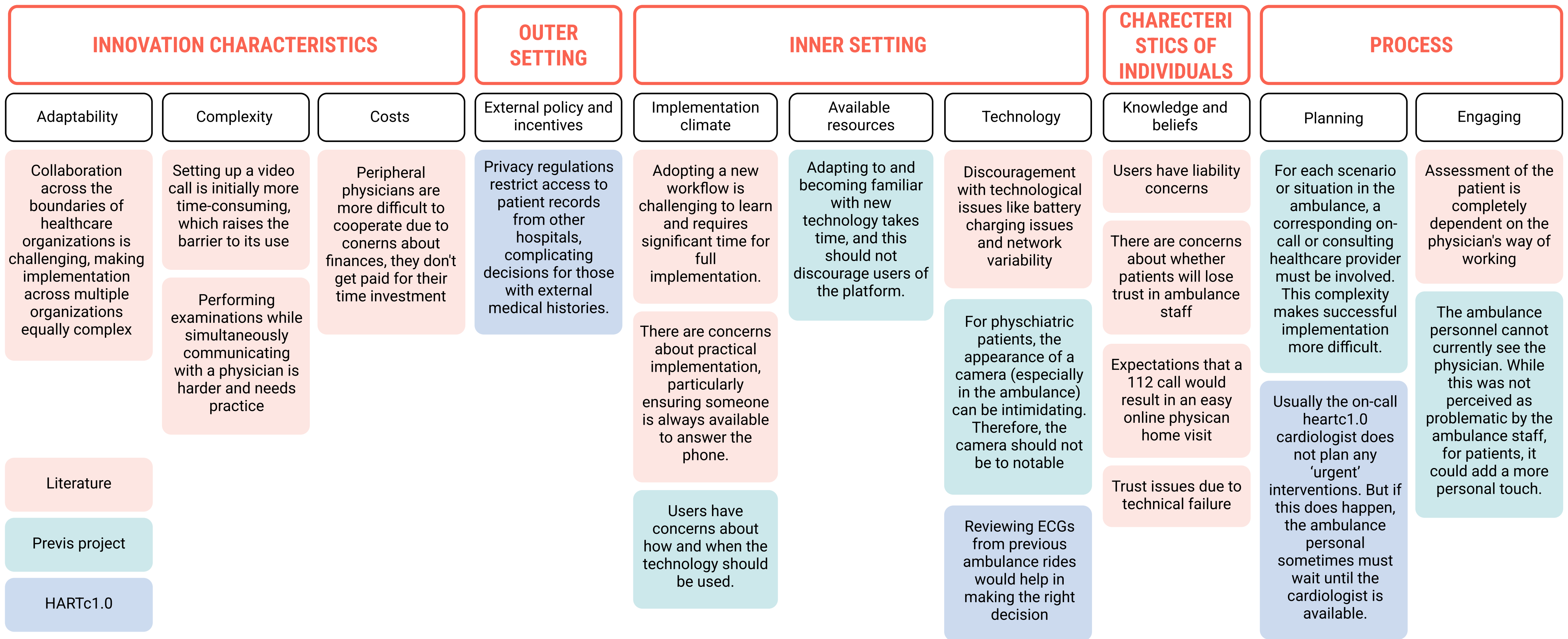


Figure 18: Contextual elements influencing the implementation of teleconsultation initiatives.

2.3 Used design methods

As discussed in the previous chapter, the implementation of a new technology in prehospital triage presents several challenges. Incorporating design practices in digital health implementation can lead to improved implementation outcomes and enhanced care quality (Karlsson et al., 2024). This chapter will explore how service design can be leveraged to create a successful and sustainable SMART Triage platform.

2.3.1 Service design

Service design is a human-centered, holistic approach that applies design principles to create and improve services by focusing on the experiences and needs of all stakeholders involved, including users and service providers (Shaw et al., 2018). Rather than concentrating on the technology itself, service design considers the broader picture that the new technology influences, such as new interactions between people or new tasks that users must perform due to the implementation of the technology (Shaw et al., 2018).

Saco & Goncalves (2008) describe service design through four key principles:

1. It aims to create services that are valuable, functional appealing, efficient, and effective
2. It is a human-centered approach, prioritizing the customer experience and the quality of service interaction as essential to success.
3. It takes a holistic view, integrating strategic, system, process, and touchpoint design decisions, considering how users interact with the service.
4. It follows a systematic and iterative process, incorporating user-focused, interdisciplinary teamwork and methods in continuous learning cycles.

These customer-focused principles of service design will be applied to design the SMART Triage platform. However, it is important to recognize that using these principles does not automatically guarantee a well-functioning and sustainable service system in the healthcare sector. In health services, key outcomes are often framed by the 'quadruple aim', which focuses on enhancing patient experience, improving the work life of healthcare clinicians and staff, improving population health outcomes, and finally controlling healthcare costs (Pannunzio et al., 2019).

So, in healthcare settings, service design needs to achieve a balance between delivering a good customer experience, improving health outcomes, ensuring a good customer experience, and reducing costs. Successfully balancing these four factors is critical in healthcare and is commonly referred to as the 'Quadruple Aim Framework (Sikka et al., 2015).

2.3.2 The Quadruple aim framework

The Quadruple Aim framework is a widely adopted approach for defining and improving key healthcare objectives, which emphasizes four essential dimensions (Pannunzio et al., 2019):

- **Enhancing the individual experience of care**: Improving the quality of care that patients receive, as well as their overall experience within the healthcare system
- **Improving the work-life balance of healthcare clinicians and staff**: Focusing on ensuring that healthcare providers have a manageable and supportive working environment
- **Improving health outcomes:** Enhancing the overall health of the population through better health services.
- **Reducing per capita healthcare costs**: Controlling or reducing healthcare costs so that care remains accessible to a wide audience without compromising quality.

To design an effective, efficient, and sustainable SMART Triage platform, it is essential to keep these four pillars (presented in Figure 19) in mind during the design process (Pannunzio et al., 2019).

It is important to note that while my design process is primarily focused on improving the user experience, I indirectly also focused on enhancing the work-life balance of healthcare clinicians and staff, as well as improving health outcomes. However, the financial sustainability aspect has been handled by my project team in parallel. For this reason, this thesis places less emphasis on the financial aspects of the SMART Triage platform, while giving considerable attention to the other key dimensions of the Quadruple aim.

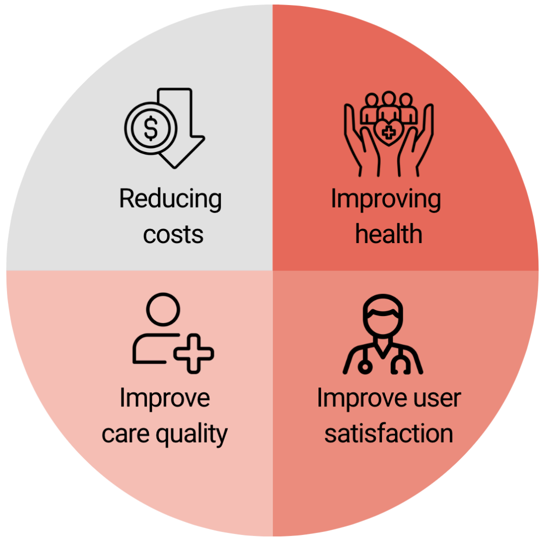


Figure 19: The Quadruple Aim framework (author's own illustration)

2.3.3 The Tool, Team, Routine framework

While service design can help address the four pillars of the Quadruple Aim framework, it remains a challenge to integrate newly designed technologies into an already existing way of working. Implementation difficulties often delay the realization of the user's benefits, leading to the new technology not being used as intended.

To tackle this challenge of implementation failure early in the design process, Shaw et al. (2018) developed a framework called [Tool, team, routine]. A visual representation of this framework is shown in Figure 20.

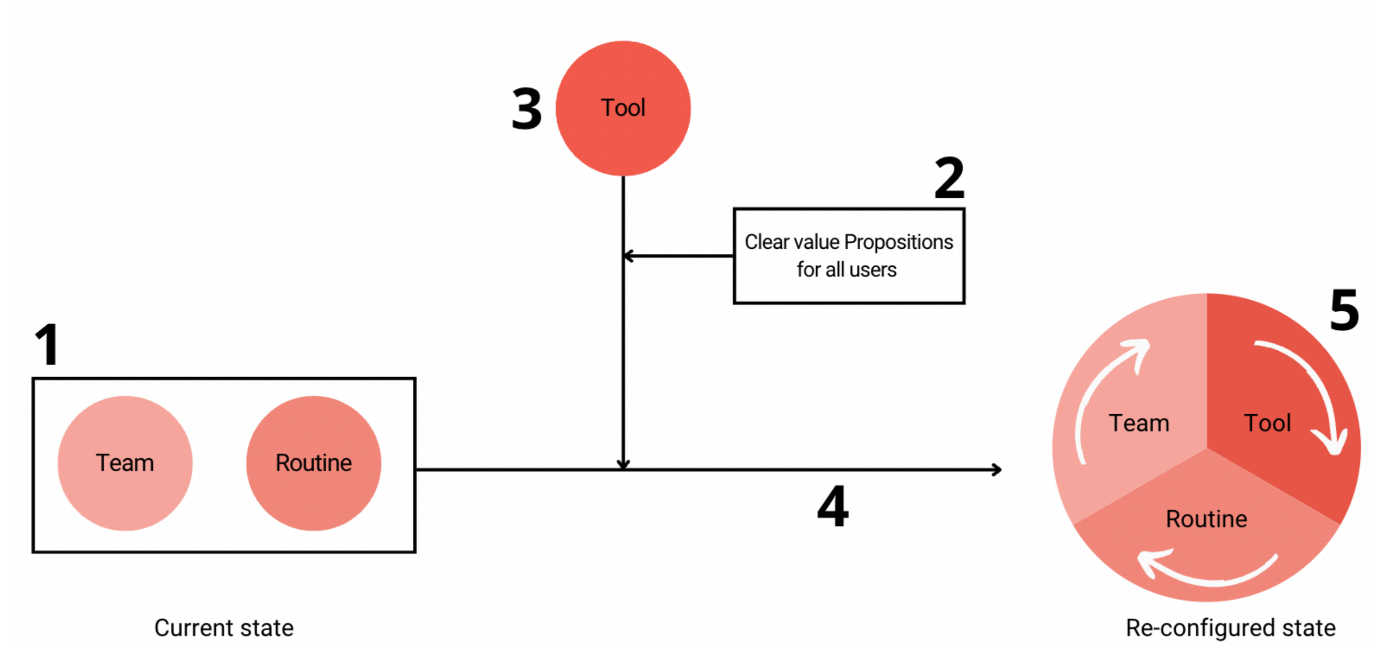


Figure 20: The Tool, Team, Routine framework (author's own illustration)

In this framework, 'Value Proposition Design' (VPD) plays a critical role. VPD challenges all users of the new technology to be brutally honest when examining the actual value that a new technology may bring to their current way of working. These values can differ for each user. For example, the users of the SMART Triage platform (neurologists, pediatricians, cardiologists, and ambulance personnel) will likely have different expectations of what value it will bring to them.

While these values may vary for each user, the same new technology must meet all these different needs. If the technology fails to provide value to any of the users, they should be challenged by the designer to suggest adjustments to the service design so that it adds value to their working routine.

Therefore, VPD is an iterative design technique that aligns perfectly with the fourth goal for service design: *a systematic and iterative process that incorporates user-focused, interdisciplinary teamwork and continuous learning cycles*.

To increase the chances of successful implementation, the design process for SMART Triage will focus heavily on identifying the value propositions of each user. Users will be asked how the solutions can better accommodate their needs through using visual prototypes.

Figure 20 illustrates how the [Tool, Team, Routine] framework and 'Value Proposition Design' will be applied in the development of the SMART Triage platform. Below is an explanation of the numbers in the figure:

1. Current situation, without SMART Triage

2. The value propositions of all users (physicians + pediatricians) are collected through interviews.
3. Using these value propositions, a SB of the SMART Triage platform is created. This blueprint is iteratively improved through interviews and co-creation sessions with the end users.
4. Once the SB meets the value propositions of the users, the final SB will be created.
5. The final SB of the SMART Triage platform ensures that each user recognizes the value of the new tool to make it easier to integrate into existing work routines.

2.3.4 Service Blueprint tool

As mentioned in point five in figure 20, one of the key deliverables is a SB. According to Bitner et al. (2008), SBs are a highly customer-focused design technique that allows for the visualization of service processes, customer touchpoints, and the physical evidence associated with the service from the customer's perspective. In addition, SBs highlight and connect the underlying support processes with the organization that drives and sustains customer-focused service delivery (Bitner et al., 2008).

Considering the following advice from the PreVis team:

"Focus on identifying the technology needed to meet the user's needs and align with their existing way of working, rather than forcing users to adapt their workflow to the new technology"

a SB grounded in customer-focused service execution would be a good tool for designing the SMART Triage platform.

When taking a broader perspective beyond SBs, Blomkvist & Segelström (2014) highlight seven distinct service design techniques. While several of these techniques, such as customer journey maps and storyboards, are effective for capturing user-technology interactions, they fall short in mapping the deeper operational mechanisms of the technology. Given that the design process for the SMART Triage service requires alignment with underlying support processes and data flows, SBs were selected for this thesis as the preferred service design technique, as they effectively represent these aspects (Bitner et al., 2008).

As mentioned in the Delft Design Guide (van Boeijen et al., z.d.), intangible components (such as these underlying support processes) often require different design skills compared to tangible ones. Consequently, service design frequently demands strong teamwork and communication. Therefore, during the blueprint design phase, I worked closely with the project team to address gaps in knowledge related to backend processes and service delivery.

How the SB is structured, including its specific layers and elements is further explained in Chapter 3.2.

2.3.5 Using tools and frameworks in service design

It is important to recognize that service design is a general design approach in which various tools and frameworks can be used. In this project, the '*Quadruple Aim*' framework is utilized to make the service design approach more healthcare-specific. The '*Tool-team-routine*' framework adds an implementation-specific focus, while the traditional '*Service Blueprint*' serves as a tool to deliver the final design.

In my opinion, using frameworks within service design can help designers provide clear direction for a design, which can then be shaped with a design tool - in this case, the Service Blueprint.

2.4 User research

Integrating innovations into an existing healthcare system is a complex task that requires a well-structured planning process, actively involving all (key) stakeholders (Franco-Trigo et al., 2020). To achieve successful integration, the diverse perspectives and opinions of stakeholders who have an interest in, influence over, or are impacted by the innovation must be considered throughout the design process (Franco-Trigo et al., 2020). Therefore, this chapter provides a comprehensive analysis of the key stakeholders, outlines the interview approach, and presents the insights derived from these interviews.

2.4.1 Stakeholder analysis

To determine which stakeholders should be involved in the design process, a stakeholder analysis can be utilized. A stakeholder analysis is defined as an approach aimed at understanding who the stakeholders are, and based on the information collected, prioritizing which stakeholders should be involved in the design process (Franco-Trigo et al., 2020).

According to Reed et al. (2009), the steps for conducting a successful stakeholder analysis are as follows:

1. Identifying the stakeholders
2. Differentiating or categorizing stakeholders based on attributes such as power, position, and level of interest
3. Investigating the relationships between stakeholders

Step 1: the identification of the stakeholders

As the project team for the SMART-Triage project had been established some time before the start of my graduation project, most stakeholders had already been defined. I extracted a list of stakeholders from internal documents at the RAV about the SMART Triage initiative and verified this with the project team.

It is important to note that stakeholder identification is typically an iterative process, during which additional stakeholders may be identified and added as the analysis progresses. If, during the process of this project, stakeholders are found to be missing, they will also be added later in the study.

Step 2: the differentiation or categorization of stakeholders based on the study of stakeholder attributes (power, position, level of interest, etc.)

A power/interest matrix was developed, which specified the extent the stakeholders are engaged in the project (Reed et al., 2009). This matrix is shown in Figure 21.

In the power/interest matrix, key players are stakeholders with both a strong power and high interest in the project, making them essential for active engagement. Context setters are highly influential, while their interest is limited. It's important to consult and inform the context setters because they can form a potential risk for the project. Subjects, though highly invested in the project, have limited influence and therefore cannot drive substantial change independently. However, their influence may grow through alliances with other stakeholders. Lastly, the "Crowd" represents those with minimal interest or influence, requiring little attention or engagement in the project. (Reed et al., 2009)

Below is an explanation of how the various stakeholders are involved with the project. It's explained in such a way that you understand why they are placed like this in the interest/power quadrant.

Players: (Collaborate and manage closely)

- Neurologist, cardiologist, pediatrician:

Each organization provides one representative from these specialties. This physician is closely involved in the development of the SMART Triage platform and is responsible for engaging other physicians when necessary. As the primary end-users of the platform, they will play a key role in determining its final design.

- RAV personnel

Each ambulance consists of a driver and an ambulance nurse. The ambulance nurse will primarily be the user of the SMART Triage platform and will communicate with the physician, making their input essential during the platform's design phase.

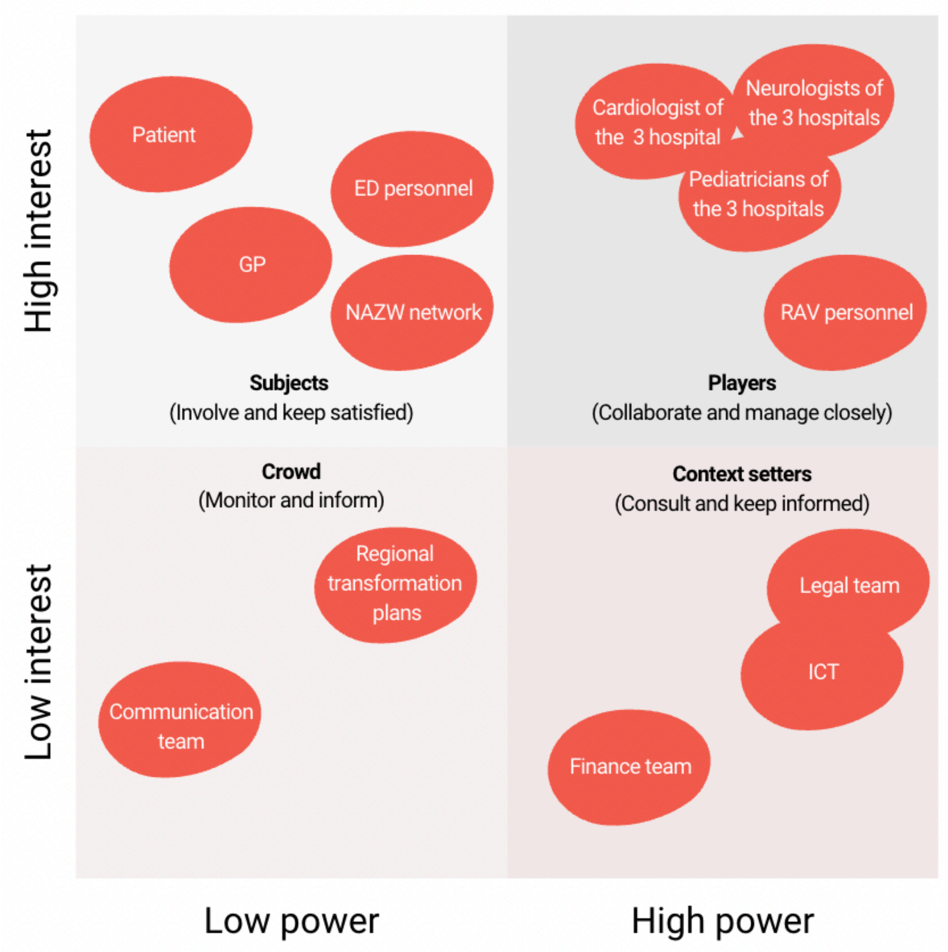


Figure 21: Involved stakeholders placed in a power/interest matrix

Subjects (Involve and keep satisfied):

- GP

As a key link in acute care, they need to sign the agreement for the SMART Triage project. However, they currently have no active role of voice in how the platform will be designed.

- NAZW Network

The Network Acute Care West (NAZW) is a key player in organizing and coordinating acute care in the Hollands Midden region. Their mission is to improve acute care in terms of availability, accessibility, and quality. In the SMART Triage project, they play a crucial role in connecting various healthcare institutions and must be kept informed of ongoing developments (NAZW, 2023). However, they do not have a key role in how the platform is being designed.

- Patient

Each organization has a patient council that acts as a sounding board group. These councils consist of patients who are being updated on SMART Triage from time to time. However, they do not influence the design of the platform.

- ED personnel:

Although ED personnel will not directly engage with the SMART Triage platform, they are included in discussions to ensure that developments within the ED are considered during the platform's evolution.

Context setters: (Consult and keep informed)

- Finance team

This team is developing the financial strategy for SMART Triage. Currently, funding comes from a designated budget during the development phase, but the long-term financing plan must include negotiations with healthcare insurers.

- ICT:

Each organization has one representative in the ICT team. Successful implementation will require close collaboration with this team, and I will work closely with them to make the implementation of the platform more feasible. Their level of power is high due to their responsibility for technical development and integration. However, their interest is low, as this project is just "one of many" they are involved in.

- Legal team:

Each organization provides one representative to participate in drafting and signing the cooperation agreement, which includes budget considerations. They review the project to ensure compliance with legal regulations and are involved in negotiations with suppliers.

Crowd: (Monitor and inform)

- Regional transformation plans

Currently, there are many regional projects focused on the digitization of healthcare. These projects are not directly linked to SMART Triage, but these initiatives are kept informed as these projects may potentially align in the future.

- Communication team

This internal team is responsible for the communication strategy around SMART Triage. Effective communication is critical in the healthcare sector, as increased interest can facilitate funding of new projects. However, the team primarily serves as a spreader to external stakeholders.

Step 3: investigating stakeholder relationships

A commonly used method to map relationships between stakeholders is the actor-linkage matrix. In this approach, individual stakeholders or stakeholder groups are visually organized, and the connections between them are described using specific keywords. To categorize the interactions between stakeholders, I choose 3 of the total 5 defined labels from (Guise et al., 2024):

1. Communication (stakeholders share information only)
2. Coordination (stakeholders from separate organizations work together to achieve common goals)
3. Fully linked (actors work together as a formal team; mutually plan and share resources to accomplish common goals)

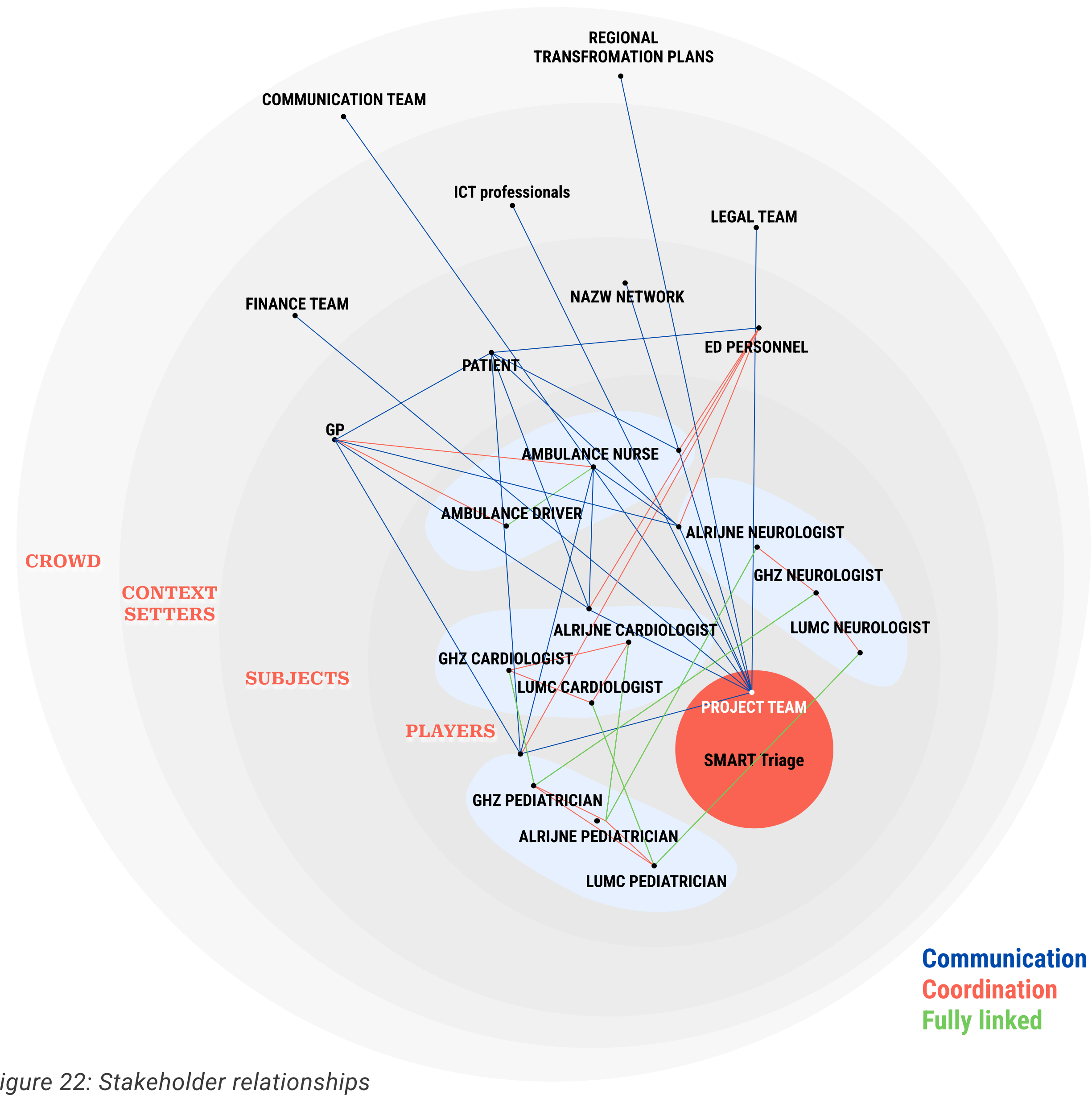


Figure 22: Stakeholder relationships

A notable observation from the stakeholder map in Figure 22 is that the project team is the only entity connected to all layers – players, subjects, context setters, and the crowd. In this analysis, the subjects and players are not directly linked to the context setters or the crowd. This disconnect could result in a lack of awareness among players and subjects regarding the actions and decisions of the context setters and the crowd, potentially leading to misalignment within the project.

In this context, the project team serves as a critical connector between the various stakeholder groups. This role emphasizes the importance of the project team taking responsibility for maintaining these connections, both during and after implementation, to prevent the risk of misalignment. I believe that ensuring continuous alignment across stakeholder groups is essential for the project's long-term success.

Conclusion stakeholder analysis

For my own research, this means that I will actively work together, interview, and co-create with the Key Players and that I will have to validate my results with some context setters and subjects, like the ICT professionals and ED personnel.

2.4.2 Interviews methodology

For this part of the user research, I have chosen to use semi-structured interviews as the primary data collection method. This approach is particularly suitable for this study because it allows me to explore the thoughts, feelings, and beliefs of the users of the platform (DeJonckheere & Vaughn, 2019).

Semi-structured interviews offer flexibility while ensuring all necessary topics are addressed (DeJonckheere & Vaughn, 2019). This flexibility is valuable as it allows for adaptive questioning based on the answers of the interviewee. Moreover, since the interviews are not the only source of data (see Figure 10), it is beneficial to incorporate insights from previous studies during the interviews.

DeJonckheere & Vaughn (2019) recommended using the following seven steps to conduct semi-structured interviews in care research:

1. Determining the purpose and scope of the interviews

Research questions (RQs) are the driving force of a study because they are associated with every other aspect of the design. Qualitative research questions typically start with *'What'*, *'How'*, or *'Why'* and focus on the exploration of a single concept based on participant perspectives (DeJonckheere & Vaughn, 2019).

The overarching research questions for the interview were:

RQ1: *What are the expectations of the users regarding the functionality and usability of the SMART Triage platform?*

RQ2: *What are the minimum technical and operational performance criteria that the SMART Triage platform must meet to ensure successful implementation?*

RQ3: *What are the potential future expansion possibilities for the SMART Triage platform?*

2. Identifying the participants

To gain a clear understanding of how the SMART Triage platform should be used, I interviewed all the platform's users, also shown in table 1. To understand the varying workflows across different hospitals, I aimed to speak with as many users from different hospitals as possible.

3. Considering ethical issues

At TU Delft, all research involving Human Research Subjects, including Master's theses, requires approval from the Human Research Ethics Committee (HREC) before it can go ahead (TU Delft, z.d.).

This graduation project complies with the HREC ethics code, with the required checklist provided in Appendix B. To ensure permission to record the interviews and use the data for my master's thesis, I asked each participant to complete and sign a questionnaire.

4. Planning logistical aspects

To contact the participants, I sent them an email. After scheduling the data, I aimed to conduct most interviews in person at the hospital or the RAV, however not all interviews could be held in person, so these were conducted online via Microsoft Teams. The locations of the interviews are listed in the participant's Table 1.

With the participant's consent, all interviews were recorded using my mobile phone or Microsoft Teams recording, allowing me to fully focus on the conversation without taking notes (DeJonckheere & Vaughn, 2019). The recordings were later transcribed using the Goodtape website (Goodtape, z.d.).

The qualitative research software ATLAS.ti was used to organize, manage, and analyze the data (ATLAS.ti, z.d.-a).

5. Developing the interview guide

Semi-structured interviews include a short list of 'guiding' questions that are supplemented by follow-up questions that are dependent on the interviewee's responses (Kallio et al., 2016).

As advised by DeJonckheere & Vaughn (2019), I aimed to formulate the questions as open-ended, neutral, and clear as possible. Four different interview templates were developed, as questions varied slightly for cardiologists, neurologists, pediatricians, and ambulance nurses. For example, I included more questions about the implementation of the HARTc1.0 system for the cardiologists, explored the role of parents with pediatricians, and focused on the video system with the neurologists.

Table 2 outlines the main topics covered in the interviews for each user group.

An example of the interview guide for cardiologists can be found in Appendix C. The interview guide was validated with 3 people from the project team before starting with the interviews. Besides, it is important to note that as I gained more knowledge about the topic and experience with the interviews, I adjusted, deleted, or added some questions before each interview.

6. The interview

In total 10 interviews were conducted, and most of them lasted between 30 and 60 minutes.

7. Analysing the data

After each interview, I immediately transcribed and coded the data to ensure the information was still fresh in my mind, allowing me to note any missing details for follow-up in subsequent interviews. In total, I identified 330 codes, all of which were organized into a network.

Profession	Participant	Hospital	Interview date	Contact
Neurologist	N1	LUMC	25-09-2024	In person
	N2	GHZ	23-10-2024	Online
Cardiologist	C1	LUMC	01-10-2024	In person
	C2	Alrijne	11-10-2024	Online
	C3	GHZ	04-11-2024	Online
Pediatrician	P1	Alrijne	04-10-2024	Online
	P2	LUMC	05-11-2024	Online
	P3	GHZ	07-11-2024	Online
Ambulance nurse	A1		22-10-2024	In person
	A2		15-10-2024	Online

Table 1: Interview participants table

Topic	Neurologist	Cardiologist	Pediatrician	Ambulance nurse
Getting to know each other – break the ice	X	X	X	X
Project introduction	X	X	X	X
Introduction questions	X	X	X	X
Current way of working	X	X	X	X
Technical resources	X	X	X	X
Contact with other hospitals	X	X	X	
SMART triage consultation	X	X	X	X
Patient files – history	X	X	X	X
Implementation barriers	X	X	X	X
HARTc1.0		X		X
Audio consult	X		X	X
The role of the parents			X	X
Potential risks	X	X	X	X
Further research	X	X	X	X

Table 2: Interview topics per participant

2.5 Research key results

After transcribing and coding all interviews, the insights were categorized. But, as mentioned earlier, the data collection phase included not only interview insights but also findings from previous initiatives. Many of these findings aligned with the interview insights, but four aspects from the 'inner setting section' were not mentioned in the interviews. These were subsequently added to the overall insights list.

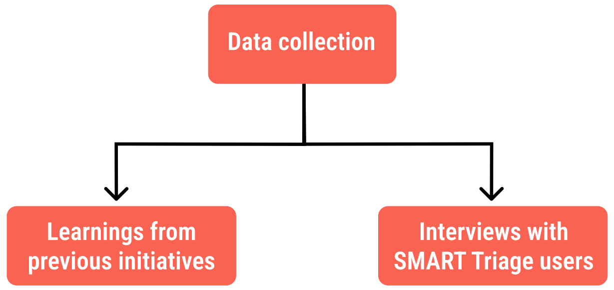


Figure 23: Two ways of collecting data for the design phase

Because the aim was to identify value propositions for all users, the insights were also formulated as 'Value Creation Statements.' These statements explain what a user needs in a particular situation and why they need it. Each statement was structured in the following way:

"When (situation) …. Do I want (action) ….. so that ….. (expected outcome)"

Note: all similar quotes from the interviews have been summarized into a single statement. The letter used for each statement (C–cardiologist), (N–neurologist), (P–pediatrician), and (A–ambulance personnel) indicates who made the statement.

De 3 main themes are based on the research questions that were phrased at the start of the interviews:

1. Expectations regarding functionality and usability
2. Minimum technological and operational performance criteria
3. Potential future expansion opportunities for the platform

The main themes with their sub-themes are shown on the next pages. The sub-themes are further elaborated upon in the text, supported by one or two supporting quotes from the interviews.

2.5.1 Theme 1: Expectations regarding functionality and usability

Subtheme 1: A unified platform for all users

The SMART Triage platform should be a unified platform usable by all users in any situation. It must be adaptable to the specific needs of different users. For example, cardiologists prioritize immediate access to ECGs, while neurologists focus on the video image. Therefore, it is essential that users can customize the platform's layout according to their preferences. Additionally, the platform should be designed for scalability, allowing for future expansion with new functionalities and users.

C1: "My ultimate dream is to create a single platform where ambulance personnel can consult various specialists. We currently have HARTc1.0, and the development of the SMART Triage platform truly opens new possibilities."

Subtheme 2: The usability of the device of the ambulance personnel

Ambulances are already equipped with many technologies. A key request from ambulance nurses is to integrate the consultation equipment with existing devices, such as the Zebra phone or the iPad used for the DRF. Additionally, the camera system must be 'vandal-proof' to withstand extreme situations. Finally, there are several usability lessons from previous initiatives regarding the camera system: (1) The camera should not always be visible to avoid giving patients the constant impression that a video consult is available and to avoid stressful situations for psychiatric patients, (2) The camera should have minimal buttons, ensuring straightforward operation during patient care, (3) When using multiple cameras, they must easily connect.

A3: "As an ambulance service, we focus on emergencies. The longer we spend at a patient's home, the less available we are for urgent cases. Extended consultations reduce our availability for critical emergencies."

A2: "Keep it simple. Everything should be click-and-go. We won't use fragile devices with cables that need connecting—integrate them into equipment we already have."

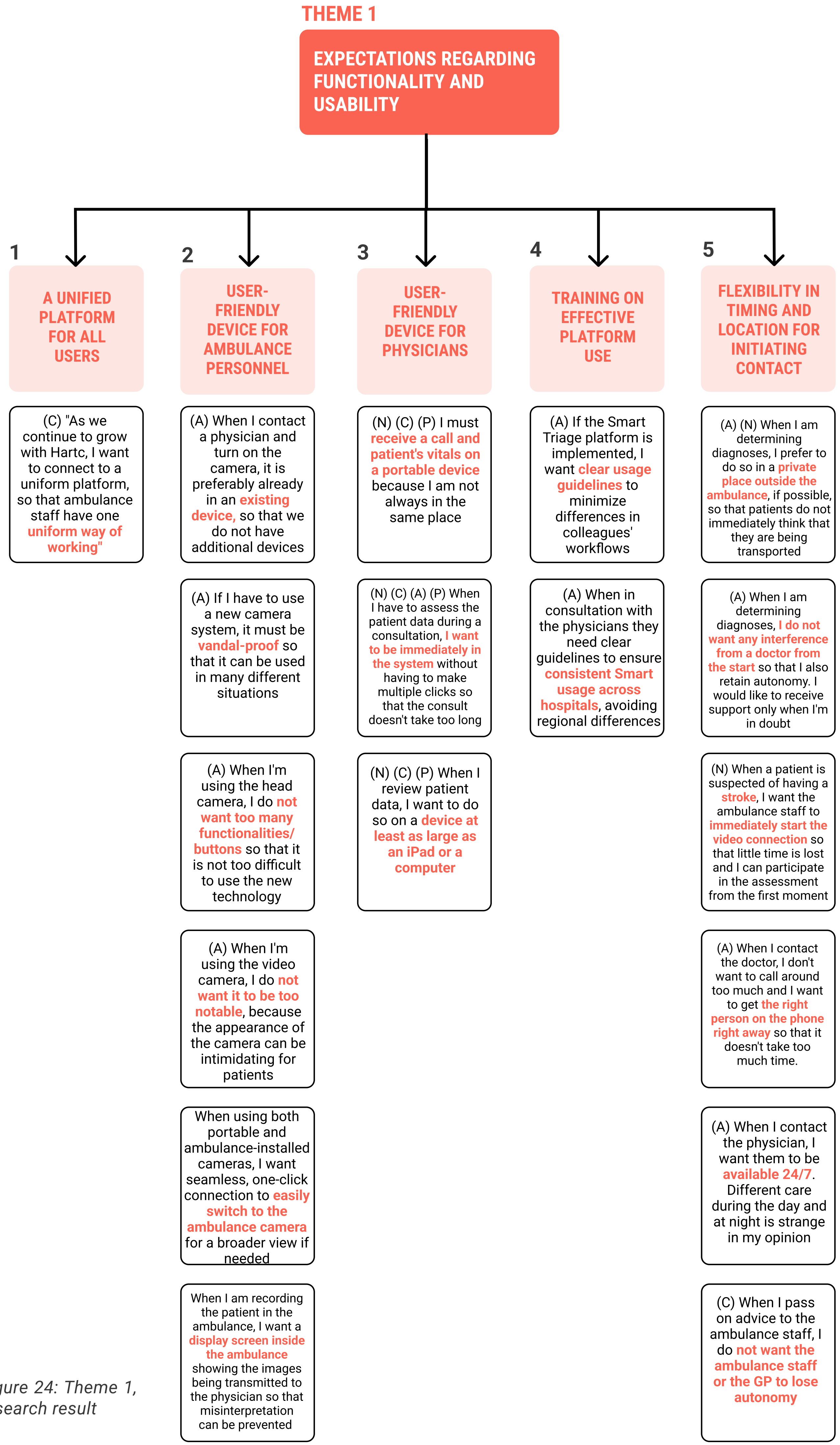


Figure 24: Theme 1, research result

THEME 2

MINIMUM TECHNOLOGICAL & OPERATIONAL PERFORMANCE CRITERIA

6 REAL-TIME DISPLAY OF PATIENT DATA FOR IMMEDIATE ACCESS

- (N) (P) When I have a consultation, I want to be able to see the **vital parameters, BSN, patient history, DRF information and video on one screen.**
- (C) When I have a consultation, I want to be able to see the **vital parameters, ECG, previous ECGs, DRF information, and patient history in one screen**
- (C) When I view the patient's information, I would like to have the information from **corsium linked to the information in epidivision**. I want to be able to open both of these on my phone, iPad, computer, website

7 AUDIO COMMUNICATION BETWEEN PARAMEDICS AND PHYSICIANS

- (A) When I contact the physician, the speaker must be on **speaker** so that I can treat transparently and so that the family can listen immediately
- (N) (C) (A) When I communicate with the ambulance personnel, I want to be able to give them instructions to perform tests on the patient so the **hands of the ambulance nurse should be free** while I can see what they are doing at the same time
- (N) (C) (P) When I communicate with the ambulance staff I want us to be able to **hear each other clearly** so that I can ask questions and they can answer
- (C) When I communicate, I also want to be able to **ask the patient questions** so that we can decide together about the treatment

8 VIDEO COMMUNICATION BETWEEN PARAMEDICS AND PHYSICIANS

- (A) When I turn on the camera, it must be possible to **control it with 1 click or voice control** so that the threshold for use remains low
- (N) (A) When in consult, it's **not always necessary to see the physician's face**, but in some situations it can be nice for patient validation and trust
- (N) When I see a patient on video I want to be able to **zoom in and zoom out** so that I can test both body movements and eye movements
- (N) (C) (P) When I see a patient on video I want a **qualitatively stable image** because in doubtful situations it is the small movements that make the difference
- (N) When I see a patient via video, it would be great to be able to **control the camera remotely** so that I can control which image I see
- (C) When I consult with the ambulance staff, I **don't always need video** during ambulance consultations, as I rely on staff descriptions. However, it can be useful in cases where the issue may not be cardiac

9 PLACE TO DOCUMENT EACH CONSULTATION

- (A) (N) (C) (P) If the ambulance nurse makes a decision, it is their responsibility to **properly document** the consult so that other ambulance personnel and the treating physician can see exactly what is discussed
- (A) If I transfer a patient to the hospital, I would like to show the video images so that I can **demonstrate the patient's condition when we arrived**
- (A) When a new technique is to be used, I want the DRF to be integrated or at least only have to **document in one place**
- (N) When a patient is transported to the hospital after advice, I would like to speak to the attending physician to ensure a **warm handover of the patient**
- (N) When I transfer a patient to the **HMC**, I want them to also be able to **receive the consultation information**

10 GIVE INSIDE IN BED CAPACITY

- (C)(N)(P) When I give advice, I want me or the ambulance staff to be able to see in which hospital there is **bed capacity** so that patients have to be transferred as little as possible

Figure 25: Theme 2, research result

THEME 3

POTENTIAL FUTURE EXPANSION OPPORTUNITIES

11 EXPANDING THE PLATFORM TO ADDITIONAL USER GROUPS

- (A) When I come into contact with a **psychological patient**, I would like to have a video with my audio consultation, because how someone acts is sometimes difficult to describe
- (A) When I have doubts about a patient with **lung complaints**, I would like to turn on the camera to show how hard someone has to work to take in air
- (A) When I arrive at a patient, I would like to have a video image of the call to the **control room**, because it is sometimes difficult to predict what situation to expect
- (P) If we roll out SMART Triage, **GPs** should also utilize consultations with us, as this would help filter out many children who don't need ED care.

12 UTILIZING THE PLATFORM AS A FEEDBACK SYSTEM FOR THE PARAMEDICS

- (A) I would like to **receive automatic feedback from the hospital** so that I know how a patient is doing and whether my diagnosis is correct or not and so that I can learn from the decisions I have made
- (P) The images can be used to better **train ambulance personnel** so that they have to make fewer calls in the future

13 INTEGRATING AI TO ENHANCE PLATFORM CAPABILITIES

- (N) When I am in a consultation I want the conversation to be transcribed by AI for **quality control**
- (N) Once I have formed an opinion, I want the images to be saved for **AI training** so that the triage consultation by a neurologist does not have to be performed twice in the future
- (A) When I talk to the patient and make a decision I would like to wear a microphone so that the **DRF is automatically filled in** so that I save a lot of time

14 INCORPORATING TOOLS FOR IN-DEPTH PATIENT DATA ASSESSMENT

- (C) When I view patient data, I would like to do so via **smart glasses** so that I can put on my glasses anytime and anywhere and view the data.
- (N) When I answer the phone, I want to be able to assess patient data from home so that I can also **assess the patient at home**
- (C) I would also like to advise the ambulance nurse to leave an ambubox at the patient's house so that we can **remotely control the condition of the patient.**
- (C) When the ambulance personnel call me, I want them to be able to measure **troponin** so that the HEART score can be determined
- (C) When I assess **ultrasound** images in the future, I want to instruct the ambulance staff on how to do this because small movements with the ultrasound machine are very precise.
- (P) If consultations extend to GPs, the ambulance can assist with accurate **saturation measurements**, reducing unnecessary hospital referrals due to incorrect measurements.

15 CONNECTING PATIENT'S MEDICAL HISTORY TO THE PLATFORM

- (A, C, N, P) During a remote consult, I want the patient's history from all hospitals and GPs to understand their symptoms and specialist agreements, **aiding proper hospital referral and better patient assessment**
- (A) When I make a decision, I **do not want to be influenced by the bias** of the data from previous rides so that I can make my own decision, especially with psychological patients

Figure 26: Theme 3, research result

Subtheme 3: The usability of the device for the physicians

With HARTc1.0, cardiologists can currently answer the phone with their mobile phones and view the vital signs of the Tempus Pro Monitor on their phones as well as on the computer when a bigger screen is needed. This system works well, and the neurologists prefer a similar setup. The most important thing is that physicians can access patient information across different devices (computers, smartphones, iPads), depending on their preference.

N1: "Everyone in the hospital can quickly access a PC, but if you're in the restaurant during lunch, you need to be able to take a consult on the spot."

P3: "You'll need at least an iPad or a computer to properly assess patient video images."

Subtheme 4: Training on effective platform use

The interviews revealed significant differences in how ambulance staff and physicians operate, despite the existing guidelines. Some ambulance nurses tend to quicker transport patients to the ED compared to other colleagues. Additionally, hospitals in Gouda rarely use the HARTc1.0 number, while it is more frequently used in Leiden. To ensure consistent practice, clear agreements are needed on how the platform should be used, preventing regional variations.

A3: "If SMART Triage is implemented, proper training on platform use and its benefits is crucial to avoid significant differences in usage."

A3: "In Gouda, cardiology always welcomes patient admissions, but at Alrijne, you almost have to pitch why a patient should be seen."

Subtheme 5: Flexibility in timing and location for initiating contact

Currently, HARTc1.0 consultations are available from 9:00-21:00, but ambulance staff hope that, once SMART Triage proves itself, 24/7 consultations will be possible. Besides, it must be clear who to call for the consult. Ideally, ambulance nurses should always call the same number to reach the physician on duty. Ambulance staff prefer to contact physicians only when they are uncertain, to maintain their autonomy. Neurologists, however, want to be contacted before arrival to have the chance to better study the impact of video consultations. Lastly, ambulance nurses prefer to consult outside the ambulance, when possible, to avoid patients assuming they will be transported.

A3: "I only want to consult a physician when I'm unsure. If the neurologist takes over entirely, what's my role?"

N2: "To truly assess the impact of video consultations, every suspected stroke patient should be brought in for proper comparison of the effect of SMART Triage."

A2: "With partial availability of physicians, care differs between day and night, which I find problematic."

Subtheme 6: Real-time display of patient data for immediate access

During consultations, physicians require real-time patient data, including (1) vital parameters, (2) BSN, and (3) DRF information. Neurologists additionally need video images, while cardiologists see this as a "nice to have" but prioritize access to ECGs from previous ambulance rides.

C2: "Ideally, I would like to see the patient's medical history displayed, but if that's not immediately possible, having the BSN number would allow me to retrieve it and make a more accurate assessment"

2.5.2: Theme 2, Minimum technological & operational performance criteria

Subtheme 7: Audio communication between ambulance care professionals and physician

For effective communication between ambulance staff and physicians, a reliable audio connection is essential. Neurologists and cardiologists may want to conduct tests on the patient, which require giving instructions from the physician to the ambulance nurse. It's important for the ambulance nurse to have their hands free during a video call. In some cases, it's beneficial to use the speaker function, allowing the ambulance nurse to conduct a transparent consultation. This also enables the family to listen along, and the physician can directly ask the patient questions if needed.

A2: "I prefer to treat patients transparently, especially when family is present. That's how I would want to be treated myself."

Subtheme 8: Video communication between ambulance care professionals and physician

For camera use, the system must be operational with a single click, as any complexity would create a barrier to use. High-quality video is crucial, and neurologists want the ability to zoom in and out to examine eye movements and body motions.

Both the neurologist and ambulance nurse agree that seeing the physician's face isn't necessary during the consultation, though it could be valuable in the future for patient validation and building trust.

A2: "Uncertainty arises with very subtle signs, like slight speech disorders, eye movements, or minor pains that are hard to recognize. In these cases, it's incredibly helpful for a doctor to observe, but these subtle signs require good video quality."

Subtheme 9: Place to document each consultation

During and after the consultation, the ambulance nurse is responsible for documenting the session so that colleagues can review what was discussed. Ideally, this is recorded in the DRF. Consulting physicians also want a separate tab/section in the DRF where they can add their notes, ensuring that the treating physician can access them.

N1: "If I need to pass on important information to the treating neurologist during my triage shift, I want to be able to do that directly through the platform."

Subtheme 10: Give inside in bed capacity

With HARTc1.0, the bed capacity app is already in use. It would be helpful for physicians to see where beds are available, allowing them to advise on the best hospital for the ambulance to head to during a consultation.

A3: "If I could check bed capacity at each hospital, I'd know who to call. If I see there's no bed available at LUMC, I can immediately call Alrijne hospital and let them know I'm on my way."

P2: "If I had better insights into bed availability, I would know more precisely where to direct a child, reducing the need for transfers and minimizing stress for both the child and their parents.

2.5.3: Theme 3, Potential future expansion opportunities

Subtheme 11: Expanding the platform to additional user groups

As mentioned earlier, the platform will initially be used by ambulance care professionals, neurologists, cardiologists, and pediatricians. However, users already see many potential expansions for future use, such as for psychological patients, lung patients, and incorporating video images in the dispatch center. Additionally, pediatricians are keen to move towards a system where GPs can consult with them directly, as the number of children unnecessarily referred by GPs is significantly higher.

P3: "One in ten, or even two in ten of the children referred by GPs don't need ED care. Concerned parents play a significant role in this."

A2: "Psychiatry is a significant challenge for us. We don't have much experience in distinguishing psychotic behavior, which can sometimes take up to 1.5 hours just to manage such a patient."

Subtheme 12: Utilizing the platform as a feedback system for ambulance care professionals

In cases of uncertainty, ambulance nurses would appreciate feedback to know whether they made the right decision. Additionally, the recorded images could be used for training, helping ambulance nurses become more confident and reducing the need for future consultations.

P1: "The footage could be used for training so that ambulance nurses feel more comfortable and confident when dealing with children in the future."

Subtheme 13: Integrating AI to enhance platform capabilities

AI could play a significant role in the future of the SMART Triage platform. It could assist with transcribing consultations and automatically filling in the DRF. Additionally, stored videos could be used to train AI, potentially reducing the need for neurologists to perform the same triage consultations twice.

N1: "There is a strong need for real videos to train AI so that it can assess cases of uncertainty."

Subtheme 14: Incorporating tools for in-depth patient data assessment

There are many future ideas for accessing patient data, such as using SMART glasses to view it anywhere, including from home. Additionally, physicians want to collect more patient data in the prehospital phase. Cardiologists are already making significant progress in developing troponin meters, enabling troponin measurements in the ambulance. They also hope to perform ultrasound imaging in the ambulance.

C1: "By assessing multiple data streams, such as troponin levels and ultrasound images, we can evaluate patients more effectively. The ambulance nurse is already capable of measuring this, but we lack the necessary technological integration."

Subtheme 15: Connecting patient's medical history to the platform

The top priority for all users is integrating patient medical history into the platform. This would allow them to determine if certain symptoms are typical and understand any agreements with specialists during the consultation. It would also assist in referring patients to the appropriate hospital. Currently, accessing records from other hospitals or GPs is not possible, but there is a strong desire for this functionality. Other projects are working toward this goal, and it would be beneficial if they could later integrate with the SMART Triage project.

N2: "Patients can be treated without their medical history, especially in acute cases, but having that history often helps in making a quicker diagnosis, particularly for patients with functional disorders."

2.5.4 Risks

At the end of each interview, I asked participants the following question: "*What potential risks do you foresee when working with SMART Triage?*" The risks identified are summarized below, supported by participant quotes:

1. **Patient Privacy and Consent for Video Recording**

A1: "How will you appropriately handle privacy regulations if a patient is unconscious and might not want to be filmed?"

2. **Impact on General Practitioners' Autonomy**

C1: "With Hartc1.0, GPs can also request a consultation with a cardiologist, which does impact their autonomy. They used to have full control over their patients and decided what would happen. With Hartc1.0 consultations, that changed. A lot of effort went into managing this relationship, and it's important to do the same with SMART Triage."

3. **Changing Patient Flows**

C1: "Sometimes, you have patients who live alone and need to be seen, but the hospital isn't the right place for them. Even though their destination is unclear, the ambulance must deal with the patient, so now they often bring them to the hospital. SMART Triage will likely change these patient flows, and this needs careful consideration. With Hartc1.0, we also had to adapt to new patient flows initially, but it was resolved over time."

4. **Responsibility for Decision-Making**

C1: "Clear agreements about responsibility are crucial. With Hartc1.0, the agreement is that the ambulance nurse always has the final responsibility, even if the specialist has a different opinion."

5. **Leaving Patients at Home Who Should Have Been Taken to the Hospital**

N1: "The biggest risk is leaving people at home who should have been seen. This needs to be monitored very closely in the beginning. That's why it's essential to thoroughly document everything in the Elektronisch Patiënten Dossier (EPD) and DRF."

7. **Technical Issues, Such as Internet Connectivity**

P1: "I'm concerned about technical problems during consultations, such as unstable internet connections. The connection must always be stable, even within concrete walls or stairwells in apartment buildings. There should also be clear protocols for what to do if the connection is interrupted."

8. **Interference from Physicians and Loss of Autonomy**

A1: "It shouldn't happen that a physician takes over my entire case remotely, preventing me from doing my job properly."

More reflections on potential risks will be provided in Chapter 6.2 *'Potential risks for SMART Triage implementation'*.

03
Design.

3.0 Design

With the conclusion of the research phase, the project has now come to the design phase. Building on the three themes identified during the research, decisions were made regarding the functionalities to be included in the Phase 1 SB and those to be added in the Phase 2 SB. Additionally, the layers considered most relevant for representing the SMART Triage platform within the SB were defined. These decisions were informed by examples from the literature and tailored to the specific relevance of this project.

Once the functionalities and layers for the SBs were determined, the Service Blueprints were constructed. Alongside these, application interface designs are presented in this chapter. These interface designs play a crucial role in the validation sessions, which are further discussed in Chapter 4.

3.1 Design process

The design process of the SMART Triage service includes 4 distinct steps which are also visualized in Figure 27:

1. Implementation phasing

This involves selecting the essential functionalities needed to meet the platform's primary objective and distinguishing those that can be added in a later stage. The technical feasibility of these functionalities was evaluated in collaboration with the IT department. Notably, the feasibility of certain functionalities (which also depend on costs and effort) is closely linked to the timing of their implementation within the platform.

2. Service Blueprint design

Building on the phasing step, SBs were created for both Phase 1 and Phase 2. These blueprints were tested for feasibility in collaboration with the IT department.

3. Interface design

In parallel with the development of the Service Blueprints, application interfaces were designed to clarify and further detail key interactions between users and the technology. Designing these interfaces required an in-depth evaluation of specific service elements. This process fostered an iterative approach, continuously moving back and forth between blueprint development and interface design to ensure consistency and refinement at every stage.

4. Tactical roadmap design

The tactical roadmap illustrates the implementation scale and technology rollout for Phase 1 and Phase 2. Additionally, the roadmap includes a proposed Phase 3, highlighting functionalities identified during interviews that could be relevant for future development beyond 2030. Chapter 5 provides a detailed explanation of how the tactical roadmap was designed and structured.

3.1.1 Implementation phasing

As discussed in the article of Bente et al. (2024), various factors – including legal, ethical, financial, and technological aspects – play a significant role in implementing new eHealth solutions. These considerations are also crucial in the rollout of the SMART Triage platform. Implementing all defined functionalities at once would be extremely costly, and besides, parts of the SMART Triage platform's development rely on other ongoing projects in the Hollands midden region. For example, integrating pharmacy medication overviews depends on accessing a national data hub (called LSP), and to display the bed capacity another platform (called LPZ) must be connected to the SMART Triage platform. The specifics of these other projects are explained in section 3.2.5, 'terminology data streams.

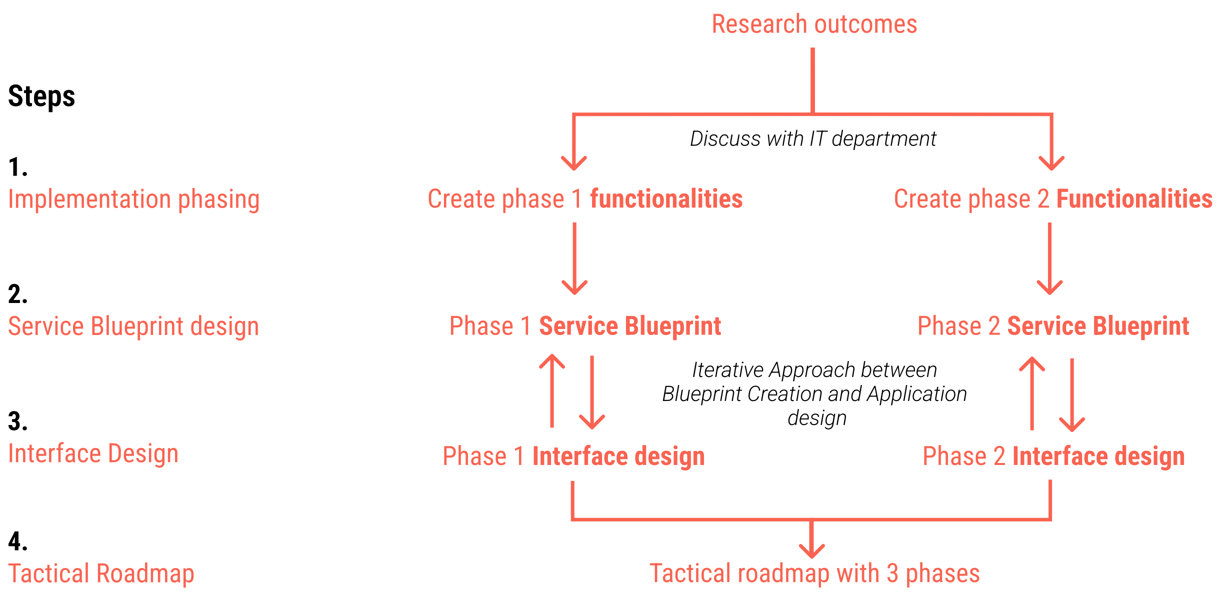


Figure 27: Visualization of the design process steps

Moreover, a phased approach provides valuable opportunities to learn from the initial implementation experiences. The focus of the IT department is on developing the Minimum Viable Product (MVP), which Stevenson et al. (2024) defines as "a set of minimal requirements that meets the needs of the core group of early users". This approach allows the platform's designer/developer to adapt the platform's setup and usage based on feedback, thereby increasing the likelihood of success in a broader rollout (Ross et al., 2018).

It is important to note that I believe it is the designer's role to ensure that expectations regarding functionality and usability are not overshadowed by the focus on implementing only the minimum in the first phase. My responsibility, therefore, is to maintain sufficient emphasis on the user experience throughout every stage of implementation.

For these reasons, the platform rollout consists of a 3-step approach. From here on, this will be referred to as:

Phase 1:

The 'minimum technological and operational performance criteria' are being implemented during the 'implementation period' from 2025 to 2027.

Phase 2:

From 2027 onward, if Phase 1 proves successful, users are used to the new technology, and additional financial resources are available, Phase 2 of the implementation will start. During this phase, additional functionalities will be integrated into the platform, and the platform will be further rolled out across other regions.

Phase 3:

This phase has been developed only from my perspective as a designer. It outlines platform functionalities identified during user interviews and validation sessions as potential directions for the future (>2030). It is important to note that Phase 3 only contains future ideas mentioned during the interviews. The functionalities for Phase 3 have not been detailed or validated with end users. Therefore, Phase 3 will not play a role further in this chapter. More information on Phase 3 will be provided in Chapter 5: *Implementation*.

In collaboration with the IT department, a "set of minimal requirements to meet the needs of the core user group" was defined, making sure that these requirements are also technically feasible for short-term implementation. This set has been incorporated into the Phase 1 SB, while the additional functionalities have been included in the phase 2 SB.

Before creating the SBs, a visual representation of the SMART Triage platform for Phase 1 and Phase 2 was developed. These high-level visualizations with description of the main functionalities served as a starting point for further detailing the service's design and structure. The visualizations are presented on the next page.

The functionalities of the platform that are being implemented from **Phase 1** (see figure 28) are:

- The SMART Triage platform enables remote consultations (audio + video) with neurologists, cardiologists, and pediatricians.
- The platform provides a real-time overview of the patient's vital signs and ECG recordings
- The platform provides an overview of the patient's DRF information, including POC troponin levels, the HEART score, and the RACE score (explained in table 3)
- In addition to patient data, the bed capacity of the ED and Eerste Hart Hulp (EEH) can also be checked.
- If the physician wants to access a patient's EPD, they can only do so if the patient is registered in their own hospital, using the hospital's internal files and systems, independent of the SMART Triage platform.

The functionalities that will be added in **Phase 2** (see figure 29), in addition to those from Phase 1, are:

- Include more medical conditions like vulnerable elderly and psychiatric care.
- Expanding to more healthcare organizations, such as the use of SMART Triage by GPs.
- Integrating regional hubs like Sleutelnet/Gedeelde zorg (explained in chapter 3.2.5) into the SMART Triage platform, enabling access to the EPDs from all hospitals within the platform.
- Expanding the range of diagnostic information available to physicians (like ultrasound images).

PHASE 1

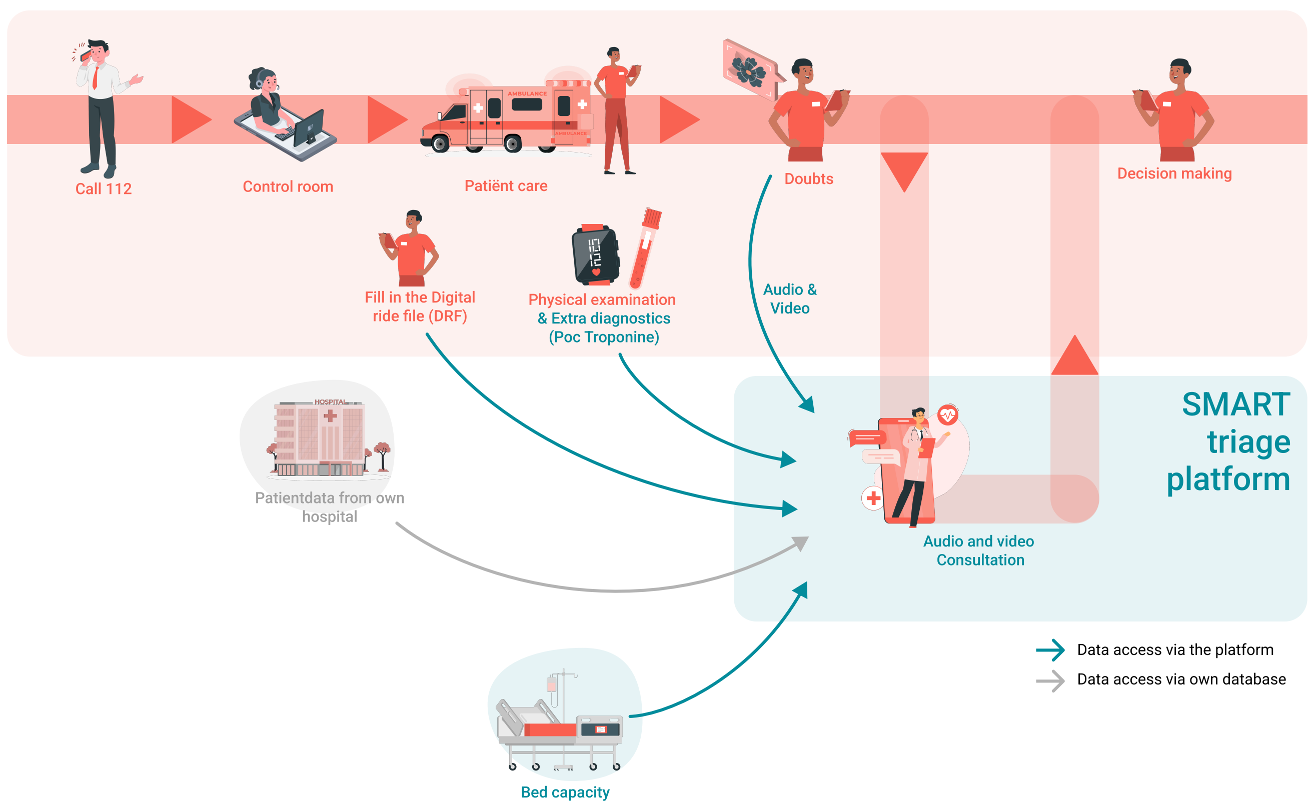


Figure 28: Phase 1 high level sketch

PHASE 2

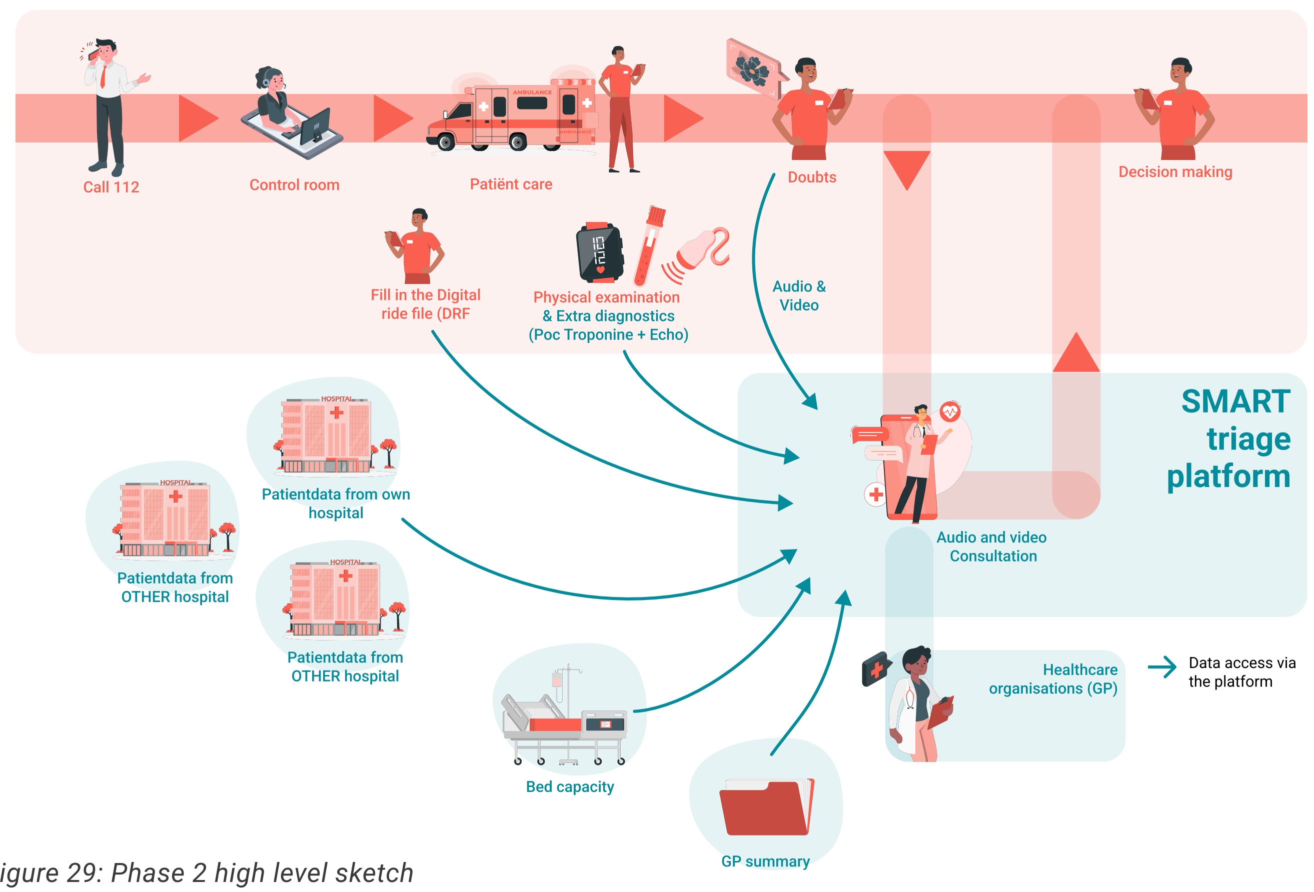


Figure 29: Phase 2 high level sketch

3.2 Service blueprint design

In Chapter 2.3.4, the rationale for selecting a SB as an appropriate design method for developing the SMART Triage platform has already been explained. This subchapter focuses on the design process and structure of the SBs themselves. It begins by explaining the structure of the SB and the key information they contain. It then outlines the rationale for complementing the SBs together with application interface designs. Finally, the SBs and a selection of interface designs are presented to provide a comprehensive view of the platform's development.

3.2.1 Parts of a Service Blueprint

According to Bitner et al. (2008), a typical SB consists of five components: physical evidence, customer actions, onstage/visible contact employee actions, backstage/invisible contact employee actions, and support processes. An example of a very simple SB is shown in Figure 30.

While these components served as inspiration, I adapted them for the following reasons:

1. There are no 'customers' or 'employees' in the SMART Triage context, but rather two user groups: ambulance nurses and physicians.
2. Both user groups use distinct technical devices needed to do the consultation, and these differences must be clearly represented and distinguished in the SB.
3. The SMART Triage platform is based on patient data, so I included a dedicated layer for data visualization.
4. In this project, privacy and legislation play a critical role, with discussions about how and where patient data is stored or whether it should only be displayed live without storage. Consequently, I added a database layer to the SB.

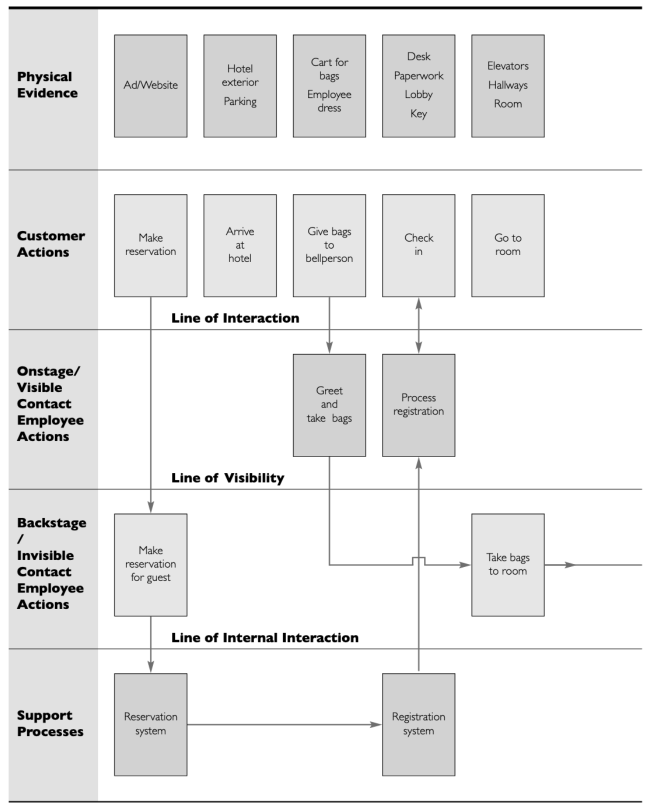


Figure 30: Blueprint of overnight Hotel Stay Service (Bitner e.a., 2008)

Based on these considerations, the following layers are included in the SB:

1. **Ambulance nurse actions**: Chronologically depicts all steps taken by the ambulance nurse during the service delivery process
2. **Physician actions:** Chronologically depicts all steps taken by the physician during the service delivery process
3. **Interaction with technology:** The two 'technology' lines showcase how the ambulance nurse and the physicians interact with the technology. These present actions performed by the user on a technical device. The icons highlight the devices on which the actions are carried out.
4. **Backstage actions:** Includes processes that occur behind the scenes and are not visible to the users. The actions are part of the SMART Triage service.
5. **Support process**: Captures activities that are not directly part of the service but are essential for delivering the SMART Triage service.
6. **Transferred data**: Indicates which data is retrieved through user actions and which data is sourced from specific databases.
7. **Database:** Specifies where information is stored or displayed.

The SBs include a '*line of interaction*', separating the users' actions from the technology. Additionally, a '*line of visibility*' distinguishes visible components (above the line) from invisible ones (below the line).

Vertical lines connect actions, while arrows indicate the direction of the interactions. The SB also includes numbered references linked to interface designs.

3.2.2 Interface design

In addition to identifying user preferences regarding their interaction with the service, digital platform application interfaces were also used during the design process to uncover unclear interactions that required further analysis. Based on my own experience as a designer, visually representing text often reveals gaps in understanding. This fact is also emphasized in the article by Blomkvist & Segelström (2014, p.332) which states that "a common trait of visualizations is that they can represent services in an external way, moving them out of the single designer's head to a shareable medium".

For instance, it became clear to me that I needed additional information about the visualization of data when considering how specialists would prefer to view the patient's vitals. Should the video image always be displayed alongside the patient's vitals, or should heart rhythm and blood pressure be shown simultaneously, or does this preference differ for each specialist? This realization highlighted the need for interface designs, which will be tested and validated alongside the SBs during the validation sessions.

Application interface

Before delving into the various sections of the blueprint, it is important to clarify the decision to run the SMART Triage platform as an application. This choice was made for the following reasons:

- An application is easily and quickly accessible across multiple devices
- An application can send push notifications when a physician is called – something a website, for instance, cannot do
- With unique login credentials, users can access a personalized interface
- Through an application, video and audio calls can be conducted seamlessly. This ensures that the video stream continues uninterrupted, even when switching mid-consultation from a phone to a computer
- An application can run personalized interface designs (as highlighted in subtheme 1)

Together with the IT department, it was therefore decided to develop interface designs specifically for a mobile application. However, it is important to note that the application can also be accessed on a computer or tablet, with the interface adapting to different screen sizes accordingly.

The interface includes a navigation bar with five distinct screens. Figure 31 illustrates how these screens are referenced.

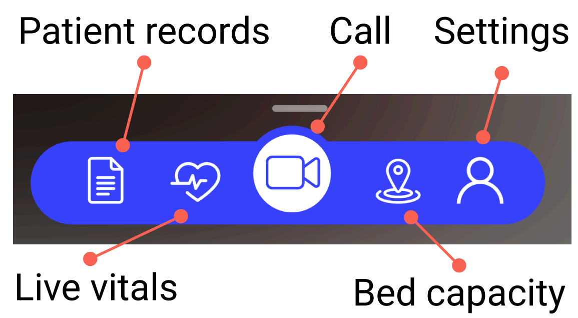


Figure 31: Navigation window interface application

3.2.3 Platform concept design phase 1

The SB for Phase 1 was developed based on insights derived from the research stage. The structure of the blueprint will be explained using 2 of the 3 themes identified during the research phase. The third theme '*potential future expansion opportunities*', is not relevant for Phase 1 as it focuses on future functionalities.

The categories from Theme 2, '*Minimum technological & operational performance criteria*, are relevant for this phase. These categories include:

1. Real time display of patient data for immediate access
2. Audio communication between ambulance care professionals and physicians
3. Video communication between ambulance care professionals and physicians
4. Place to document each consultation
5. Provide insight in bed capacity of the hospitals

Additionally, several 'Expectations regarding functionality and usability' from Theme 1 were important during the design process:

6. A unified platform for all users
7. User friendly device for ambulance personnel
8. User friendly device for physicians
9. Flexibility in timing and location for initiating the contact.

The numbering of these points corresponds to the numbers in the blueprint, which will be elaborated on in the tekst. The Phase 1 blueprint is presented in two segmented parts on the following pages. The legend for the blueprint is provided in Figure 32.

The section after the '*draft phase 1 SB*' demonstrates how the previously mentioned themes are incorporated into the design of the SB.

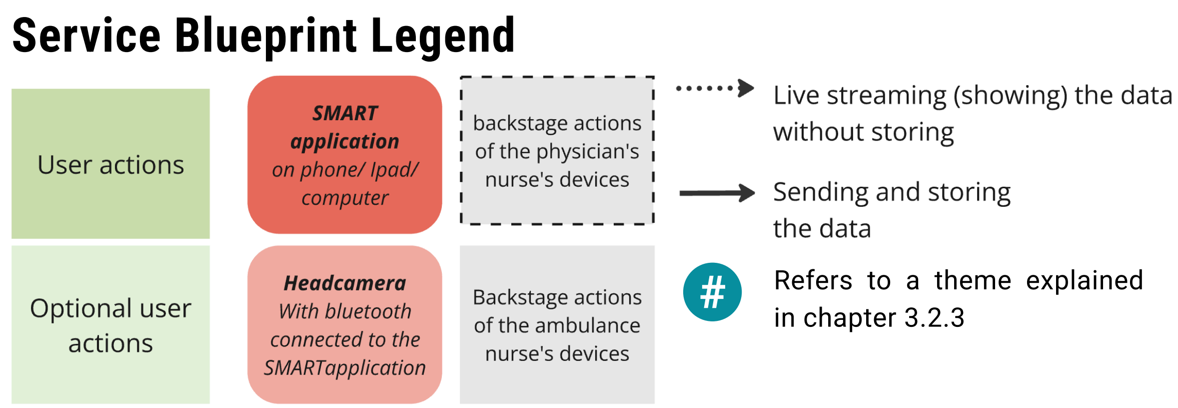
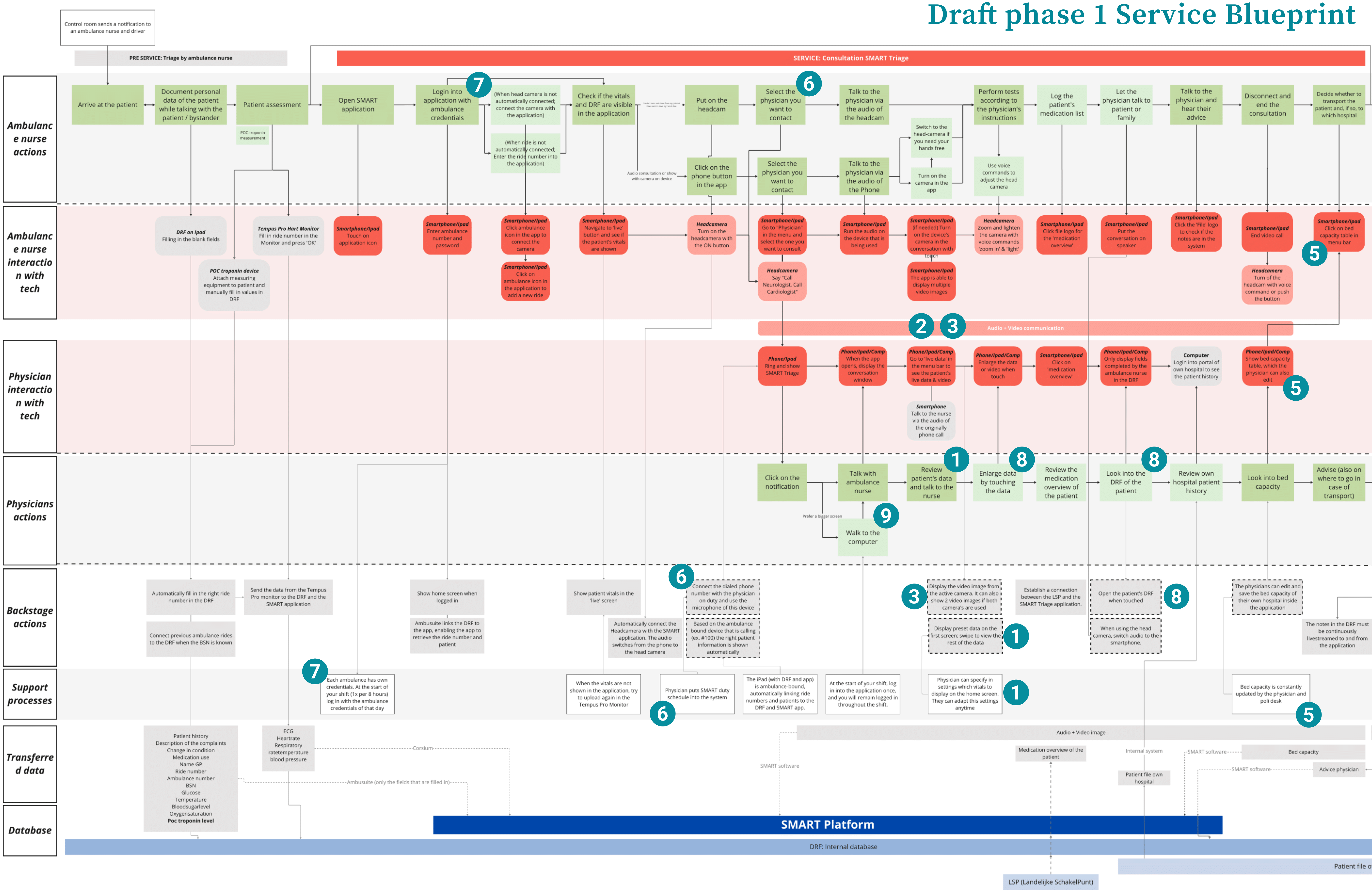
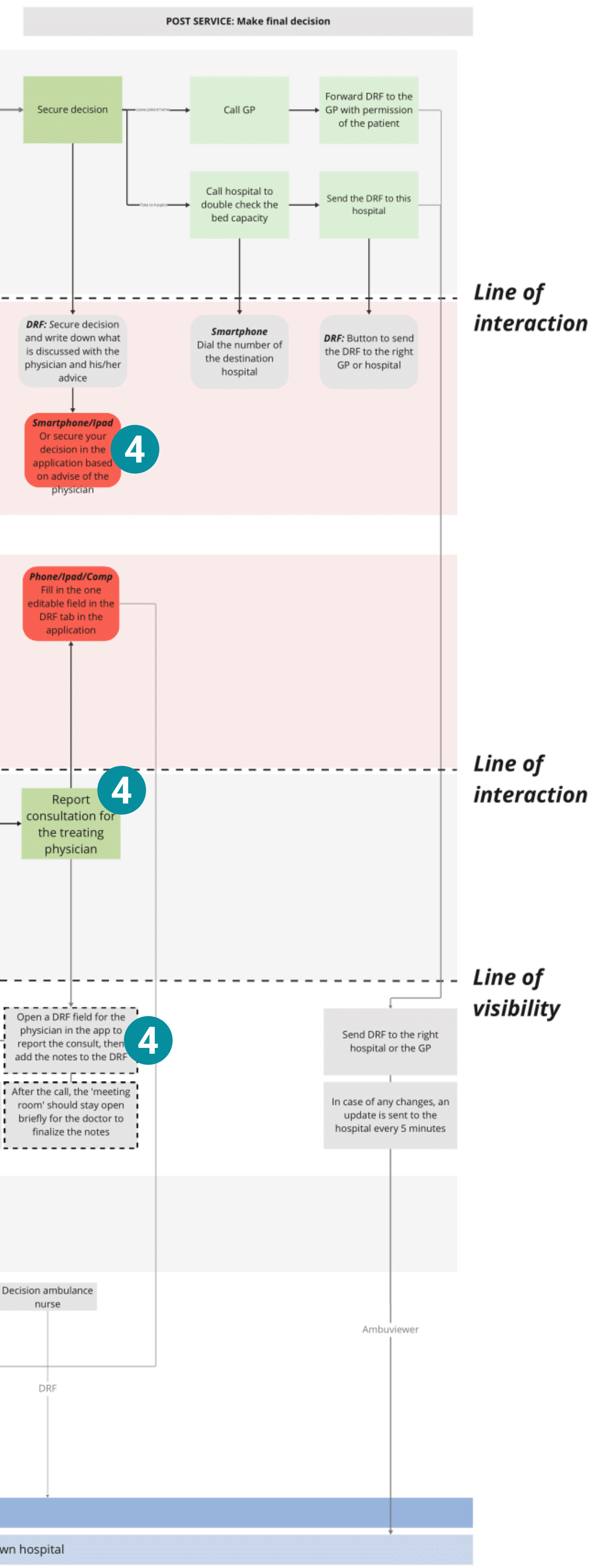


Figure 32: Legend of the draft Service Blueprint

Draft phase 1 Service Blueprint





User-friendly device for ambulance personnel

- Number 7 in the blueprint

I have designed the entire service to be as simple as possible to maximize user-friendliness. I'd like to elaborate on the login process (number 7) since it has been a point of discussion within the project team. Due to privacy regulations, it's not yet clear how users will log in to the system, and the IT department is currently investigating this. However, to maintain the platform's ease of use, it has already been agreed that users will have their own login credentials and will only need to log in once per shift. They will then remain logged in for the entire duration of their shift. Ambulance nurses have login credentials assigned per ambulance, ensuring that the application is linked to the specific ambulance and, consequently, to the patient.

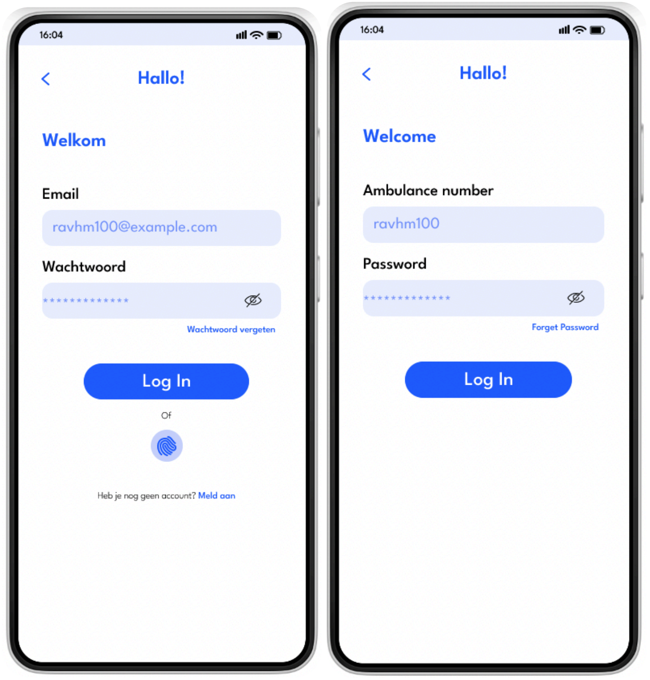


Figure 33: Login screens. Left: ambulance nurse. Right: physician

A unified platform for all users

- Number 6 in the blueprint

It is not possible to assign a single number to this requirement, as the uniform workflow has been implemented throughout the entire platform design. For instance, the interface layout and steps required by different physicians are nearly identical. I would like to elaborate on number 6 in the blueprint, as it was important for the ambulance personnel to be able to contact the physician on duty in the same way, without needing to check a schedule first.

As shown in Figure 34, an ambulance nurse can always press the same button, and the system will automatically connect to the on-duty physician. This is made possible by periodically updating the SMART Triage schedule within the application.

Audio communication between ambulance care professionals and physicians

- Number 2 in the blueprint

Through the 'Call screen', the ambulance nurse can select the type of specialist they wish to contact. When the 'Neurologist' option is chosen, the system identifies which neurologist is on call that day and sends a notification to their application.

Both the ambulance nurse and the physician can mute the call if they need to discuss with a colleague or if there is background noise. Additionally, the call can be put on speaker, allowing the physician to communicate directly with the patient or their family.

The speaker and mute functions were included based on user feedback during the interviews, as some users expressed a preference for these features (A2, P1, interviews).

Figure 34: Interface design 'call screen' (2 left screens are for the ambulance nurse, right screen is for the physician)

Video communication between ambulance care professionals and physicians

- Number 3 in the blueprint

As shown in Figure 35 on the next page, ambulance nurses can turn the head camera and the device's camera on/off within the same interface window. The use of the device camera was primarily enabled to allow testing during the pilot phase without the need to purchase an expensive external camera from the start. This approach was also recommended by the PreVis team. The ambulance care professionals can connect various cameras (e.g., head, body) to the application. At the start of a shift, external cameras can be connected to the application (see the left interface in Figure 35). The system also supports simultaneous video streams from multiple cameras if needed (see the right interface in Figure 35).

The physician can also activate their device's camera through the call menu, enabling a two-way video connection if desired. Interviews revealed this feature can help make conversations feel more personal (N1, interviews).

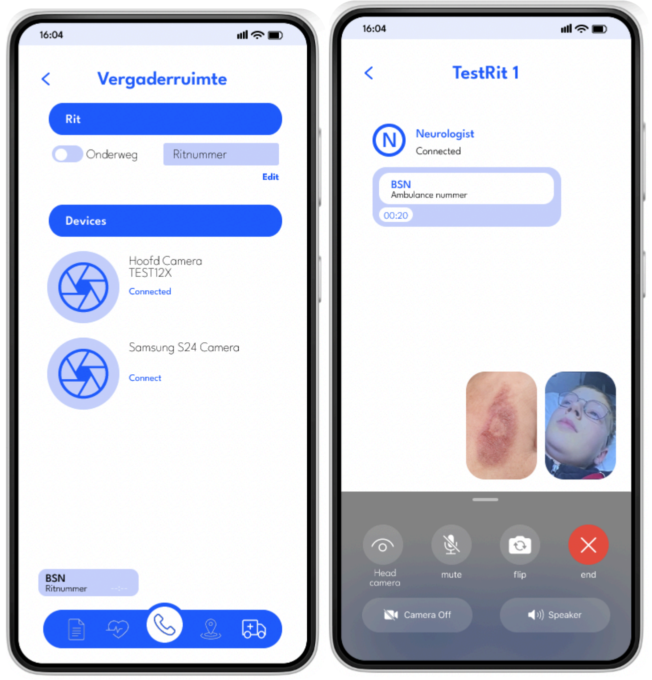


Figure 35: Left; connecting the cameras with the application, right; call connected with 2 video images

Real-time display of patient data for immediate access

- Number 1 in the blueprint

When the physician clicks on 'Live vitals', they are directed to the interface where the patient's vital parameters can be monitored. These vital parameters are sourced from the Tempus Pro Monitor and live-streamed to the SMART Triage platform via Corsium (explained in Table 3).

As noted during the interviews, video connectivity is less critical for cardiologists compared to neurologists. Therefore, I developed multiple designs for the 'Live Vitals' screen.

These designs show the vital parameters either alongside the video image or without the video image.

The preferred way for physicians to view the vital parameters will need to be evaluated during the validation sessions. The interface designs presented during these sessions are shown in Figure 36.

Flexibility in timing and location for initiating the contact.

- Number 9 in the blueprint

Since the application can be installed on any smart device, consultations can take place on the go. If physicians begin the consultation on their mobile phone, they can later switch to their computer if they want to view the patient information on a larger screen. By logging into the same account, the conversation seamlessly transitions from the mobile application to the desktop application.

User-friendly device for physicians

- Number 8 in the blueprint

Number 8 can also be found in multiple parts of the blueprint. One example is that neurologists indicated the importance of being able to zoom in on the video, while cardiologists expressed a preference for enlarging ECGs. Additionally, the physicians can view the patient's DRF data within the application (see Figure 37). This information is sent to the SMART Triage platform via the AmbuSuite software. As a result, during the consultation, the physician can independently review the filled-in fields, such as the medication overview, patient details, and records of previous ambulance trips. This eliminates the need to ask for this information during the conversation, saving valuable time.

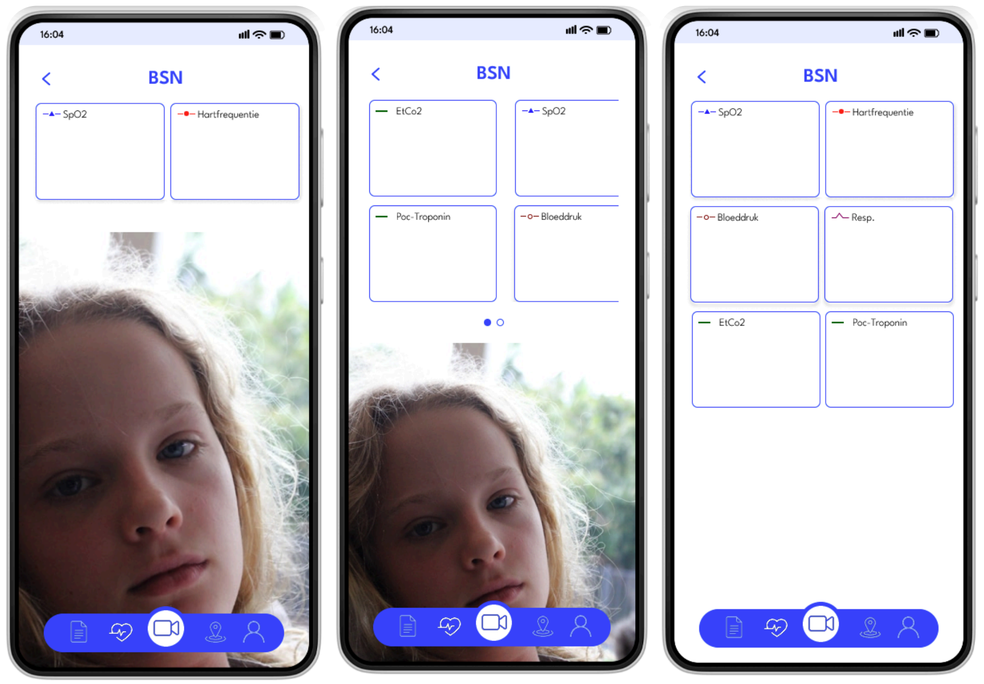


Figure 36: Three interface designs for displaying the live vitals

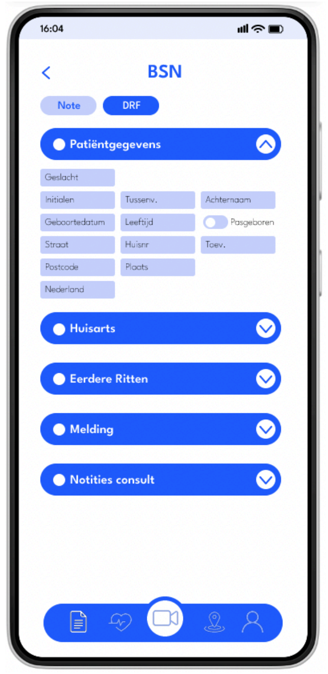


Figure 37: Insight into patient data in the application

Give inside in bed capacity

- Number 5 in the blueprint

As revealed during the interviews (A1, interviews), ambulance personnel often need to call multiple hospitals to check the bed capacity, which can be extremely time-consuming. To streamline this process, ambulance nurses and physicians expressed the need for real-time insight into bed capacity, allowing them to notify the appropriate hospital of their arrival in one step. In the current Hartc1.0 system, cardiologists manually track bed capacity.

Figure 38: Bed capacity interface design (Left for physicians, right for ambulance care professionals)

For now, the platform is designed in the same way. The consulting physician and the ambulance care professionals can view the ED bed capacity of all three hospitals and, if necessary, the physician can adjust the bed capacity for their own hospital. Additionally, users can call the hospital directly from the application to announce the patient's arrival.

A place to document each consultation

- Number 4 in the blueprint

During the interviews, physicians indicated that they wanted a designated space within the platform to document the consultation and advice provided. This ensures documentation from both sides, preventing misunderstandings. It is also important because the consulting physician may not be the same as the treating physician. For instance, if a neurologist from LUMC conducts the consultation and the patient is referred to Alrijne, the LUMC neurologist can leave a message for the Alrijne neurologist regarding their observations during the consultation.

The physician's notes are then added to the DRF and, if the patient is referred, can be sent to the treating hospital.

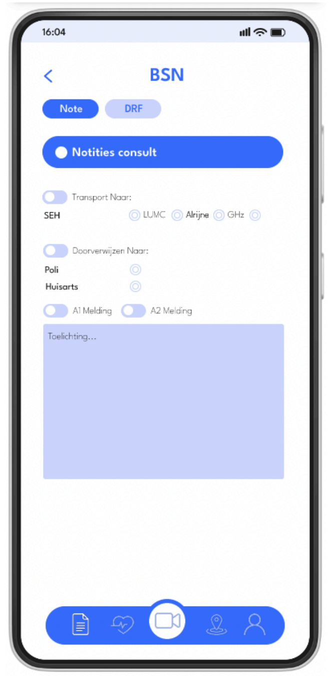


Figure 39: Note field for the physicians to document the consultation

3.2.4 Platform concept design phase 2

For Phase 2, several changes and adjustments have been made to the SB from Phase 1. These modifications are marked with an orange exclamation mark. The changes are primarily based on the outcomes of Theme 3: "Potential Future Expansion Opportunities":

1. Expanding the platform to additional user groups
2. Utilizing the platform as a feedback system for ambulance care professionals
3. Integrating AI to enhance platform capabilities
4. Incorporating tools for in-depth patient data assessment
5. Connecting the patient's medical history to the platform

Not all expansion opportunities have been included in the Phase 2 blueprint. When certain opportunities are excluded, an explanation is provided as to why.

Note: The last section of the SB is not displayed on the following pages, as there are no differences compared to the Phase 1 blueprint. The legend of the blueprint is provided in Figure 41.

Expanding the platform to additional user groups

- Number 1 in the blueprint

In addition to expanding the SMART Triage platform to cover more medical conditions (psychiatric care and vulnerable elderly), Phase 2 will allow GPs to request a SMART Triage consultation. If a GP wants to consult a physician about a patient, they can contact the control room to request an ambulance. The ambulance can then use its camera and diagnostic equipment to transmit vital parameters to the consulting physician. The advantage of this feature is that GPs can use the consultation function in cases of uncertainty, potentially reducing the number of unnecessary referrals from GP to ED. Hartc1.0 already utilizes planned ambulance visits to GPs, and this approach has proven to be highly effective (HARTc, z.d.).

Utilizing the platform as a feedback system for ambulance care professionals

According to ambulance staff, there is a need for a feedback system from the ED to the ambulance service (A1, interviews). While there are ongoing projects in this area (ICT&Health, 2023), the IT department has determined that integrating such a system into the SMART Triage platform during Phases 1 and 2 would be too complex. Moreover, the primary goal of feedback – *"to train ambulance personnel and provide insight into whether they made the correct decisions"* – currently falls outside the scope of the SMART Triage platform. The feedback system could be implemented in phase 3.

Integrating AI to enhance platform capabilities

The IT department has indicated that Phase 2 is far too early to integrate AI into the platform. Training AI requires significantly more experience with working with SMART Triage and a larger database of stored images. As a result, this expansion opportunity has not been further developed in the SB but has instead been included in the tactical roadmap.

Incorporating tools for in-depth patient data assessment

- Number 2 in the blueprint

In phase 2, additional diagnostic tools can be tested on patients and transmitted live to the consulting physician. This could further enhance physician's ability to assess a patient's condition remotely. For example, cardiologists have indicated that they are currently working on a study to equip ambulances with ultrasound devices. If these devices can be integrated with the SMART Triage platform, cardiologists will be able to view live ultrasound images of patients remotely.

Connecting patient's medical history to the platform

- Number 3 in the blueprint

In phase 1, physicians can only access a patient's EPD if the patient is already registered at their own hospital. In phase 2, the aim is to establish a connection with the EPDs of other hospitals in the region. This would allow a consulting cardiologist at the LUMC, for instance, to see if a patient has a history of heart problems treated at the GHZ. Knowing whether a patient has experienced similar symptoms in the past can be crucial for deciding whether to leave a patient at home or transport to the ED.

Additionally, Phase 2 could include integration with the GP emergency summary and the pharmacy's medication overview. This would provide even more detailed information about the patient's medical history and eliminate the need for ambulance nurses to manually enter the medication overview into the DRF.

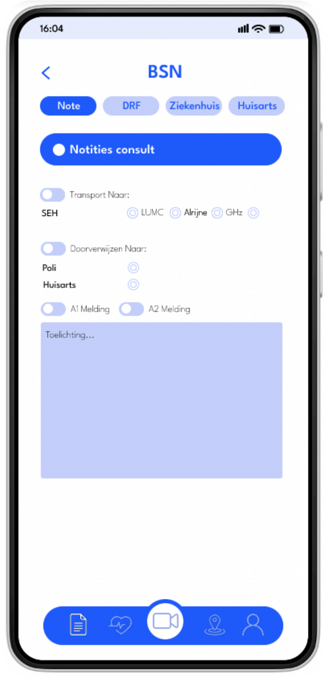


Figure 40: Application with access to the EPDs of other hospitals and the GP summary

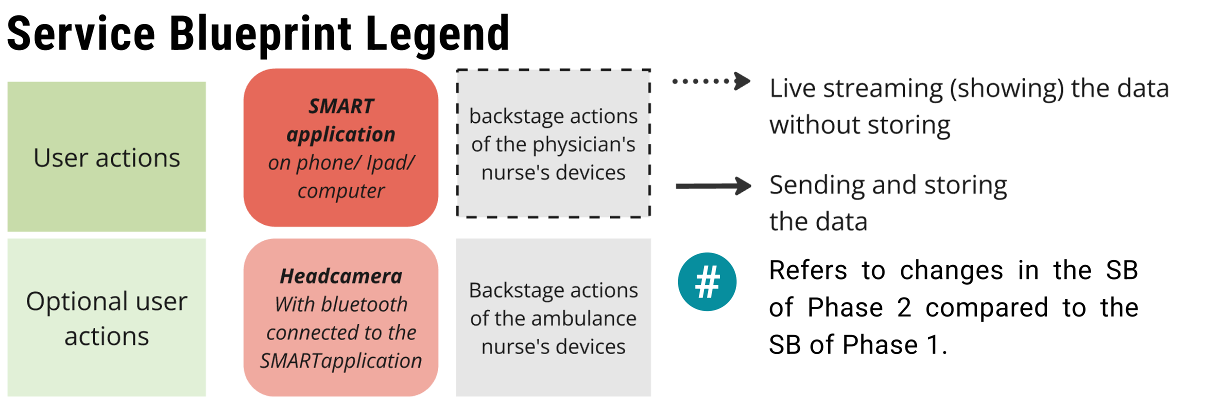


Figure 41: Legend of the draft Service Blueprint

Draft phase 2 Service Blueprint

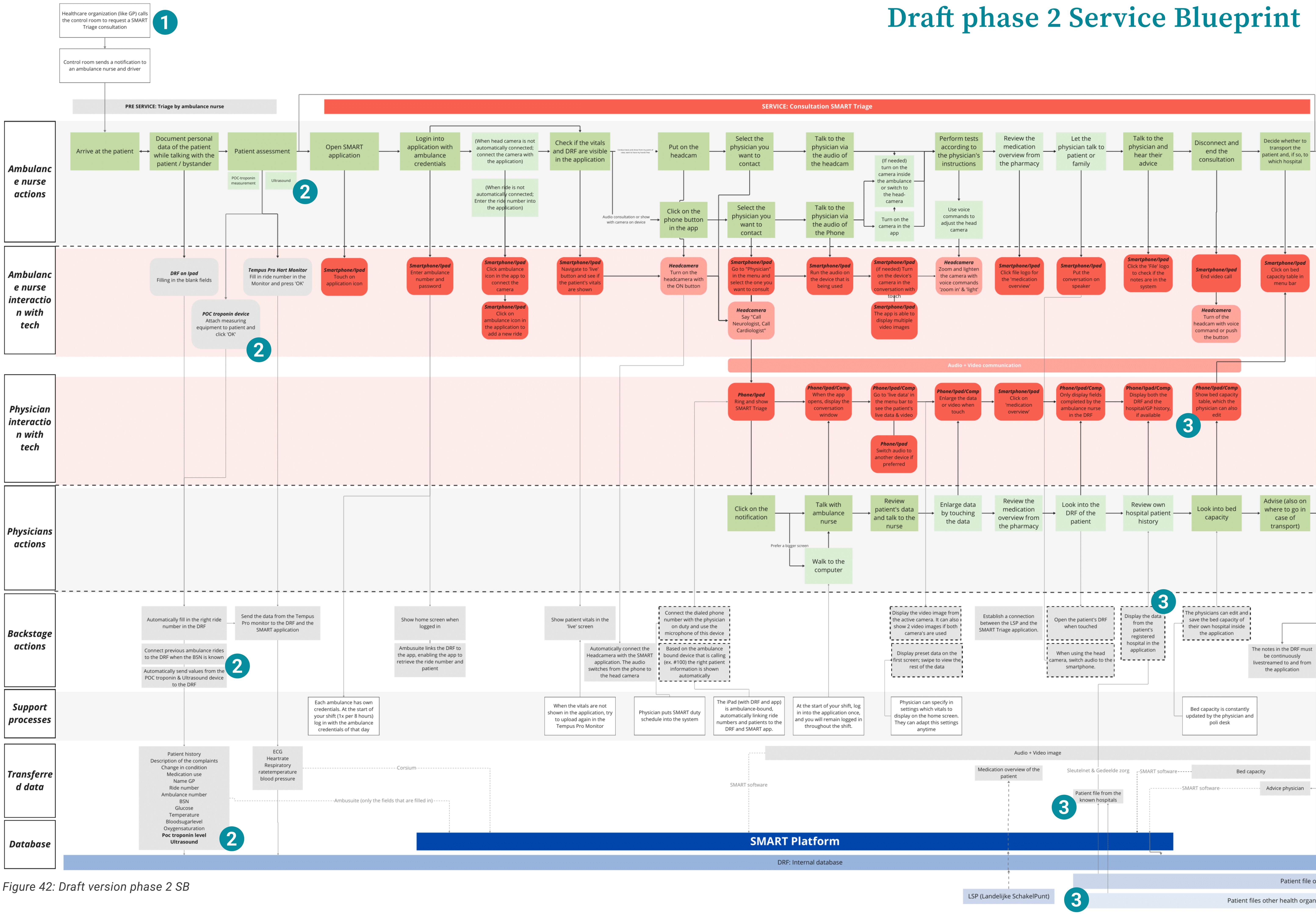


Figure 42: Draft version phase 2 SB

3.2.5 Terminology data streams

In the SBs, several terms require further explanation. As previously mentioned, one of the main challenges of the platform is to connect the data and determine where it should be stored. Table 3 explains key terms from existing data platforms that will also be linked to the SMART Triage platform. Additionally, two scores, HEART and RACE, are explained. These are currently recorded by the ambulance nurse in the DRF and are crucial for the physician in assessing the patient's condition.

Data stream terminology	Explanation terminology
Corsium	Corsium is a web-based software developed by Philips that enables real-time sharing of patient data measured by the Tempus Pro Monitor (Philips, 2024). In the SMART Triage platform, Corsium will transmit real-time patient data from the Tempus Pro Monitor to the platform.
Ambusuite	AmbuSuite is a technology used for ambulance care registration, process management, and reporting to the ED (VIPLive, z.d.). Within the SMART Triage platform, AmbuSuite will be used to send DRF information to the platform as well as to transmit the DRF to the hospital.
LSP (Landelijk Schakel Punt = National Exchange point)	The LSP is a healthcare infrastructure network that healthcare providers can connect to. Through this network, medical data about patients can be exchanged between care providers (VolgJeZorg, z.d.). Through the LSP, emergency summaries from the GPs and medication overviews from the pharmacy can be sh Triage platform (when the patient has given consent).
LSDV (Landelijk Systeem Digitale Vooraankondiging)	The LSDV facilitates the exchange of patient information between ambulance services, hospitals, and GPs on a national level. The LSDV may play a larger role in the future if more regions connect to the platform.
Sleutelnet & **Gedeelde zorg**	'Sleutelnet' and 'Gedeelde Zorg' are two separate collaborative initiatives in the Hollands Midden region. Both are partnerships between healthcare organizations focused on communication in healthcare and providing technical solutions for information exchange. Sleutelnet operates in the Leiden region, while Gedeelde Zorg serves the Gouda region, and each has access to different sets of information. Both initiatives have the potential to facilitate access to data from the LSP hub.
LPZ (Landelijk platform zorg-coördinatie)	The LPZ provides real-time insight into the available capacity of hospitals in The Netherlands. By integrating the LPZ with the SMART Triage platform, the bed capacity of the ED and EHH of the three hospitals can be displayed.
Data terminology	
HEART score	The HEART score is a scoring system for patients presenting with chest pain at the ED. By assigning zero, one, or two points — towards a patient history, ECG abnormalities, the patient's age, any risk factors present, and troponin measurement — patients receive a score on a scale of 0–10.
RACE score	RACE stands for Rapid Arterial Occlusion Evaluation Scale. It is a scoring system used for patients suspected of having a stroke. This score helps determine which nearby hospital can provide the most effective treatment options for the patient. The RACE score is recorded in the DRF.

Table 3: Terminology data streams and data platforms

04
Validate, iterate.

4.0 Validate, iterate

As previously mentioned, user validation sessions form a significant part of the design process. This chapter begins by explaining the structure of these sessions and identifying the participants involved. The outcomes of the sessions are then presented, followed by a discussion of the results. This discussion addresses proposed changes to the initial design and the rationale behind these decisions. Additionally, risk scenarios are explored, with suggestions on how to respond to these scenarios or how the design can support these scenarios. The chapter concludes with the presentation of the final Service Blueprint.

4.1 Methodology validation sessions

The goal of the validation sessions was to further enhance the desirability, feasibility, and viability of the service. The feasibility of the Service Blueprints was iteratively tested in collaboration with the IT team. Desirability was validated with SMART Triage users, while viability was assessed with the head of the ED to ensure alignment with other developments in the emergency department and to evaluate its long-term sustainability.

4.1.1 Used prototypes during the validation sessions

During the validation sessions, the Service Blueprints (SBs) and interface designs functioned as prototypes. Prototypes are often associated with physical product prototypes, as they have long been a fundamental tool in product design (Blomkvist, 2014). However, prototypes can also take other forms and are widely used in various design disciplines, including service design. Across design fields, prototypes serve as representations of a future state, allowing designers to explore and evaluate potential solutions before implementation (Blomkvist, 2016).

According to Blomkvist (2014), Service Blueprints exhibit three key traits that make them valuable as prototypes:

1. Shareable Object of Thought – SBs present complex service processes in a clear and visual format, ensuring all stakeholders develop a shared understanding.
2. Facilitating Re-Representation – SBs are flexible tools that can be continuously refined as new insights emerge.
3. Persistent Points of Reference – SBs provide a consistent foundation, allowing users to refer back to them throughout the design and implementation process—something not feasible when using role-playing as a prototype.

Alongside Service Blueprints, interface designs were used to test how specific elements of the blueprint could be implemented. The interface designs provide additional clarity on how user-technology interactions should look and feel (Blomkvist, 2016). During validation sessions, they help refine aspects such as interface color schemes, data structuring, and the visibility of key buttons.

4.1.2 Validation sessions approach

The validation sessions conducted are summarized in Table 4. It is important to note that the validation with the IT department is not discussed, as they occurred at various points via email and informal workplace talks. In the '*results & discussion*' section, references to discussions with the IT team are frequently made.

Session	Profession	Participant	Hospital	Interview date	Contact
1	Neurologist	N1	LUMC	04-12-2024	In person
2	Ambulance nurse	A1	RAVHM	11-12-2024	In person
3	Cardiologist	C1	LUMC	13-12-2024	In person
4	Cardiologist	C2	Alrijne	13-12-2024	In person
5	Pediatrician	P1	Alrijne	20-12-2024	Online
6	Head of ED	ED1	LUMC	30-12-2024	Online
7	IT team	IT		Multiple	Multiple e-mails and informal talks at the office

Table 4: Participants validation sessions

The validation sessions lasted on average 45 minutes. Each session began with an explanation of the purpose of the validation. I then presented the entire SBs, providing a high-level overview of its key elements. Next, I zoomed in on the section relevant to the specific user. Using a printed version of this zoomed-in section, I guided the participants through the steps while presenting the interface designs on my laptop. A schematic overview of the validation sessions is presented in Figure 43. The red boxes in this figure indicate the specific part of the SB that was being focused on at that moment.

Before presenting the SBs and interface designs, I asked users to interrupt me if they had any questions or suggestions for changes. Additionally, I prepared a set of questions for each user, presented in Table 5. During the sessions I took notes using pen and paper, allowing me to sketch changes to the SB and interfaces for clearer communication.

In some cases, I also asked users to sketch their desired changes directly on the printed SB and interface designs. After summarizing the desired adjustments, I continued guiding the user through the SB. The handwritten notes were digitized after the session.

General questions	Does this step fit within your daily work routine?
	Are any of the steps unclear to you?
	Are the interfaces user-friendly or would you like to lay it out differently?
	What potential risks or 'what-if' scenarios related to the use of this platform should I consider?
	How do you want the patient's vital parameters displayed?
Ambulance nurse	Can you use this technology in addition to the other technology you already use in the ambulance?
	Are there steps you normally take during a patient visit that you don't see reflected in the service blueprint now?
Cardiologist	Are there any features that didn't work well at Hartc1.0 that you are now seeing again in the Smart triage platform?
	Are there functionalities of Hartc1.0 that you don't see reflected in the Smart triage platform?
Neurologist	Do you want to be able to see the vital parameters simultaneously with the video image?
Pediatrician	Are all the vital parameters for children also important or do you want a simpler display of values where you don't need to see them all?

Table 5: Questions per user discussed during the validation sessions

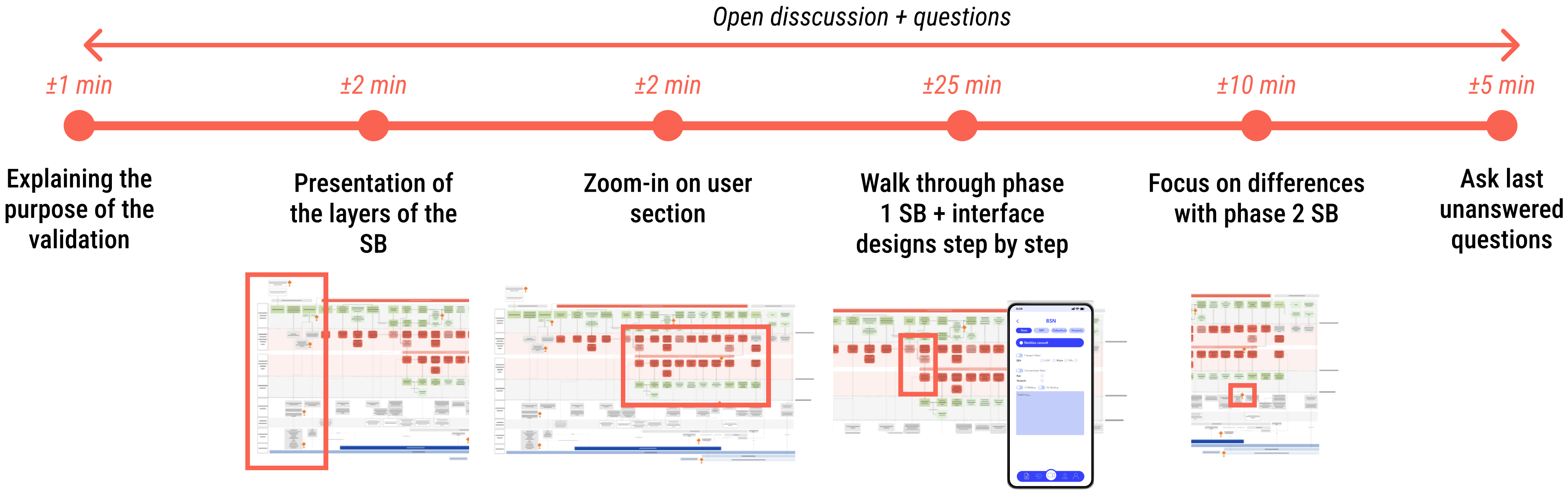


Figure 43: Timeline validation sessions

4.2 Results and Discussion

This chapter presents the results and discussion of the validation sessions in the order they were conducted. Each section begins by specifying with whom the validation session was held. Subsections will follow, with titles suggesting changes or additions to the service blueprint or interface design. The quote contains feedback mentioned during the validation session. After the quote, either 'Design decision' or 'discussion' is indicated, where I, as the designer, reflect on the feedback.

"**Design decision**" means the feedback was immediately accepted, and no further validation with other users or the project team was needed. In these cases, the feedback was directly applied to the interfaces, the SB, or included in the Program of Requirements prior to the next validation session. "**Discussion**" indicates that the feedback required further review or discussion with the project team or other users. Changes based on this feedback were only made after the final validation session.

A summary of all proposed changes, including the conclusion on whether to incorporate the change into the design, is provided in Table 6 at the end of this subchapter.

It is important to note that not all changes to the SB and interface designs are described in this 'results and discussion' section. Minor adjustments, primarily discussed within the project team (e.g., how data streams are connected and whether the data is live-streamed or stored in the platform), are shown in the final SB in chapter 4.3 and not discussed here.

4.2.1 Neurologist 1

1. Open the application without logging in

"It's inconvenient to have to log in to the application first. I want to access the application immediately when I receive a notification for a call."

Discussion:

The exact login process has not yet been finalized, as it depends on specific privacy standards. We also need to consider compliance with login requirements if additional data sources, such as the LSP, are integrated into the platform. For now, each user will receive a unique username and password, which must be re-entered every eight hours.

After logging in, ambulance care professionals will need to specify the ambulance number they are assigned to that day, allowing their account to be linked to the ambulance for the duration of their shift. This is decided after discussing it with the IT department.

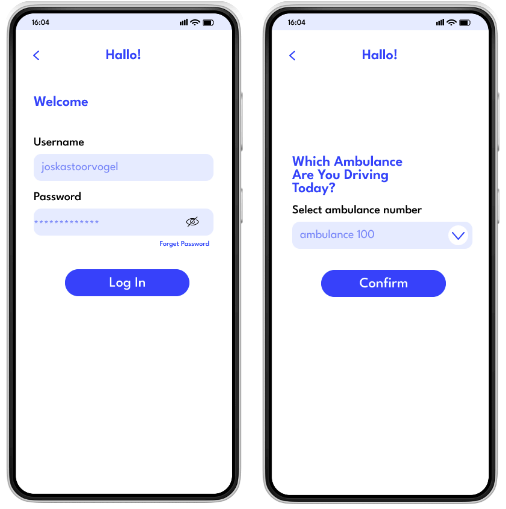


Figure 44: Login screen for ambulance care professionals

2. Automatic synchronization between devices running the application

"Since the application can be accessed on multiple devices, it is essential that text typed (for example in the note field) on one device is also visible on others, such as your phone and computer. Continuous synchronization between devices is required to ensure consistency when logged into the application on multiple platforms."

Design decision:

Include in the list of requirements.

3. Copy-paste functionality for efficient data handling

"I want to be able to copy and paste information such as the BSN number, GP name, and written text on my device so I can look it up and process it in other systems."

Design decision:

Include in the list of requirements.

4. Automatic screen rotation

"When I hold my phone horizontally, I want the screen to rotate automatically."

Design decision:

Include in the list of requirements.

5. Include ride priority in note field for physicians

"I want to be able to indicate whether it is an A1 or A2 notification."

Discussion:

After discussing with N2 and C2, we decided not to give physicians the option to choose between an A1 or A2 call. This decision follows established protocols, and the responsibility lies with the ambulance team.

C2 quote: *"I don't believe the physicians should have a say in whether the ride is classified as an A1 or A2 ride. The reason C1 wants this is for their own research, but especially in the initial stages, it is crucial that ambulance nurses decide where to go."*

Visualization

See the updated interface in response to feedback 6.

6. Enhanced input and referral options in note field

"I want to indicate whether it is a stroke (yes/no) and have additional referral options such as a GP, home care, or a different hospital. Besides, the note field needs to be larger"

Discussion:

This feedback on the referral options was also mentioned during validation with C1 and C2, so additional referral options have been incorporated into the interface design. Neurologists can now indicate "yes" or "no" for a stroke. The '*note screens*' for the neurologists are presented in figure 45, for pediatricians in Figure 52, and the note screen for cardiologists is presented in Appendix D.

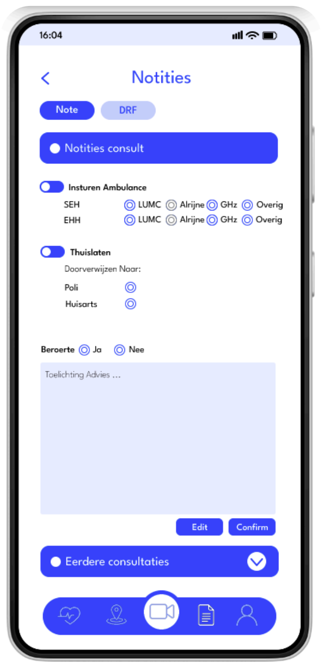


Figure 45: Note field for Neurologists

7. Integration with LPZ

"For stroke patients, each ED has designated 'stroke' beds. I would like more information about the availability of these beds. The LPZ provides greater insight into this"

Discussion:

We will attempt to establish a connection between the LPZ and the SMART Triage platform starting from Phase 1. However, it remains to be determined how up-to-date the LPZ bed capacity data is. More information about the LPZ bed capacity was collected after the validation session with the head of ED.

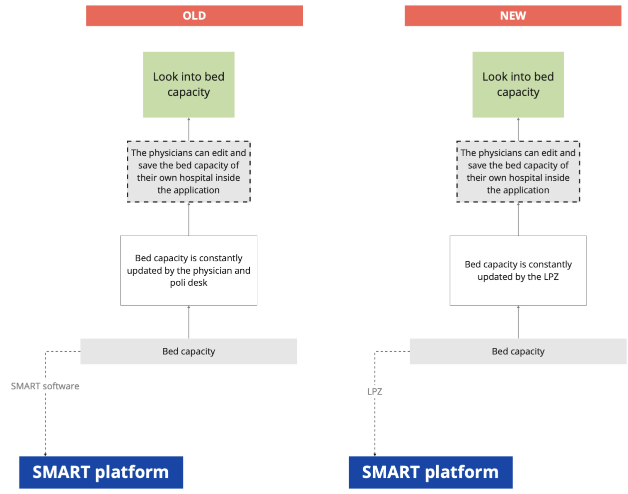


Figure 46: Bed capacity data is extracted from LPZ

8. Shift overview for patient follow-up

"To provide appropriate follow-up care, I would like to receive an overview at the end of my shift of the patients I attended to via the platform that day. This would allow me to follow up with someone if needed."

Discussion:

After discussing with the project team, this feature will not be implemented in Phase 1, as it alters the physician-patient relationship and would require adjustments to the authorization process, which is currently too complex. However, it may be considered for inclusion in Phase 2.

4.2.2 Ambulance nurse 1

9. Remove ETCo2 value from display

"EtCO2 can be removed. We do not use it, especially not during a consultation."

Discussion:

After discussing with C2, it was decided to keep the value displayed, as it is being measured and can be referenced if needed. I will position it at the bottom or include it in a swipe field.

Visualization:

See the updated interface in response to feedback 15.

10. Adding heart rhythm in live vitals

"I am missing the heart rhythm. This is particularly important for cardiologists."

Discussion:

C1 and C2 indeed indicated that they missed the heart rhythm, so it will be added to their interface.

Visualization:

See the updated interface in response to feedback 15.

11. Incorporating EHH bed availability

"The interface currently only shows the beds in the ED. I also want to see the beds in the EHH"

Discussion:

The two cardiologists also indicated that this is important for them. It has been added to the interface design. The interface of the bed capacity is also adjusted, including the logos of the hospitals and a smaller call button to reduce the chance of accidental clicks.

Note that the bed capacity interface changed again after the validation session with the head of ED.

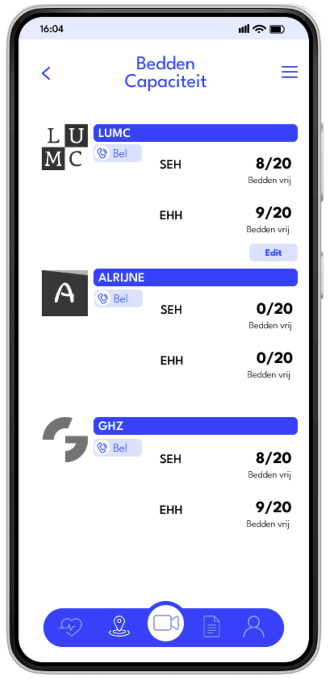


Figure 47: Bed capacity insight for physicians

12. Easy camera connection during shifts

"With a single connection at the start of the shift, the main camera should remain connected throughout the entire shift"

Design decision:

Include in the list of requirements

13. Moving hospital referral to the notes field

"The toggle for bed capacity is inconvenient. I don't understand why I need to activate it when selecting a hospital."

Design decision:

Since we are uncertain about the accuracy of the bed capacity connection with the LPZ, it may not be active from the start of phase 1. Therefore, I have decided that ambulance personnel should indicate in the notes field which hospital they are riding to. This also allows them to provide an explanation for their choice in the same field.

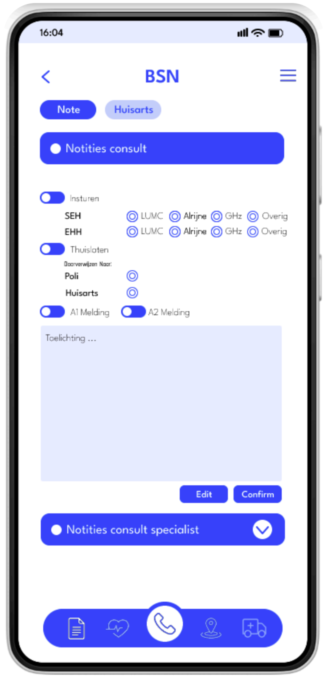


Figure 48: Note field for ambulance nurses

4.2.3 Cardiologist 1

14. Add a 'call back to ambulance' functionality

"It would be helpful to have the option to call the ambulance back if you forget to ask something."

Discussion:

Since the consultation in Phase 1 is limited to a live connection and no data will be stored on the physician's device, implementing a call-back function is too complex for Phase 1. However, it has been included as an expansion opportunity for Phase 2 in the roadmap.

15. Want access to Previous ECGs in the Application

"I want to be able to view previous ECGs in the application. This is something we can already do in Hartc1.0."

Design decision:

Since this functionality is already available in Hartc1.0, it is important to include it in the SMART Triage platform as well. Below, the desired interface design for cardiologists is shown, allowing them to access previous ECGs. Additionally, the ECG can be enlarged and viewed in a horizontal layout by rotating the phone.

Figure 49: Vitals screen for cardiologists

16. Seamless Integration of Diagnostic Equipment

"Diagnostic equipment should be easy to integrate into the application. This is crucial for future development. For instance, if ultrasound images are added in phase 2, a corresponding section displaying these values should be seamlessly included."

Design decision:

Include in the list of Requirements.

17. Reordering home bar buttons

"The buttons in the home bar should be arranged in the order of the consultation."

Design decision:

Changed in interface design

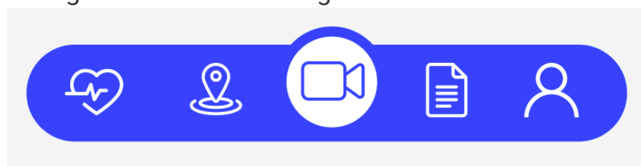


Figure 50: New home bar

4.2.4 Cardiologist 2

18. Finalizing notes post-consultation

"After the consultation, I want to be able to finalize my notes about that consultation"

Discussion:

This feature is important and must be included in the Program of Requirements. All patient data will no longer be visible to the physician once the consultation ends. However, the notes field must remain editable for some time after the consultation. Additionally, if consultations occur quickly after each other, it should still be possible to add notes to the previous consultation. For this reason, a "Previous Consultations" bar has been added to the notes screen. See the interface design in response to Feedback 13.

19. Bed capacity visibility after consultation

"You should always be able to view bed capacity, even when not in a SMART consultation."

Design decision:

Include in the list of Requirements.

4.2.5 Neurologist 2

20. Clear ringing alerts for incoming calls

"The application on my phone should emit a clear ringing signal when I receive a call."

Design decision:

Include in the list of Requirements.

21. Removing irrelevant values for neurology

"The POC-Troponin and CO2 values can be removed for Neurology, as they are not relevant."

Design decision:

This is also something I heard during the validation session with Neurologist 1, so I changed it in the interface design for the neurologists.

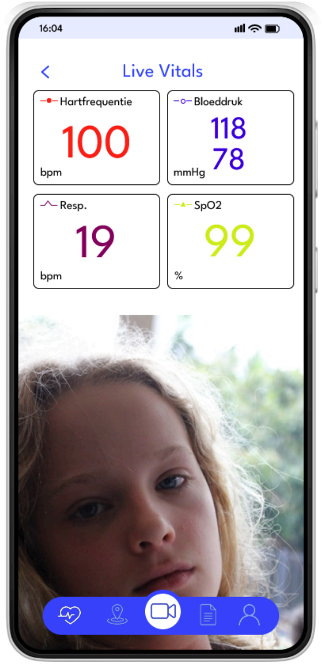


Figure 51: Neurologists' vital parameters interface

4.2.6 Pediatrician 1

22. The neurology interface is suitable for pediatrics

"I find the neurology interface user friendly, and it works well for pediatrics too"

Design decision:

The pediatricians will get the same interface as the neurologists. See the updated interface in response to feedback 21.

23. Displaying children's weight in the interface

"The weight of the children is important, so I would like to have it displayed somewhere."

Discussion:

Following the ambulance nurse, this information is entered by them in the DRF and then automatically appears in the patient data section of the application.

24. Referral option for using own transport with scheduled arrival

"I would like to have the option to mention when I want to see a child but they can come with their own transport. Additionally, I want to specify the time they are welcome. This is quite common in situations where I want to check on the patient, but an ambulance ride as a taxi service is unnecessary. Especially since an ambulance ride for a child can be traumatic sometimes."

Design decision:

Added to the interface design for pediatricians.

Figure 52: Note field for pediatricians

25. Protocol agreements for consistency

"Agreements need to be established regarding protocols to ensure everyone follows the same procedures."

Design decision:

Include in the list of recommendations.

4.2.7 Head of ED

After the validation sessions with the end users, a new version of the SB was created, incorporating all the discussed adjustments. I realized that I lacked some knowledge about how the LSP hub and the LPZ platform (explained in Chapter 3.2.5) could be integrated with the SMART Triage platform. Since the Head of ED is well-informed about these initiatives, I decided to validate this with her.

26. Make the LPZ bed capacity visible for ambulance nurses and physicians

As mentioned earlier, the LPZ provides insights into the bed capacity of the three hospitals in the region. Currently, ED personnel can access this information via the LPZ website and ambulance personnel do not (yet) have access to this information. The goal is to give them and the consulting physicians access to this information in the platform. On the website, each hospital's capacity is indicated using color codes: green=sufficient capacity, orange=try to avoid this ED, red=no capacity (at LUMC, patients requiring specialized treatment only available there are still welcome), black=absolutely no access due to a calamity such as fire or power outage. These statuses are maintained by the medical assistant and are updated in real-time for each hospital.

If a connection is established with the SMART Triage platform, these color codes can also be displayed within the platform, providing all users with a clear overview of de ED bed capacity.

In addition to the ED bed capacity, the LPZ system also shows the bed capacity of clinical departments in exact numbers. However, these numbers are not always up-to-date for all hospitals. Peripheral hospitals are often reluctant to share precise bed capacity information as they prefer to control when and which patients they treat. This is partly because certain patients generate more revenue than others, and as such, these hospitals – which function more like businesses – prioritize maintaining control over their admissions. Efforts are being made among EDs to improve agreements on this matter to ensure greater transparency across hospitals.

If these numbers become more consistently updated, they too can be integrated into the SMART Triage platform. Due to concerns about reliability, it has been decided that, in Phase 1, only the color codes of the ED department will be made visible on the platform.

In Phase 2, the goal is to also display the exact bed capacities of the clinical departments, allowing neurologists to identify the availability of stroke beds during consultations.

The revised bed capacity interface for phase 1 is shown in Figure 53.

27. LSP Hub Integration for EPD and Medication Sharing in Phase 2

The Head of ED confirmed that sharing EPDs from all hospitals, emergency GP summaries, and medication overviews from pharmacies is indeed dependent on developments related to the LSP hub. The ultimate aim is to implement this in Phase 2, allowing for integration with the SMART Triage platform. Since this is a key objective, it has been included in the SB and the roadmap.

The adjustments based on the new insights regarding the LPZ have been incorporated into the SB and final interface designs, which are presented in Figure 54 and Appendix D.

Figure 53: Revised bed capacity interface for phase 1

4.2.8 Results & Discussion conclusion

Table 6 provides a summary of all feedback categorized by user. The “design decision” column includes a green checkbox to indicate feedback that was immediately incorporated into the design and carried forward to the next validation session.

In the “discussion” column, a red checkbox means that the feedback was not implemented following the discussion, leaving the design unchanged. A green checkbox in the discussion column indicates that the feedback was incorporated after further discussion with other stakeholders. So, the feedback marked with a green box in the discussion has been incorporated, but only at the end of all validation sessions and not in between the sessions.

	Design decision	Discussion
Neurologist		
1. Open the application without logging in		
2. Automatic synchronization between devices running the application		
3. Copy-paste functionality for efficient data handling		
4. Automatic screen rotation		
5. Include ride priority in note field for the physicians		
6. Enhanced input and referral options in note field		
7. Integration with LPZ		
8. Shift overview for patient follow-up		
Ambulance nurse 1		
9. Remove ETCO2 value from display		
10. Adding heart rhythm in live vitals		
11. Incorporating EHH bed availability		
12. Easy camera connection during shifts		
13. Moving hospital referral to notes field		
Cardiologist 1		
14. Add a 'call back to ambulance' functionality		
15. Want access to previous ECG in the application		
16. Seamless integration of diagnostic equipment		
17. Reordering home bar buttons		
Cardiologist 2		
18. Finalizing notes post-consultation		
19. Bed capacity visibility after consultation		
Neurologist 2		
20. Clear ringing alerts for incoming calls		
21. Removing irrelevant values for neurology		
Pediatrician 1		
22. Neurology interface is suitable for pediatrics		
23. Displaying children's weight in the interface		
24. Referral option for own transport with scheduled arrival		
25. Protocol agreements for consistency		
Head of ED		
26. Make the LPZ bed capacity visible for ambulance nurses and physicians		
27. LSP hub integration for EPD and medication sharing in phase 2		

Table 6: All feedback from the validation sessions combined

4.3 Final Service Blueprint

4.3.1 Visual changes

In addition to content-related adjustments to the SB following the validation sessions, several visual improvements were made to the final SB.

- **Phases Combined**: Phase 1 and Phase 2 have been merged into a single blueprint to make the differences between them more apparent immediately. This was based on observations in the first blueprint version, where Phase 2 primarily added to the Phase 1 blueprint rather than altering the Phase 1 workflow. A clear separation between Phase 1, Phase 2, and optional activities has been included in the legend.
- **Phasing of the service**: The phasing of the SMART Triage service is now clearer, represented by vertical bars. Instead of a single service component, the service now consists of four parts: Preparing for Consultation, Consultation, End Consultation, and Decide and Secure Consult.
- **Storyline Visuals**: Visual elements were added to clarify the storyline, drawing more attention to the core focus—the consultation.
- **Information Levels**: Small changes were made to highlight key sections where possible, such as by enlarging certain text elements and playing around with the colors.
- **Database of the SMART Triage platform**: The data layer at the bottom of the SB has been expanded, and the data sent to the platform has been incorporated into this layer. This adjustment aims to clarify what data is available within the platform and how it is integrated.
- **Color Coding**: Colors were used to better distinguish between elements above and below the "line of visibility."
- **Text to Icons**: Some text (e.g., device names) was converted into icons to reduce the amount of text on the blueprint.

The final SB is presented on page 80.

Blue numbered circles in the SB refer to the final application designs, which can be found in Appendix D.

4.3.2 Phase 2 functionalities explained

In the SB the green numbered circles indicate the differences between Phase 1 and Phase 2, which are briefly further explained below:

1 GP consultations

In phase 2, GPs can request a consultation, similar to the functionality in Hartc1.0, when they are unsure what to do with the patient. In that case, the GP contacts the control room, which arranges for an ambulance to visit the GP's location. The ambulance nurse conducts a patient assessment and facilitates a consultation with the physician, who then advises the GP. In this setup, the ambulance personnel take on a more facilitative role.

2 Remote cardiac ultrasound

Ongoing research explores the capability of ambulance personnel to perform cardiac ultrasounds, with cardiologists remotely viewing and interpreting the results. This offers cardiologists enhanced diagnostic capabilities from a distance. In the coming years, ambulances are expected to be equipped with additional diagnostic tools, enabling more comprehensive prehospital triage.

3 Integration of Measurement Data

In Phase 1, values from diagnostic equipment, such as the POC troponin meter, must be manually entered into the Digital Reporting Framework (DRF) to make them visible to the consulting physician. By Phase 2, these devices are expected to integrate software, allowing automatic data transmission to the platform, and ensuring seamless and real-time access for physicians.

4 Ambulance Camera Enhancements

Phase 2 will introduce an additional in-ambulance camera, complementing the remote head and device cameras already in use. This camera setup will enable multi-angle video capture, simplifying the physician's assessment process. Furthermore, these cameras could support smoother patient handovers during transport to the ED, especially if expanded for other purposes, such as real-time monitoring during emergencies (Amsterdam UMC, 2024).

5 **LSP data sharing**

If a patient consents, the LSP can share their medical data with other healthcare institutions, such as hospitals and RAVs. For example, the pharmacy medication overview, linked to the patient's BSN can be made accessible, ensuring continuity of care across institutions.

6 **EPD and GP summary access**

Through the LSP hub, EPDs from other hospitals and GP summaries can be integrated into the SMART Triage platform. This information can aid consulting physicians and ambulance personnel in determining whether a patient requires transport and, if so, the most suitable destination based on their medical history.

7 **Hospital Bed Capacity Updates**

In Phase 1, the bed capacity of the ED will be displayed using color codes (green, orange, red, black). The integration of clinical department bed capacity is planned for Phase 2, as the exact numerical data is currently unreliable across all hospitals. In Phase 2, it would be particularly valuable for neurologists to identify the availability of stroke beds - information that is not included in the ED bed capacity displayed in Phase 1.

4.4 Reflection on validation sessions

The validation sessions with the end users provided valuable input to make the service more desirable and viable. Maintaining short communication lines with the project team and other colleagues at the RAV allowed for quick discussions about the feedback. This made it possible to make necessary adjustments before the next validation session. The iterative approach between sessions resulted in progressively less feedback as the validation sessions progressed, indicating that the adjustments made were well-received by other users.

However, scheduling individual validation sessions was time-consuming. Due to the physicians' busy schedules, it was impossible to organize a group session. In the future, I would like to explore group validation sessions, as they could foster discussions and generate new insights among users. This approach might be more feasible with a less time-constrained user group.

Besides, it was encouraging to see how enthusiastic users became when interacting with a tangible prototype compared to when I did the initial interviews. All participants confirmed they could envision working with the SMART Triage platform. Based on this experience, I believe using a more visual prototype together with the SB, is an effective way to build excitement among users. Reflecting on the Previs team's tip – 'use enthusiastic users to inspire others' – I believe it would be a great idea to use a visual prototype, such as the interface application, to engage and excite users about the SMART Triage platform during training sessions.

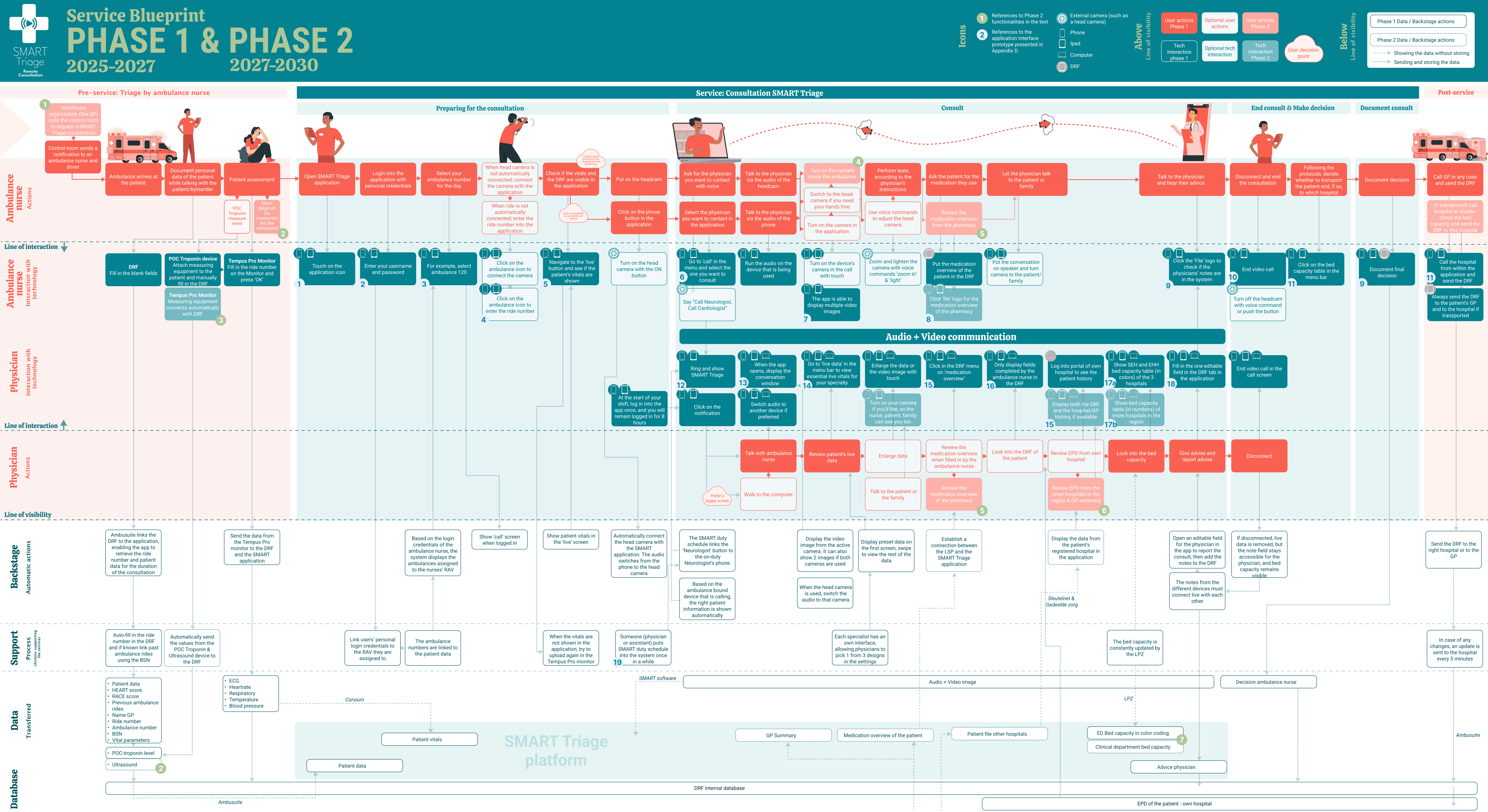


Figure 54: Final Service Blueprint SMART Triage

05

Implementation.

5.0 Implementation

This chapter presents a tactical roadmap that provides a high-level visual representation of the three phases in which the SMART Triage platform will be rolled out.

5.1 Tactical roadmap

As discussed in Chapter 3.1.1, the SMART Triage platform will be implemented in three phases. Since the SB is highly detailed and does not include information on Phase 3, I wanted to create a high-level visual representation of the three-phase rollout. According to Probert & Radnor (2003), a tactical roadmap can ensure that the right functionalities are implemented at the right time to achieve their desired objectives. For instance, if the goal after 2030 is to train AI to recognize eye movements related to strokes, video recordings would need to be stored starting in 2027.

Moreover, a tactical roadmap can serve as a communication tool in the office, acting as 'a flexible framework for supporting effective dialogue and communication within and between teams' (Phaal, 2007). It can function as a guideline that can be updated over the years, even after my involvement in the project has ended.

The framework of the tactical roadmap, with its vertical and horizontal components, was inspired by the Design Roadmapping methodology by Lianne Simonse (2018). The course taught me to align strategic goals (vertical) with actionable timelines (horizontal) for a clear implementation plan.

The Tactical Roadmap is presented on the next page.

5.1.1 Vertical components

The roadmap consists of three distinct horizons. Horizon 1 represents Phase 1 (2025-2027), Horizon 2 covers Phase 2 (2027-2030), and Horizon 3 outlines Phase 3 (>2030). The timing of the horizons is determined together with the project team. It is important to note that the content of Horizon 3 has not been validated for feasibility with the project team. The ideas presented in this phase are based on insights gathered during interviews and validation sessions. Therefore, horizon 3 serves purely as inspiration for potential future implementations. Additionally, phase 3 is highly dependent on the developments in phases 1 and 2.

5.1.2 Horizontal components

During the interviews, significant insights were gathered regarding the development and rollout of the SMART Triage platform that could not be incorporated into the SB. For example, as discussed in Chapter 2.5, insight 11, ambulance personnel suggested expanding SMART Triage to include consults for psychological patients. Similarly, pediatricians proposed using SMART Triage video recordings to enhance the training of ambulance personnel, potentially reducing the frequency of consultation requests.

These insights are further complemented by discussions with the project team, which were, for example, about working hours for the physicians and the regions where SMART Triage is planned for future expansion. The horizontal layers included in the roadmap are:

1. **Availability of specialists**: what are the working hours that ambulance care professionals can consult physicians?
2. **Medical conditions**: for which specific conditions will SMART Triage be deployed?
3. **Regional rollout**: which regions will SMART Triage be implemented?
4. **Usage among healthcare organizations**: which stakeholders can make use of the SMART Triage platform?
5. **Diagnostics**: which measuring equipment makes live parameters available for the platform?
6. **Patient data access**: which patient data will be made accessible to users of the SMART Triage platform?
7. **Additional features**: which other features (like bed capacity) will be integrated into the SMART Triage platform?
8. **Cameras**: Which cameras can be connected to the SMART Triage platform?

The tactical roadmap (visualized on the next page) illustrates how these elements will be rolled out vertically across the three horizons, providing a clear overview of the platform's phased development and expansion.

5.1.3 Explanation of roadmap components

The lower section of the roadmap, the Technology Rollout, has been extensively detailed in Chapter 4. Below, the focus shifts to the upper section of the roadmap, the Implementation Scale. It is important to note that several aspects discussed here were not derived from my own research but were established by the project team. Nonetheless, I aim to elaborate on these elements to provide a clear understanding of the growth potential of the SMART Triage platform in phases 2 and 3.

Availability of physicians:

During phase 1, users will need time to adapt to the new technology. Additionally, the system itself must demonstrate its value by proving that SMART Triage can enable more patients to safely stay at home. Due to the need for user acclimatization and cost considerations, it has been decided that in phase 1, physicians will be available for SMART Triage consultations only between 09:00 and 17:00.

In phase 2, the plan is to extend physician availability to 24/7. This aligns with feedback from ambulance personnel, who emphasized the importance of the same care during the day and the night. As one interviewee stated: "*Different care during the day and at night is strange, in my opinion*" (A1).

Medical conditions

From the early start of this project, neurologists, cardiologists, and pediatricians have been actively involved in this project, recognizing the mutual benefits of remote consultation for both specialists and ambulance personnel. Looking ahead, there are plans to expand the platform to address additional medical conditions, such as psychiatric care.

Interviews highlighted this potential, with one respondent stating:

"*When I come into contact with a psychological patient, I would like to have a video with my audio consultation, because how someone acts is sometimes difficult to describe*" (A1).

Furthermore, the interviews revealed that psychiatric cases often cost a significant amount of ambulance personnel's time, primarily because it can be challenging to determine the appropriate facility for these patients. A video connection with a psychiatric department could provide much-needed support to ambulance staff in these situations.

Regional rollout

Interviews revealed that ambulances occasionally operate across regional boundaries, such as transporting patients to HMC Antoniushove Hospital in The Hague. Additionally, it is not uncommon for patients to have medical records at hospitals outside the local network of GHZ, LUMC, or Alrijne, as they may be registered at other facilities in the Netherlands.

For these reasons, expanding the SMART Triage platform to additional regions, starting with RAV Haaglanden, RAV IJsselland & Brabant, is an important step. To ensure a smooth rollout, it is crucial to address potential expansion barriers early on. For example, the login system for ambulance personnel must be designed to support uniform access across regions, allowing staff from other services, such as RAV Haaglanden, to easily create accounts and integrate their ambulance numbers into the system.

Usage among healthcare organizations

To enable ambulance personnel to consult for psychiatric care, they must have the ability to contact GGZ psychiatrists, who belong to a different department than the LUMC. Thus, in addition to physicians and GPs, psychiatrists will also gain access to the platform in phase 2.

Additionally, in phase 3, the platform can enable dispatch centers to establish video connections with ambulance personnel. This idea emerged during interviews, with one participant expressing: "*When I arrive at a patient, I would like to have a video image of the call to the control room because it is sometimes difficult to predict what situation to expect (A2).*"

Personally, I also observed this experience during the day in the ambulance, where Marcel suspected they were dealing with a psychiatric patient, but based on the written text alone, he could not trust this feeling. Similarly, video calls from panicked bystanders could offer more context and reduce unnecessary A1 priority calls.

Lastly, the platform could adopt use cases like those being piloted at Amsterdam UMC (Amsterdam UMC, 2024). Here, ambulance personnel can notify the ED staff about their arrival in advance, enabling better preparation and facilitating smoother patient handovers.

I recognize that the goal of some of these initiatives diverge from SMART Triage's original goal. However, if the platform's technology proves effective, it has immense potential to enhance prehospital care in other ways as described above.

Tactical roadmap

SMART Triage platform

Implementation scale

	Phase 1	Phase 2	Phase 3
Availability of physicians	Working days/hours: 9:00-17:00	Every day: 24/7	
			Do consultation wherever you want with the use of smartglasses
Medical conditions	Neurologists	Vulnerable elderly	New groups based on emerging developments
	Cardiologists	Psychiatric care	
	Pediatricians		
Regional rollout	RAV Hollands Midden	RAV Haaglanden	National scale
		RAV Ijsselland and Brabant	
Usage among healthcare organizations	Ambulance care professionals can contact the hospital Physicians	Ambulance can contact the GGZ psychiatrists	Dispatch centre can contact the Ambulance care professionals
		GPs can contact the physicians	Ambulance care professionals can contact the ED personnel

Phase 1
2025-2027

Implementation and pilot phase within the local region — with potential room for experimentation with the new working method

Phase 2
2027-2030

Scaling SMART Triage beyond the local region to increase impact and accelerate implementation.

Phase 3
>2030

Further scaling and preparing AI to take over tasks currently performed by physicians.

Technology rollout

	Phase 1	Phase 2	Phase 3
Diagnostics	Tempus Pro Monitor	Ultrasound	More diagnostics based on future development
	POC Troponin		
Patient data access	EPD own hospital	EPD Other hospitals via LSP	
	DRF	GP emergency summary	
	Manually fill in medication overview in the DRF	Medication overview of the pharmacy via LSP	
Camera's	Camera on a device (smartphone, ipad, etc.)	Camera inside the ambulance	Smartglasses
	Headcamera		
Additional features	ED bed capacity LPZ (using color coding)	Clinical department bed capacity LPZ (exact numbers)	AI transcribtions of the consultations
		Storing of video recordings	AI video training
		Ambulance callback function for physicians	Feedback system for physicians & ambulance nurses

06
Discussion & Conclusion.

6.0 Discussion & Conclusion

This chapter outlines the limitations of this project, emphasizing aspects that require further research and refinement before the SMART Triage platform can be implemented. It also examines potential risks that could influence the success of the implementation process. Finally, based on the insights gained during this project, several recommendations are provided for the path toward implementation. The chapter concludes with a summary of this thesis.

6.1 Unaddressed research directions

It is important to recognize that the Service Blueprint I created is primarily based on user preferences. This means that all functionalities of the service and the ways in which users interact with these functionalities are largely derived from the outcomes of interviews and validation sessions with users. During validation sessions with the IT team, they confirmed that the entire service could be technically implemented. However, they identified two aspects that still require investigation on their end, as these could potentially influence the final design: cost benefit analysis of platform functionalities, and legislation on data sharing. In addition to the unaddressed research directions identified with the IT team, I have identified three more constraints that are relevant for future research: patient privacy, used camera type, and collaboration with GPs.

Cost benefit analysis of platform functionalities

As previously mentioned, cost considerations were not included in my design process. However, the IT department highlighted that certain functionalities, such as integrating bed capacity data and EPDs from other hospitals, could be expensive to implement. They questioned whether such integrations would significantly benefit SMART Triage, noting that bed capacity data is already available on external websites. This study did not investigate the cost-benefit of individual functionalities or their direct impact, and if these cost-related considerations are necessary, it will be essential to talk to the users again about this.

Legislation on data sharing

The SMART Triage service design integrates data from various other platforms, such as the LSP hub and LPZ bed capacity data. However, the IT team highlighted ongoing uncertainty about whether this data can legally be shared. For example, in the current design, physicians enter consultation notes into the SMART Triage platform, which are then attached to the DRF and sent to the appropriate hospital. To enable this, a connection with the DRF provider (Topicus) is required. While this is technically possible, discussions with Topicus are necessary to confirm this integration. Beyond technical feasibility, a service developer should explore how data from various initiatives can be effectively displayed on the platform.

Patient Privacy

This study did not include patients' perspectives. Apart from findings from previous studies (see section 2.2.2), I have limited insight into how patients in the Netherlands feel about being filmed during prehospital triage. For patients with certain beliefs or cultural backgrounds, privacy concerns may carry more weight (interviews, N1). It would be valuable to investigate this issue further, gathering patient opinions and establishing protocols for situations where individuals refuse to be filmed.

Used camera type

Most previous initiatives relied on head cameras (see section 2.2.2), so this study assumed they would be used as the external camera. Besides, earlier this year, a study at RAV Hollands midden tested the usability and image quality of body and head cameras during a pilot day with the ambulance personnel. The results showed that body cameras did not provide the image quality physicians require, leading RAV Hollands Midden to favor head cameras. Once suppliers provide more details about available camera options, organizing another pilot day would allow ambulance personnel and physicians to test the technology and confirm their preferences.

Collaboration with GPs

As noted earlier, the implementation of the SMART Triage platform will impact patient flows. More patients may remain at home, and some may be referred to GPs instead of EDs. This study did not consider the perspectives of GPs, despite the potential impact on their daily workflows. Maintaining strong communication with GPs before implementation is crucial to ensure they understand SMART Triage and its implications for their work. This was also a recommendation from cardiologists based on their experience with Hartc1.0, making it an essential step for SMART Triage as well.

6.2 Potential risks for SMART Triage implementation

Section 2.5.4 highlights several risks identified during the user research phase, summarized in Figure 55. These represent potential risks as perceived by users during platform use. In addition, I have identified several potential risks that may arise during the platform's implementation.

1. Dependence on other (national) initiatives

Some SMART Triage platform functionalities rely on other initiatives, such as bed capacity integration via LPZ or shared EPDs through the LSP. Delays or issues with these initiatives could hinder implementation into the SMART Triage platform. However, the platform's core functions—audio, video, and the display of vital parameters—are independent of external dependencies, reducing the impact of this risk on its primary functionality.

2. Insufficient user commitment

The platform's success depends on sufficient participation from physicians during the pilot phase. Inconsistent availability may discourage ambulance personnel from using SMART Triage for consultations. Continued user support is also critical for evaluations and development. The project team must actively foster stakeholder engagement, as they maintain contact with all parties (see Figure 22).

3. Over-simplification of the functionalities in Phase 1

While the primary functions are essential, certain usability features—such as integrating vital signs and video within one application, automatic routing to the on-duty physician, and multi-device accessibility—are critical for a positive user experience. As highlighted in limitation 1, this study did not account for the costs of implementing these features.

Launching a minimal viable product with a cost-driven approach may compromise usability, risking lower user acceptance. Such limitations could delay or reduce the platform's ability to achieve the intended outcomes outlined in section 1.1.4.

4. Inconsistent user practices

User interviews revealed variability in current workflows among ambulance personnel, such as differing thresholds for hospital referrals. Inconsistent use of SMART Triage could lead to mismatched patient expectations, such as overreliance on remote specialist consultations. Standardizing workflows is essential to mitigate this risk.

5. Lack of scalability in platform development

If the SMART Triage platform is developed without considering scalability, it may hinder future expansions planned for Phase 2 and Phase 3. For instance, a platform that cannot be technically adapted for use in other regions would lack long-term viability. Besides, it's crucial that data from new diagnostic devices, like ultrasound, can be easily integrated into the platform. Delayed integration hinders physicians from accessing this data, affecting patient assessment. It is crucial to ensure that software developers are informed about these potential expansion needs during the development process to create a future-proof platform.

In addition to these risks, it is important to acknowledge further risks related to the financing of the SMART Triage platform, its legal feasibility, and the quality assessment of consultations. However, as these risks fall outside the scope of this research, they are not addressed in this sub-chapter.

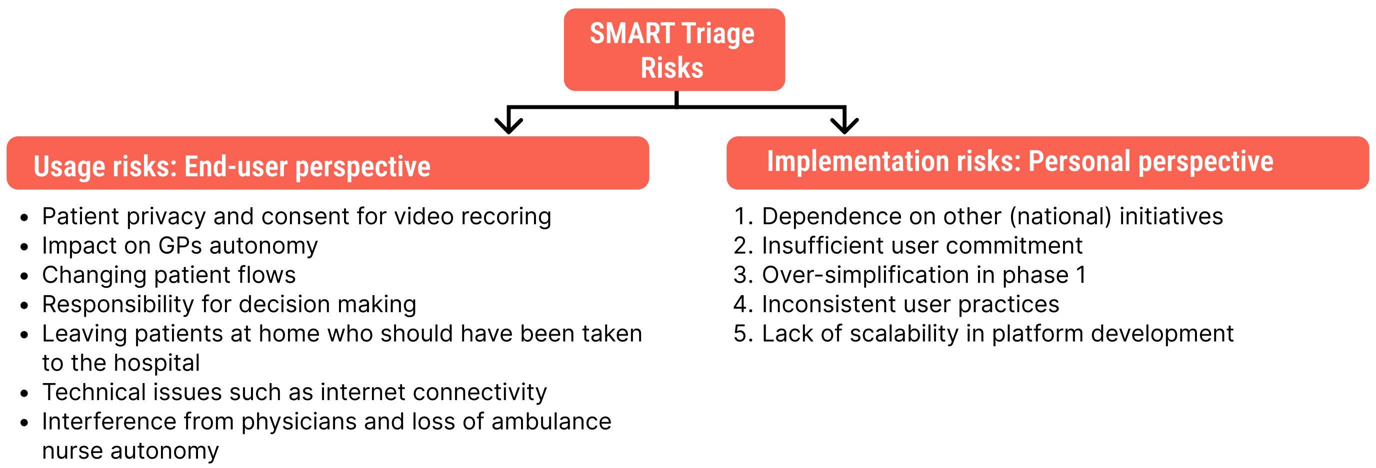


Figure 55: Risks associated with the use and implementation of SMART Triage

6.3 Recommendations towards implementation

In the SB, there are still a few uncertainties about whether certain aspects can be implemented in phase 1 as described. These include:

- Whether the SMART Triage platform will be developed as a custom-built application or as a plugin for a platform like Microsoft Teams. This depends on whether all the requirements and functionalities can be achieved with a plugin. If so, it would be a faster and more cost-effective alternative than a custom-built application.
- Whether Phase 1 will initially begin with just the camera of a device (e.g., a phone or iPad) or if head cameras/smart glasses will be introduced right away. This decision depends on the results of a quality test with the cameras and the budget available for the pilot phase.
- Whether the bed capacity table will be integrated into the SMART Triage platform or if ambulance nurses and physicians will need to view it separately on the LPZ website. This is a cost-benefit decision.
- Whether physicians' notes can be sent to the DRF and made accessible to the treating physician. This depends on the relevant legislation.

In the coming months, it will become clearer how these 'moving parts' will take shape. As my involvement in this project is nearing its end, I want to share some recommendations for the moths ahead from my perspective as a designer.

During discussions with potential software developers, I attended meetings where companies offering combined hardware (head cameras) and software (the application) were considered. These companies use pre-built software blocks tailored to specific needs. While this means the application won't be custom-built and may not fully match the interfaces I designed, it offers faster, more cost-effective implementation and easier maintenance. If this plugin application is chosen, it's important to review my service architecture and its underlying rationale behind the user interactions I designed to ensure it meets user needs. If these key interactions can also be integrated into the plugin application, it doesn't matter if the application differs from the prototype in appearance.

It's also possible that not all phase 1 functionalities can be implemented at once. The project team is considering starting with a 'phase 0' pilot, focusing on the core functionalities: audio, video, and vital parameter display. During this pilot, designated 'super users' will test the system with five cameras deployed in five ambulances over several weeks. It is essential to establish workflows during this phase that reflect the processes envisioned for the full implementation. For example, a physician should be able to seamlessly transfer a consultation from a mobile phone to a computer, which would not be possible if we rely on a simple hyperlink to access the platform. Setting up such workflows correctly from the start will enable super users to adopt and model the desired practices, ensuring other users can easily follow and adapt to the intended processes.

Additionally, setting clear usage guidelines is crucial for the platform's success. When I asked the PreVis team about the most challenging aspect of implementation, they stated, "*The hardest thing with implementation is definitely that all the users of the device only see their own benefits, so you need strict guidelines for when and how to use the technology*". Without clear agreements, inconsistent practices may arise, leading to inefficiencies and reduced effectiveness.

Additionally, several risk scenarios were identified and discussed during the interviews and validation sessions. While these scenarios are not included in the SB, they need careful consideration as they may arise during service use. The identified risk scenarios include: 1. multiple ambulances calling at the same time, 2. a physician being unable to answer the phone, 3. a dropped connection. These scenarios, while not detailed in the SB, must be thoroughly evaluated, and agreements should be established with end users prior to the pilot phase of the new technology. Discussions with end users about these scenarios and their preferred resolutions are documented in Appendix E.

The project team's active involvement throughout the implementation process is crucial to maintaining stakeholder alignment. As the central point of contact for all stakeholders (see Figure 22), the team must ensure clear communication and address the broader implications of SMART Triage. For instance, shifts in patient flows may affect GPs, who will need to manage patients who are not transported to hospitals. As highlighted in limitation 5, maintaining open communication with GPs is vital to ensure that the SMART Triage platform will not have negative effects on them.

Beyond regional considerations, the project team should stay informed about external developments. National initiatives, such as Spoedzorg Connect (Amsterdam UMC, 2024), are also focused on improving prehospital triage with the use of teleconsultation.

I recommend creating a national project group to enable knowledge exchange across regions. Such collaboration can prevent redundant efforts and support a smoother scaling process for SMART Triage in subsequent phases.

Finally, I want to stress the importance of keeping user needs at the heart of the implementation process. Throughout this project, I have consistently prioritized designing systems based on user needs rather than expecting users to adapt to new systems. My research, along with discussions with the Previs team and insights from similar initiatives, underscores the value of understanding user needs to ensure active engagement and participation. To maintain this focus, I strongly recommend regularly checking in with users during implementation to ensure their satisfaction and adjust as needed. This will ensure that practical constraints, such as costs or technical limitations, will not undermine usability and adoption.

Figure 56 presents a conceptual timeline for the implementation over the next six months. The recommendations have been mapped onto this timeline to indicate when they should be initiated. It is important to note that this timeline is highly dependent on the software developer responsible for creating the software and hardware, the duration of the pilot phase, and the user's adaptation speed. Therefore, it should be viewed as a rough guideline.

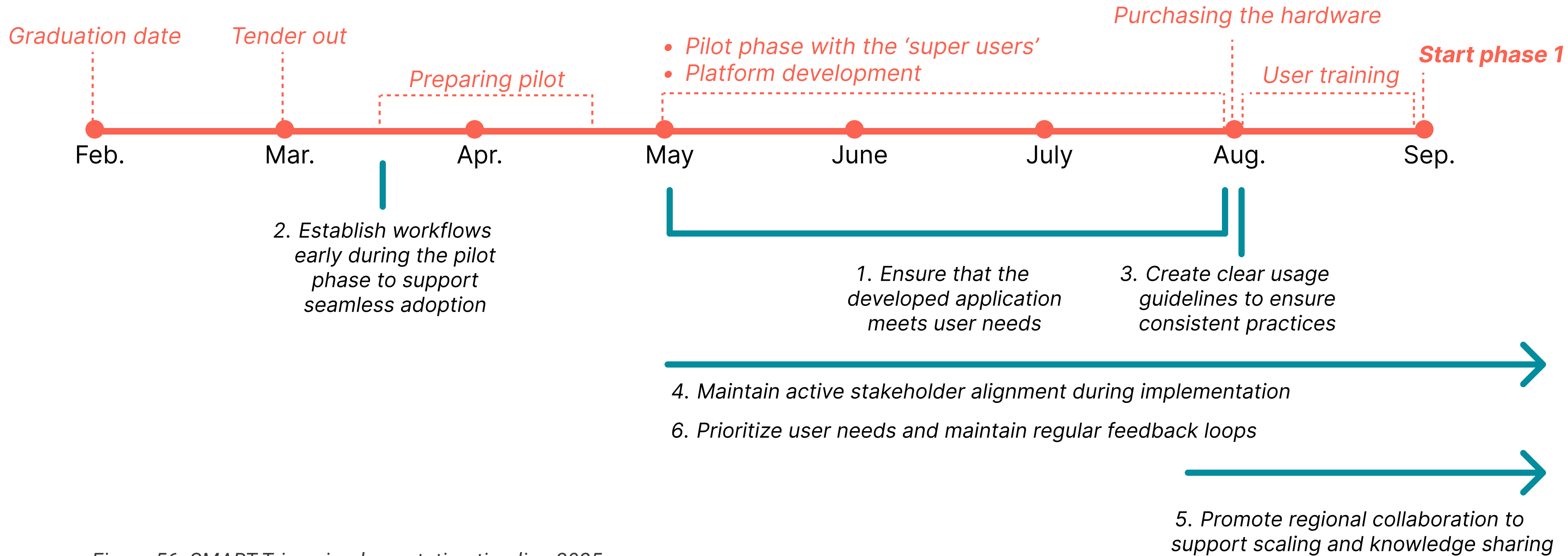


Figure 56: SMART-Triage implementation timeline 2025

6.4 Reflection on applying service design in digital health implementation

Figure 57 illustrates how I applied service design in creating the SMART Triage platform and which frameworks and tools guided me throughout the process.

The Quadruple Aim framework (Sikka et al., 2015) helped tailor the design process to the healthcare sector by keeping its four pillars in mind throughout the design process. The Tool, Team, Routine framework (Shaw et al., 2018) contributed to increasing the likelihood of successful service implementation. Specifically, it guided me during interviews to identify 'clear value propositions' for users, enabling me to cluster the insights effectively.

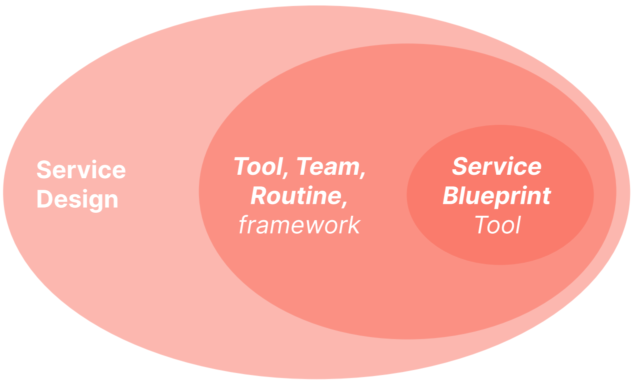


Figure 57: Frameworks and Tools used in the design process of SMART Triage

6.4.1 Using the SBs and interface designs as prototype

As described in Chapter 3.2.1, the original blueprint structure (Bitner et al., 2008) was adapted for this project also to enable its use as a prototype. To accommodate two distinct user groups, each interacting with the technology differently, I introduced two user layers and two interaction layers instead of the standard single layer. Figure 58 visualizes the three different blueprint layouts I considered.

The first layout was unclear because the technology components of the service were separated across the blueprint, making it difficult to see how one part of the technology interacted with another. The second layout seemed impractical for validation sessions, as the actions and interactions of both user groups mixed. This made it challenging to isolate the actions and interactions of ambulance personnel during a validation session with a physician. The third setup resolved these issues, which is why I used it. In this layout, all technological actions are grouped, allowing for the inclusion of 'audio + video communication' between the interactions with the technology.

For designers creating a SB with two distinct user groups and two separate aspects of the technology, I highly recommend the third version of the blueprint layout. I haven't seen this type of blueprint visualization in the literature before, and I believe that this layout could also be useful for other projects that involve two distinct user groups with different interactions with the service.

In Chapter 4.1.1, Blomkvist & Segelström (2014) outline three key traits of Service Blueprints as prototypes. Based on this project, I will share my experiences with these key traits:

1. Shareable object of thought

My experience showed that, when working with time-constrained professionals, it was more effective to visualize specific sections of the SB – such as through interface designs – rather than discussing the entire blueprint. While the SB provides a comprehensive service overview, it proved too complex for 45-minute validation sessions. Instead, using interface designs to illustrate key interactions generated significantly more feedback. These visualizations not only enhanced engagement but also encouraged critical feedback, making it evident that a text-heavy blueprint was less suitable for such sessions.

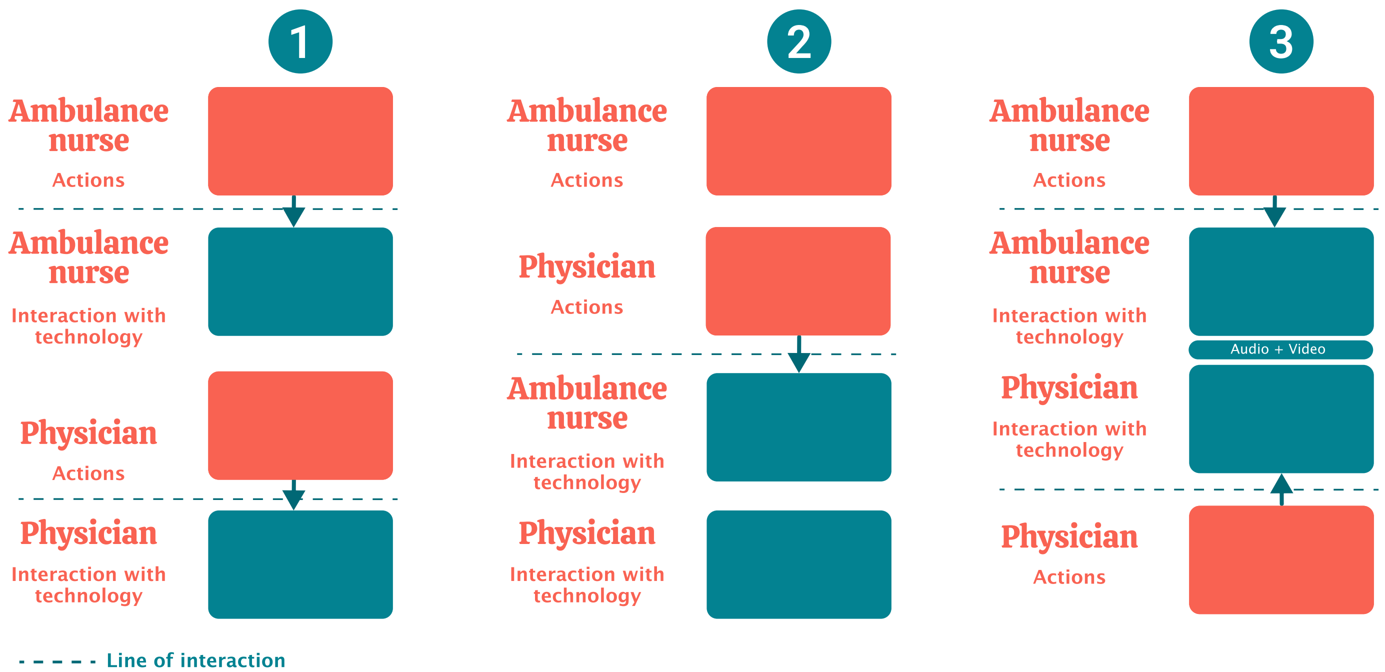


Figure 58: Considered Layout structures for the Service Blueprint

Additionally, interface designs helped refine interaction details and revealed differences in user preferences that might have otherwise been overlooked.

2. Facilitating re-representation

The SB proved to be a highly adaptable tool, evolving continuously after each validation session. Often, I received feedback only on the interface designs, which I later incorporated into the SB's structure. This iterative process demonstrated that combining interface designs with the SB was an effective approach to refining the service.

3. Persistent points of reference

Certain sections of the SB served as key reference points for collaboration and decision-making. For instance, the database layer I added significantly improved clarity on data storage and accessibility. This layer also enhanced the feasibility of the project, as it allowed me to easily and frequently discuss the lower section of the blueprint with the IT team. The data layer was also designed specifically for this project, but it can equally assist in detailing other services more thoroughly.

In summary, I found the SB to be an excellent tool for mapping out a service in its entirety, with the data layer at the bottom being particularly useful for testing feasibility with IT professionals. However, during validation sessions, I observed that more visual prototypes, such as interface designs, fostered greater active engagement from end-users.

6.4.2 Project's contribution to digital health implementation

In Chapter 2.2.2, various teleconsultation initiatives were analyzed, highlighting both positive and negative user experiences with ambulance video triage implementations. To the best of my knowledge, these cases, including the PreVis project, all followed a similar implementation approach: the technology was implemented directly, and user feedback on their needs and satisfaction was gathered only afterward. This contrasts with the method I employed in this study, where user needs were investigated first, and the technology was developed based on those insights.

The design process for the SMART Triage platform stands out due to its application of the 'demand-pull' approach, as defined by Shaw et al. (2018): a scenario where a team identifies a problem or need and decides on the right technology to solve it. In contrast, the initiatives described in Chapter 2.2.2 followed a 'technology-push' approach, where providers secure adoption through decision-makers, often without involving end-users beforehand (Shaw et al., 2018). According to this source, the technology-push approach generally makes successful implementation more challenging compared to demand-pull scenarios. This suggests that the SMART Triage platform has a greater chance of successful implementation. If this proves to be the case, I hope the demand-pull methodology used in this project serves as an inspiration for other digital health innovations, encouraging the more standardized involvement of service designers in similar initiatives.

The outcome of the implementation remains to be seen, but referring to Figure 13 on page 25, which outlines negative experiences with ambulance video triage, some of these challenges are likely to be experienced less due to the demand-pull approach used in developing SMART Triage.

For example, in previous initiatives, users faced significant difficulties adapting to new workflows with the technology (Jaeger et al.,2023). However, since SMART Triage has been designed around the user's needs and requires minimal changes to existing routines, users in Leiden are expected to face fewer challenges. For the same reason, frustration related to technological issues (Jaeger et al.,2023) and the additional time needed to activate the video system (Vincente et al., 2021) is also likely to be reduced because the technology is built around their wishes.

A follow-up study could provide valuable insights by comparing the implementation outcomes of SMART Triage with those in Figure 13, where a technology-push approach was used. This would help assess how the demand-pull method influences digital health implementation.

Another benefit of the demand-pull technique is the additional insights gathered during user interviews, which could inform future teleconsultation studies. For instance, I gained a valuable understanding of the positive and negative effects of the Hartc1.0 system, which could guide further research by cardiologists. Moreover, the interviews uncovered risks identified by end-users when working with teleconsultation systems. These risks can also be considered in the design of other teleconsultation initiatives. Besides, many interview quotes also touched on usability, and analyzing this data further could provide a deeper understanding of what 'usability' means for physicians and ambulance nurses specifically. This definition of 'usability' can again be used during the design phase of other teleconsultation initiatives.

In summary, the data collected from these interviews holds potential for future studies if analyzed from different perspectives, contributing further to the advancement of digital health initiatives.

Lastly, I hope that the successful implementation of the SMART Triage platform later this year, supported by my study, can serve as an inspiration for similar initiatives in other countries. During the development of SMART Triage, I had three calls with someone from the PreVis team, and I hope the project team in Leiden can also become a leader that inspires other countries. Developing a system like this remains a challenge, as such systems cannot simply be copied due to national differences in healthcare structures, hospital distances, and ambulance operations. However, the more teleconsultation systems are successfully implemented, the more we can learn from each other, reducing the need for research to start entirely from scratch.

6.5 Conclusion

The primary goal of this project was to design a Service Blueprint (SB) that illustrates how ambulance care professionals can be supported by physicians during prehospital triage via the SMART Triage platform. The aim was to ensure the platform effectively meets user needs for seamless integration into daily workflows, thereby contributing to a smooth implementation, as the SMART Triage platform is set to be deployed later this year.

During the research phase, ten users were interviewed to uncover their expectations regarding functionality, usability, minimum technical and operational performance criteria, and potential future expansion opportunities for the SMART Triage platform. To gain a deeper understanding of prehospital care and workflows, I joined an ambulance shift for a day, observing real-time triage processes and challenges. Furthermore, national and international teleconsultation initiatives were analyzed to extract positive and negative experiences of ambulance video triage implementation. All these findings were used to create a phased implementation plan for the platform: Phase 1 (2025-2027), Phase 2 (2027-2030), and Phase 3 (>2030).

The user needs identified during the interviews were translated into concrete functionalities during the design phase and visually represented in application interface designs. These designs played an important role during the validation sessions.

During the validation phase, the Service Blueprints for each phase, along with the interface designs, were reviewed with five different users, the IT department and the head of ED. Feedback from these sessions led to adjustments that enhanced the platform's usability, alignment with current workflows, and alignment with other innovations. The validation process also highlighted differences in user preferences, resulting in multiple personalized interface designs and tailored user interactions incorporated into the Service Blueprint. As the iterations progressed, the amount of feedback decreased, reflecting increasing user satisfaction with the designs.

The final Service Blueprint and interface designs reflect the expectations of neurologists, cardiologists, pediatricians, and ambulance personnel for the SMART Triage platform. While the actual implementation this year will not be a replica of the designs due to cost and regulatory considerations outside the project scope, these outputs provide a strong foundation for the platform's architecture. Furthermore, the result provides a clear vision for service developers to work towards, ensuring that the SMART Triage platform not only aligns with user needs but also integrates seamlessly into existing workflows.

07 Personal reflection.

Looking back on this graduation project, I can absolutely say it has been an incredibly interesting and challenging experience. I chose this project because of my passion for combining design with healthcare, and I hoped to better understand how to apply my skills as a strategic designer in environments where people are not familiar with the value of design. I'm proud to say I achieved this goal.

By collaborating closely with the SMART Triage project team in Leiden, I had the opportunity to connect early on with neurologists, cardiologists, pediatricians, and ambulance nurses. Initially, I noticed some hesitation from future users to schedule interviews, often due to their busy schedules. However, as the project progressed, organizing validation sessions became much easier. Users were enthusiastic when they saw that their needs had been translated into tangible concepts. This sense of being heard generated excitement about working with SMART Triage, and their enthusiasm was contagious, significantly boosting my confidence in both the design process and my abilities as a designer. The user's enthusiasm and collaboration with diverse people with different interests have deepened my interest in UX/UI design.

Before this project, I sometimes found it difficult to start working on a project with an uncertain trajectory and unknown outcomes. This experience taught me to approach processes with an open mind, listen carefully to user needs, and allowed me to embrace the surprises I encountered along the way. I believe my limited prior knowledge of this subject helped me remain open-minded and consider all input. It was also a unique privilege to immerse myself in an entirely new field, including the chance to join an ambulance shift for a day and gain firsthand insights into ED workflows while I was writing this thesis at the LUMC and the RAV. This experience has deepened my interest in design consultancy, where you often work in unfamiliar sectors.

This project also taught me the value of visual tools as conversation starters. The SBs and interface designs served as a bridge between my understanding as a designer and the users' understanding of their daily routines and desired interactions with the technology. Furthermore, I developed the ability to navigate between different stakeholder groups. User interests were not always aligned, which required me to make thoughtful decisions, and the practical priorities of the IT team sometimes conflicted with the user-centric approach I followed. In such cases, I often had to explain the rationale behind my design choices and emphasize the importance of listening to user needs. These experiences have made me more confident and assertive in my role as a designer.

Reflecting on my contributions, I believe that due to this research the RAV, LUMC, Alrijne, and GHZ will save significant time and effort during the implementation of the platform. Before my involvement, the LUMC had no clear vision of what the SMART Triage platform would entail, what functionalities it should include, how users would interact with it, or when consultations would take place during the triage process. I defined and shaped all of this. Furthermore, before I started this project, ambulance nurses had not yet been involved, communication was primarily with physicians from LUMC, with only limited involvement from physicians at GHZ and Alrijne hospitals. I aimed to conduct diverse user research, which revealed differences in interests between hospitals and users. It was very interesting to highlight these differences to enable well-informed decision-making. Additionally, my extensive research enabled me to act as a bridge between stakeholders. For example, I attended several internal project team meetings where I represented the users and their needs.

Reflecting on the final outcome, I am super proud of my ability to immerse myself in an unfamiliar domain within just six months. It is especially rewarding to know that the results of my thesis will contribute to the Dutch healthcare system and will be implemented later this year – a thought that kept me motivated during the final stages of the graduation process.

Additionally, it's exciting to know that I will likely return to Leiden for the implementation of SMART Triage. Pilot days to test the hardware with the users are being planned, and I've been invited to participate. Seeing this process unfold will be particularly exciting, especially since the hardware was not directly within the scope of my graduation project.

I am excited to see how this experience will shape my professional future—perhaps even in healthcare.

08
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09
Appendices.

9.0 Appendices overview

Appendix A: Project brief

Personal Project Brief – IDE Master Graduation Project

Name student Joska Stoorvogel **Student number** 4667840

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Improving triage in prehospital care

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Patients arriving at the emergency department by ambulance are promptly diagnosed, and their treatments are determined upon arrival. Adequate staffing is essential to provide the necessary care. However, the healthcare sector is facing a growing shortage of qualified personnel. Meanwhile, the demand for healthcare services is rising and is expected to keep increasing in the coming years. This escalating demand, combined with the staffing shortage, is putting significant pressure on the quality and accessibility of healthcare in the Netherlands.

To address this challenge, LUMC, in collaboration with other hospitals and healthcare institutions across the Hollands Midden region, is working on the SMART Triage project (Smart Medical Applications for Regional Triage Use). The project aims to facilitate real-time visual and audio communication between ambulance personnel, patients, and physicians before the patient is transported to the emergency care.

The goal of the SMART Triage project is to reduce the increase in 'unnecessary' ambulance trips to the emergency department by treating patients at home when possible and only transporting them to the emergency departement when absolutely necessary.

➔ *space available for images / figures on next page*

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

To make the SMART Triage project at the LUMC a success, a project team was formed last year, bringing together various stakeholders such as physicians, ambulance personnel, researchers and the ICT department. While the 'what' and 'why' of the project are now largely clear, the 'how' still needs to be defined.

As a service designer, I will address the 'how' by collaborating with all the different stakeholders from a holistic perspective to gather information about what they need to make the SMART Triage project a success. Additionally, I will test & iterate on the the newly designed concept with the stakeholders via a prototype.

To achieve this, the following key questions need to be addressed:
- What are the current workflows for neurologists, cardiologists, pediatricians, and ambulance personnel without SMART Triage?
- What are the process differences across the other involved institutions (Groene Hart hospital, Alrijne hospital) and how does this impact the design?
- What are the 'pain points' in the current workflows, and what are the 'needs' of each stakeholder?
- How can SMART Triage address these needs?
- What type of prototype is needed to gather input from stakeholders to further improve the SMART triage platform?

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design a service map that illustrates how ambulance personnel can be assisted by a neurologist, cardiologist, or pediatrician during triage using the SMART Triage platform. The map outlines the specific technology required at each stage of the triage process to meet the needs of both RAV personnel and physicians.
A holistic approach will be used to collect the requirements of both direct users (physicians, RAV personnel) and system developers (ICT staff) to ensure implementation into LUMC's operational framework.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

-> Understand stakeholder challenges
1. Analyze (by observing and doing interviews) current workflows for neurologists, cardiologists, pediatricians, and RAV personnel without SMART triage
2. Research existing digital health and video triage solutions, exploring case studies from other countries
3. Discuss with the ICT team to identify key technical features required for SMART Triage integration

-> Develop main design objectives that meet the user needs and fit in the technical possibilities:
5. Create detailed user stories (visualization of the current way of working) with user needs
6. Define where and how SMART Triage technology comes in to meet these stakeholder needs

-> Create a suitable prototype and iterate on the prototype:
8. Draft future user stories showcasing SMART Triage's impact, using them as tool for feedback
9. Combine the iterated user stories into a first version of a service map (persons involved, actions, smart Triage technology, place of interacting with tech. etc.)
10. Create a suitable prototype(s) to test different parts of this service map and iterate

-> Create the final service map tested and validated by all stakeholders
11. (If it's not possible to address all needs at once, I will look at a step-by-step implementation plan)
12. Create a list of requirements/recommendations for developers and interaction designers so that they can easily take over the project.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	17-09-2024
Mid-term evaluation	13-11-2024
Green light meeting	09-01-2025
Graduation ceremony	06-02-2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

After my minor in biomedical engineering, I haven't worked on any more assignments related to healthcare. However, my interest in design combined with healthcare has always remained and therefore I would like to explore again during my graduation project if this is something I might want to pursue after finishing my masters.
In addition, during my internship at Elemental (Strategic consultancy), I developed a great interest in co-creation and I think it would be really interesting to apply this creative design method in an environment with doctors and other health professionals.

During my graduation I hope to learn better how to use my qualities as a strategic designer in an environment where people are not aware of the qualitites a designer possesses. I sometimes find it hard to explain this, and I hope to get a better grasp of it by working with people from very different fields.

Appendix B: HREC Documents

Delft University of Technology
HUMAN RESEARCH ETHICS
PROJECT AMENDMENT FORM
(Version: January 2022)

This project amendment form can be used to request approval for amending or extending research which already has recent HREC approval. If you are seeking approval for a new project **related to** an existing approval, then you should submit a standard HREC application as normal.

If you have any questions about your applying for HREC approval which are not dealt with on the Research Ethics webpages, please contact HREC@tudelft.nl

I. **Please provide the following information:**

Submission number of existing HREC approval	**3454**
Title of existing HREC approval	Visualizing implementation
Date of existing HREC approval	**28-Feb-2024**
If the amendment is simply a change in personnel, please provide: • the name/s and function/s (eg: researcher with access to confidential data) of the existing personnel • the name/s and function/s of the new personnel • the reason for these changes.	We are adding one person, Joska Stoorvogel, graduation student She will have access to the data that she collects. She is added to the HREC as she is doing a graduation project on the same topic.
If the amendment is simply an extension of the original, please provide: • the old end date • the new end date • the reason for this extension	The same timeline applies for the entirety of the HREC. Joska will leave the collaboration on the 28th of February.
For any other amendment/s please summarise:	
• What exactly you are proposing to change compared to your original application	I am adding one researcher (Joska Stoorvogel)
• What are the reasons for these changes	She is added to the HREC as she is doing a graduation project on the same topic.
• How these changes will affect the potential risks to your participants	It is the same as before, but with another person. The data is not sensitive and the same procedure for storage will be followed.
• What steps you will take to mitigate against these risks	Keep to the same approved steps for storing the data.
• How you will address these changes in your DMP and/or Informed Consent	We will add Joskas name on the informed consent. Everything else will be the same.

II. **Signature/s**

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)
Joska Stoorvogel

Signature of Corresponding Researcher: 
Joska Stoorvogel (Sep 5, 2024 08:55 GMT+2)

Date: Sep 5, 2024

Name of Responsible Researcher (print)
Fredrik Karlsson

Signature (or upload consent by mail) Responsible Researcher: Fredrik Karlsson

Date: 2024-09-04

Appendix C: Example interview guide

		Interview 1
Datum		
Naam		
E-mail		
Functie		
Achtergrond informatie		
Relatie smart triage project		
Ziekenhuis		
Introductie		
SMART triage: heeft u wel eens gehoord van het Smart-Triage project?	*Kunt u in eigen woorden omschrijven wat SMART Triage is?*	
Mening: Wat vindt u van het idee om video bellen in te zetten bij prehospitale triage?		
Frequentie: Hoe regelmatig ziet u patienten in het ziekenhuis die ook thuis behandelt hadden kunnen worden?	*Schatting in percentage. Een op de ...*	
Probleem: Wat is volgens u de voornaamste reden dat ambulance personeel de patient alsnog vervoert naar de SEH?		
Proces overview: Ik probeer de verschillen tussen de betrokken ziekenhuizen in kaart te brengen. Kunt u stap voor stap uitleggen wat er gebeurt als een patient binnenkomt op de SEH?	*Deze processen verschillen per klacht - meerdere verhalen uitvragen of 1 veelvoorkomende klacht kiezen.*	
Proces overview: Wie draagt welke verantwoordelijkheid tijdens dit proces?		
Proces overview: Als een ambulance binnenkomt op de SEH kunt u uitleggen wanneer u opgeroepen en hoe u precies opgeroepen wordt?		
Proces overview: Bent u meestal meteen beschikbaar als u wordt opgeroepen?		
Techniek: Welke techniek (computer programma's, websites, telefoon gebruik) wordt er gebruikt om data uit te wisselen tijdens dit proces?	*Focus op techniek die wordt gebruikt voor het uitwisselen van data (verkrijgen, versturen, opslaan).*	
Techniek: Welke data wordt er momenteel uitgewisseld?		
Techniek: Hoe wordt momenteel de data van patienten opgeslagen?		
Andere ziekenhuizen: In hoeverre heeft u tijdens werktijd contact met cardiologen van de andere betrokken ziekenhuizen (groene hart ziekenhuis en alrijne ziekenhuis) en hoe ziet dit contact eruit?		

HARTc1.0		
Frequentie: Met welke regelmaat wordt er weleens een consult aangevraagt met HARTc1.0?		
Techniek: Welke technische hulpmiddelen (computer programma's, websites, telefoon gebruik) worden er gebruikt om data uit te wisselen tijdens dit proces?	*Focus op techniek die wordt gebruikt voor het uitwisselen van data (verkrijgen, versturen, opslaan).*	
Plaats: Op welke plek bent u momenteel als een consultatie plaats vindt?		
Plaats: Op welke plek bent u momenteel als u wordt opgeroepen?		
Reden: In welke gevallen wordt er gebruik gemaakt van HARTc1.0?		
Parameters: Tot welke parameters heeft u momenteel inzicht bij het gebruik van HARTc1.0?		
Tevredenheid: Hoe tevreden bent u momenteel over het gebruik van HARTc1.0 en zijn er nog zaken die u mist of verbeterd kunnen worden?		
Onzekerheid: Bij welke gevallen kunt u momenteel niet met zekerheid advies geven over een situatie en laat u de patient momenteel altijd naar de SEH vervoeren?		
SMART-triage consult		
Gegevens: Tot welke gegevens zou u tijdens prehospitale triage op afstand nog meer toegang willen krijgen om te bepalen of iemand meegenomen moet worden naar het ziekenhuis?		
Video: Zou een video verbinding kunnen helpen bij het verkrijgen van deze informatie?	*Zo ja, welk visueel beeld heeft u dan nodig?*	
Data: Welke andere vorm van data transfer is nodig om deze gegevens op afstand te kunnen verkrijgen?		
Tijd: Hoe lang heeft u gemiddeld nodig voor een consult op afstand?		
Belanghebbenden: Welke belanghebbenden zijn er volgens u allemaal betrokken bij de implementatie van het SMART Triage concept?		
Creatief: Hoe zie jij werken met SMART triage voor je? Omschrijf als een ideale situatie voor jezelf.	*Omschrijf zowel de techniek als de interactie die je hebt met de techniek. Bv. Als cardioloog wil ik ... zodat ik ...*	

Patienten dossiser		
Moment: Tijdens een audio consult, op welk moment pakt u het patientendossier erbij?		
Plek: Op welke plek bent u als het patienten dossier erbij wordt gepakt en welk device gebruikt u hiervoor?		
Voor-Nadelen SMART Triage		
Voordelen: Wat is volgens u de belangrijkste reden om SMART-triage te implementeren?		
Nadelen: Wat zijn volgens u de risico's bij het implementeren van SMART triage?	*Risico's zijn op meerdere niveaus - organisatie, techniek, implementatie, zorg niveau.*	
Implementatie barrieres		
Barrieres: Voorziet u barrieres bij het imlementeren van het Smart-triage platform in de huidige werkwijze?		
Gebruik: Aan welke eisen moet het platform sowieso voldoen, wilt u het in gebruik gaan nemen?		
Gebruik: Wat zou u ervan weerhouden om het platform te gebruiken?		
Vervolg		
Vervolg interview: Wie moet ik volgens jou nog meer spreken om een goed beeld te krijgen van hoe het Smart triage platform eruit moet komen te zien?		
Communicatie: Wilt u op de hoogte worden gehouden van de voortgang binnen het SMART Triage project?	*Via kerngroep, mail, anders,demodag, niet...*	
Belangrijkste inzichten 💡💡💡		
Inzicht 1		
Inzicht 2		
Inzicht 3		

Appendix D: Final application interfaces ambulance personnel

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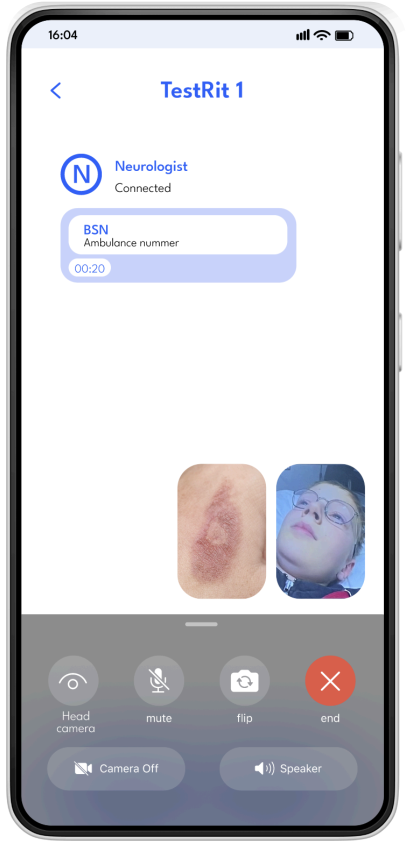

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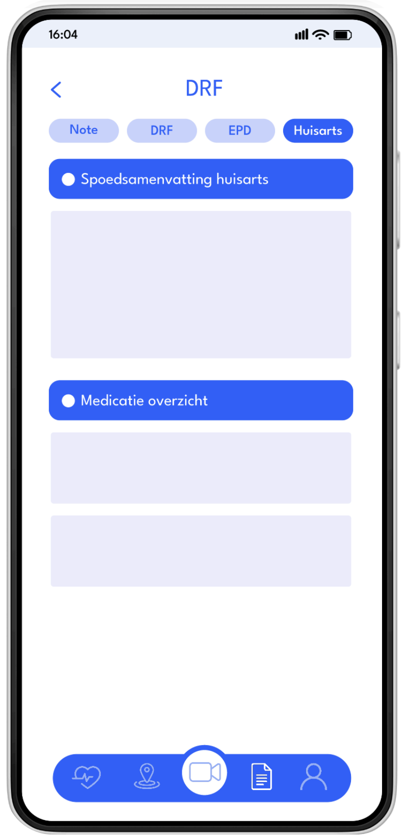

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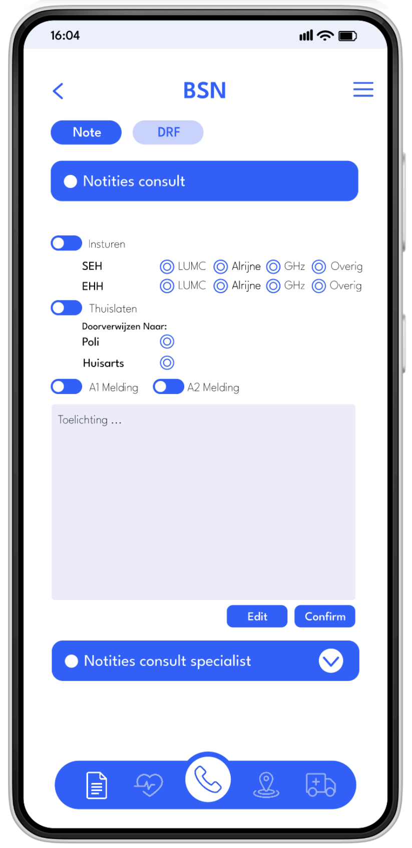

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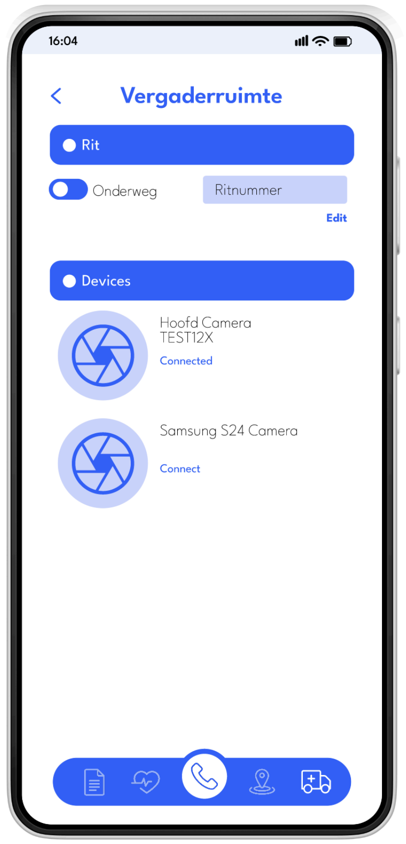

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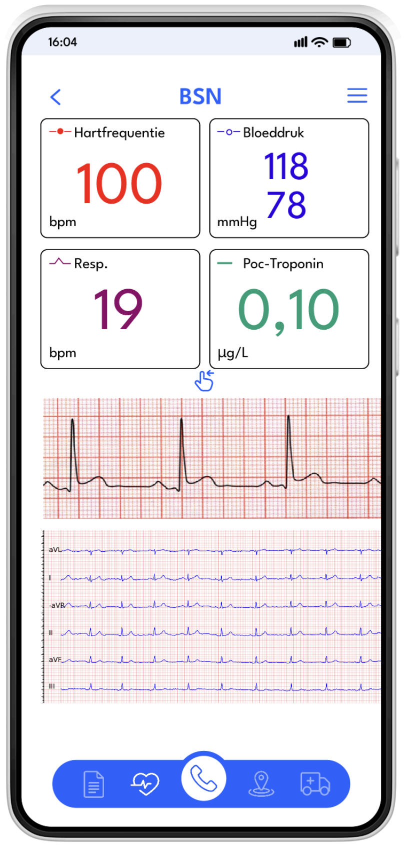

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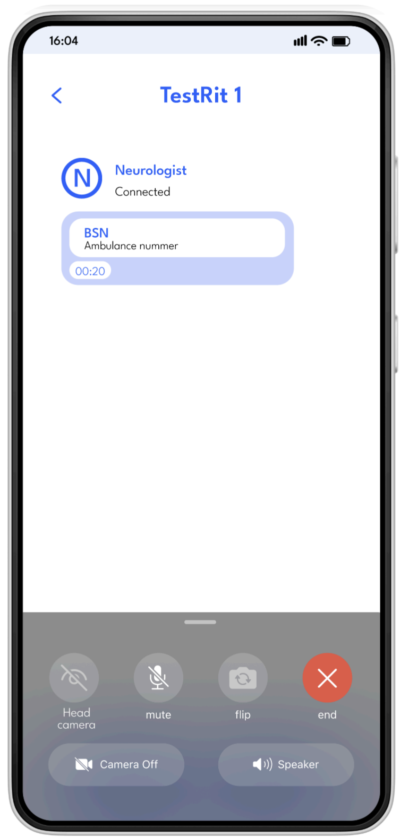
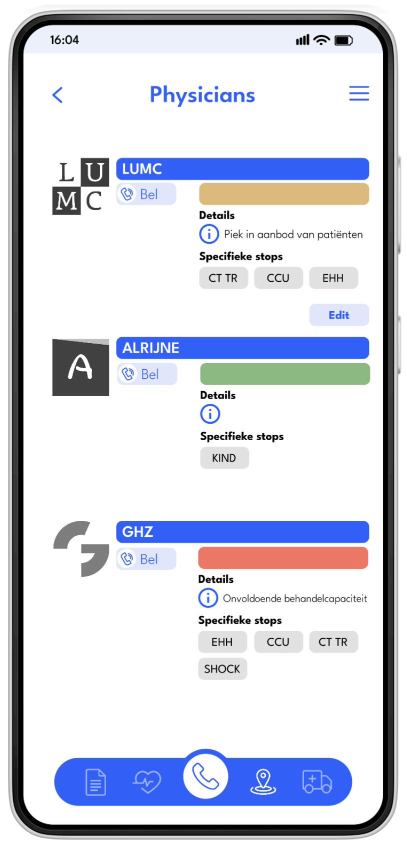
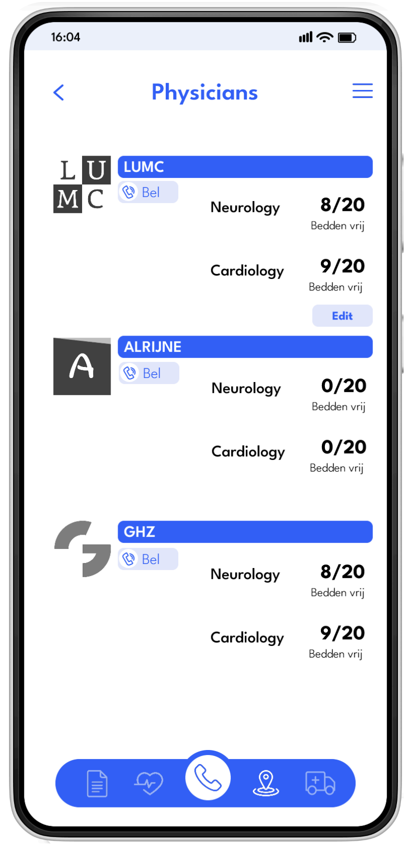


11 Phase 1



11 Phase 2



Appendix D: Final application interfaces physicians

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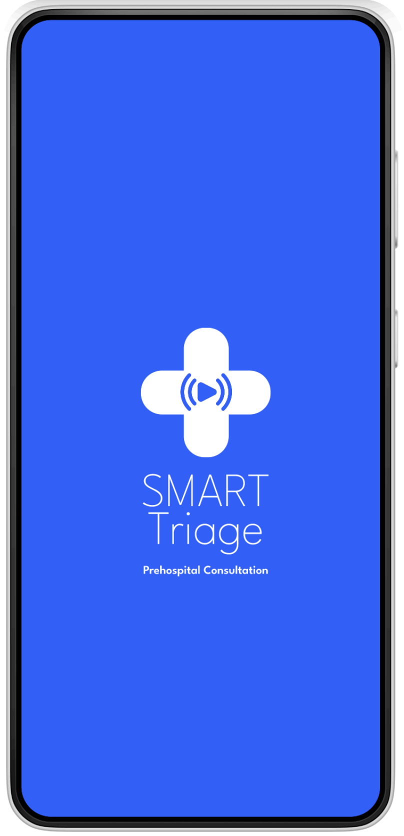

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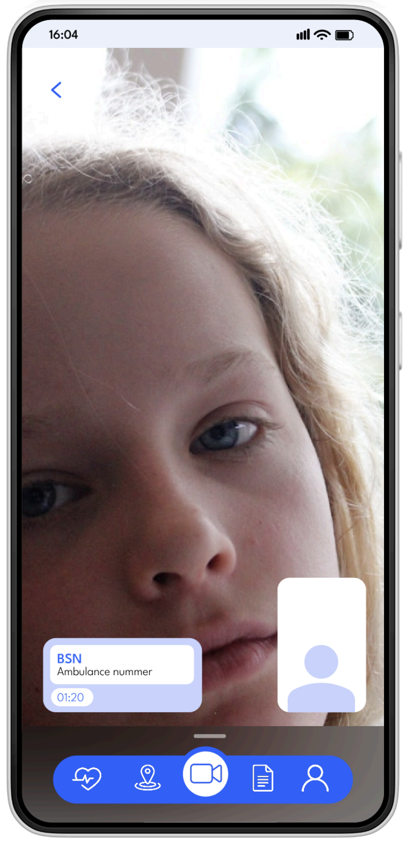
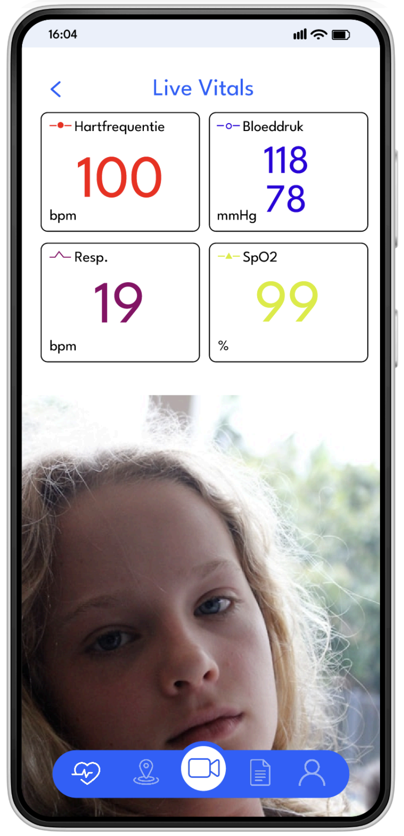
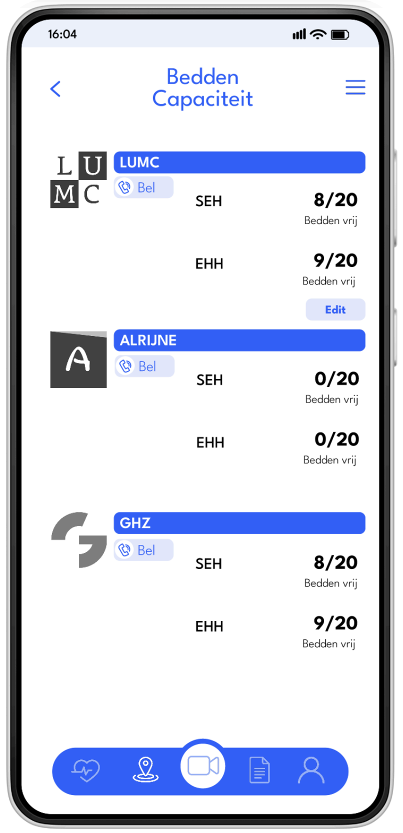


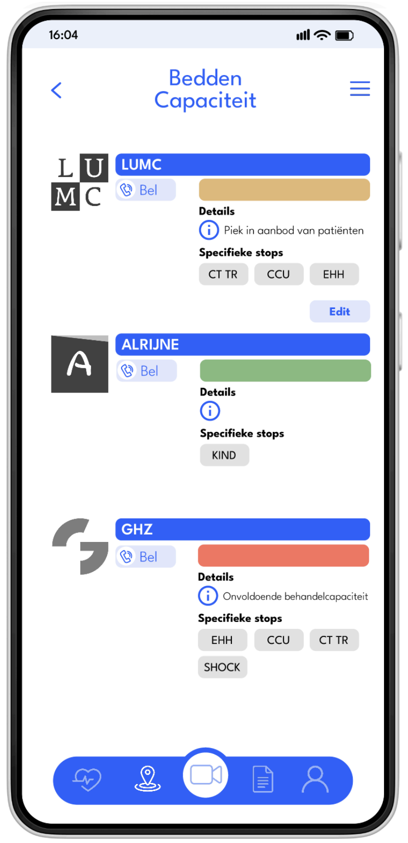
14 Neuroligst & Pediarician



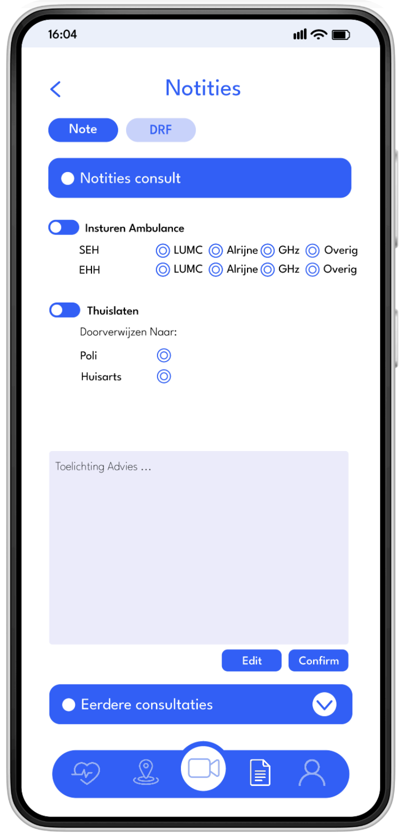
17a Phase 1



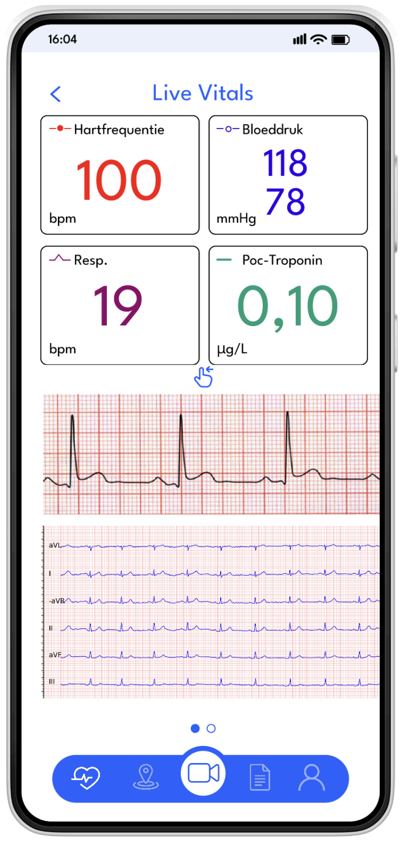
17b Phase 2



18 Cardiologist



14 Cardiologist



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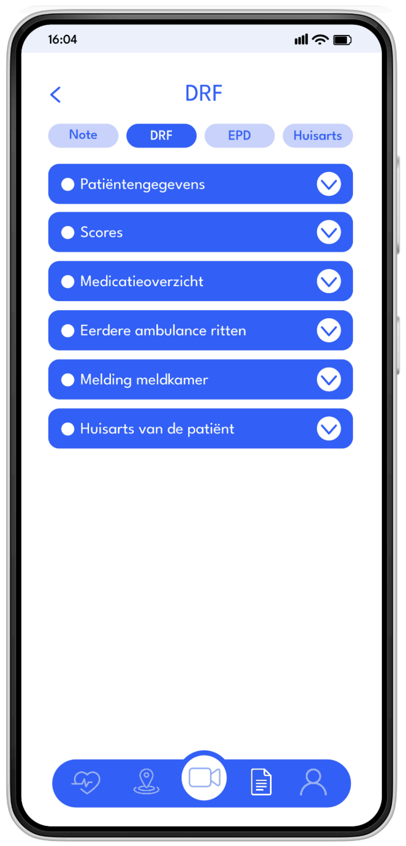

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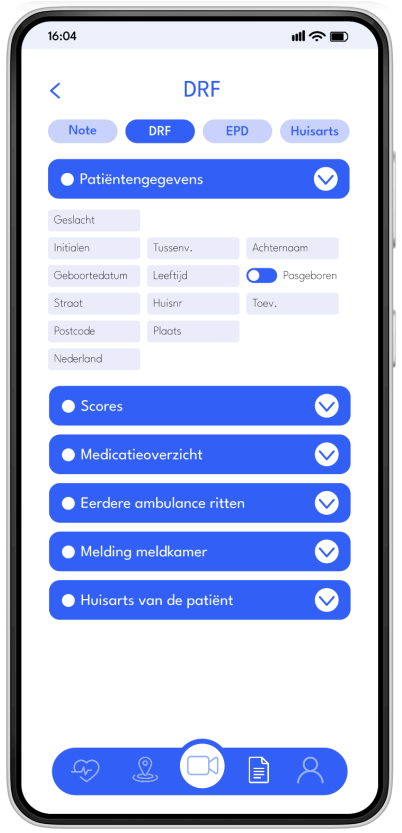
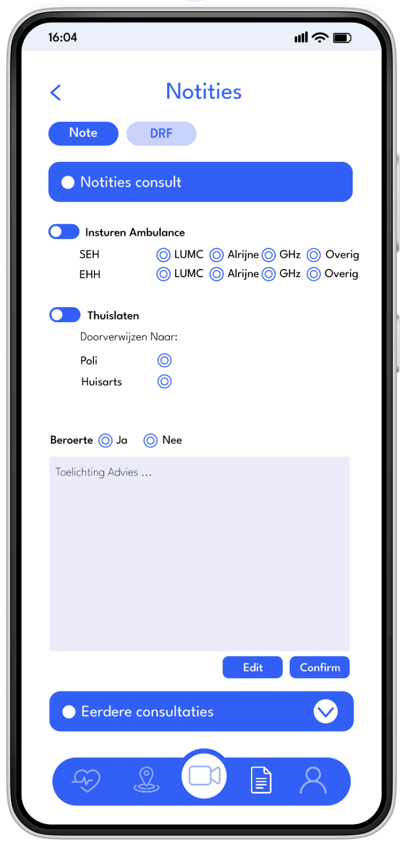
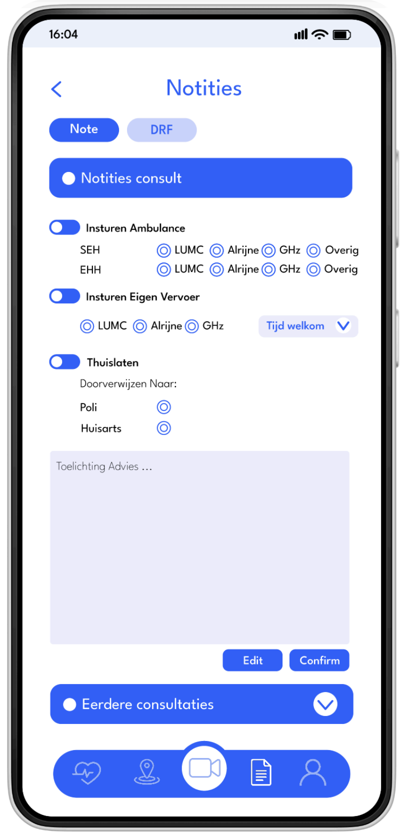


18 Neurologist



18 Pediatrician



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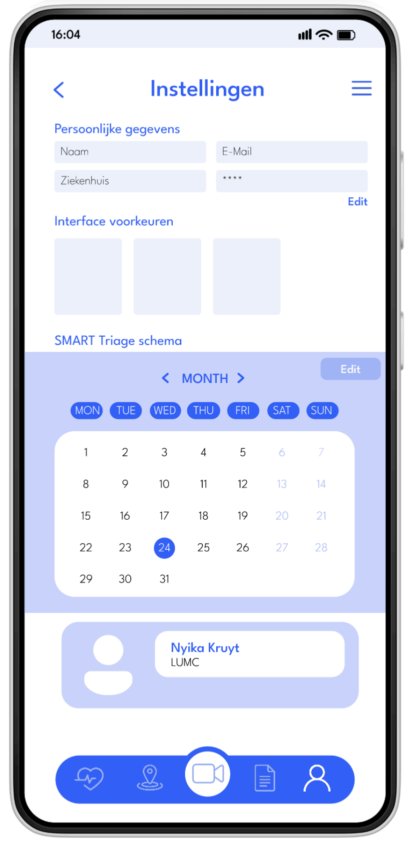

Appendix E: Potential risk scenarios identified by end-users

During the interviews and validation sessions, several potential risk scenarios were identified and discussed. These risk scenarios are not included in the SB but require consideration as they may occur during the use of the service. At the end of the validation sessions, users were asked to identify potential risk scenarios, resluting in three realistic cases. These scenarios were further discussed with the users, providing valuable insights through their quotes on the preferred resolutions for each scenario.

- **Multiple ambulances calling at the same time**

N1, C2: *"I want to be able to place someone on hold and return to them later. It would be helpful if they could wait on the line, so we don't have to call them back."*

C2: "With Hartc1.0 this usually never happens"

- **A physician is unable to answer the phone at that moment?**

N1, A1: " *If you have a SMART Triage service, you ensure that no tasks are scheduled that prevent you from handling consultations alongside them. Therefore, I don't expect to be unavailable for more than 10 minutes. In the worst case, ambulance nurses will have to manage without a consultation, like they do now."*

- **What if the connection drops?**

P1: *"When reconnecting, you should be able to rejoin the same conversation you were already in."*

The 'on-hold option' and the 'reconection function to join your earlier call' must be added to the list of requirements to ensure the software developer includes these features during the platform's development.

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