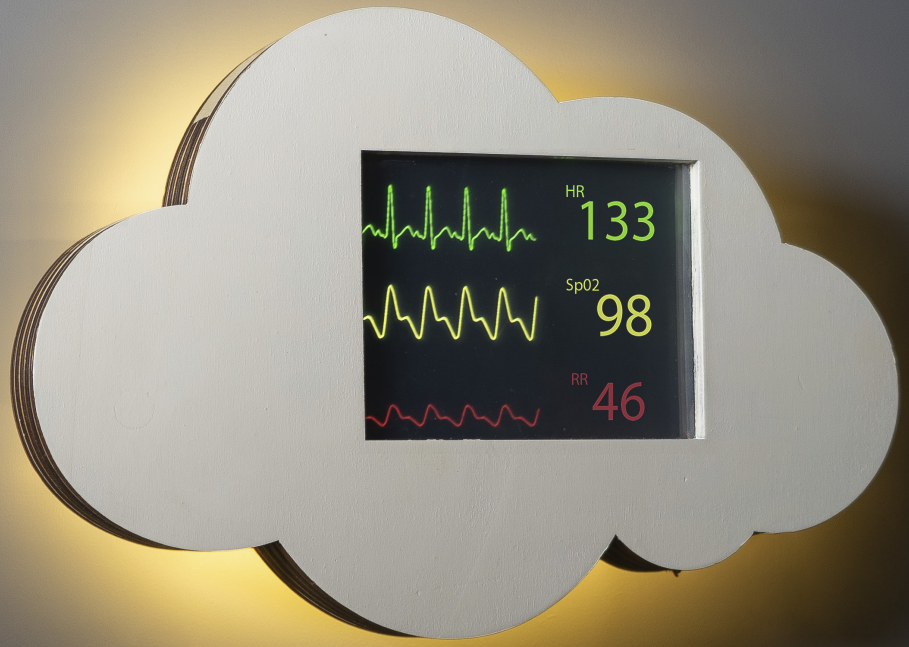
The Care Cloud:

A solution for continuously monitoring neonates at the maternity ward



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PREFACE

Dear reader,

Presented here is my master thesis "The Care Cloud: A solution for continuous monitoring neonates at the maternity ward." This graduation project marks the completion of my Master's in Strategic Product Design at the Faculty of Industrial Design Engineering at the TU Delft. I have been working on this project with a lot of enthusiasm and enjoyed exploring new aspects of designing in the medical field. I am grateful to conclude my time as an Industrial Design Engineering student with a project that has grown into a real passion of mine. It brings together different aspects of my education —qualitative research, stakeholder collaboration, product-system design, prototyping and roadmapping— while also allowing me to work with many great people.

First of all, I would like to express my gratitude to my supervisory team, my chair Sylvia Mooij, my mentor Kim Boltjes and my external mentor Justien Dingelstad. Your guidance and support helped shape this project while giving me the freedom to make it my own. I appreciate your valuable feedback, encouragement, and the time you invested in helping me improve my work. My final academic journey would not have been the same without your dedicated time and sincere attention. I also want to thank the experts who shared their knowledge and insights throughout this process. Your input has been very helpful in refining my ideas.

Finally, I am grateful to my dear family, friends, and fellow designers for their support along the way. Your input and encouragement have been greatly appreciated.

Hope you enjoy reading it!

Karlijn Sanders

ABSTRACT

Background
Around 130 million births take place worldwide each year (Ohuma, et al., 2023), these neonates are highly vulnerable due to their immature immune systems. Some neonates are at a higher risk of developing infections, known as early-onset neonatal infection. This occurs in 0.5–8.0 out of every 1,000 births (Tesini, 2022) and refers to bacterial infections that develop within the first 72 hours after birth. Early-onset neonatal infections could be life-threatening and must be recognized quickly. According to (WHO, 2020), 84% of neonatal deaths from infections could be prevented with early diagnosis and timely treatment. However, identifying infections early is challenging, necessitating close monitoring at the maternity ward. Currently, neonates are monitored manually through intermittent visits by care professionals. Unfortunately, gaps between monitoring visits may lead to unrecognized deterioration, delaying recognition and treatment.

Aim
This thesis emphasizes the importance of closely monitoring neonates and aims to provide a solution for introducing continuous monitoring at the maternity ward. The design goal focuses on three main areas: medical aspects, nurses, and parents, each with specific requirements identified through research and close collaboration. Based on these considerations, the design goal was: "To create a nurse- and parent-friendly way of continuous neonate monitoring at the maternity ward, to improve response time and patient outcomes. To support this, a strategic roadmap will be developed to explain the steps that should be taken to reach this way of monitoring."

Approach
The project begins with an overview of current neonatal monitoring methods and an analysis of associated challenges and opportunities. Furthermore, this thesis explores the possibilities of continuous monitoring at the maternity ward and determines the most effective implementation approach. The collected data included stakeholder opinions, literature research, design principles, and other valuable insights. The gathered data is carefully integrated to ensure that the outcomes meet the stakeholders' values and needs. The design process led to the development of the designed Care Cloud, with the implementation detailed in the strategic roadmap.

Results and conclusion
The Care Cloud integrates both technical and social aspects to address the needs of the stakeholders in the maternity ward. Within the Care Cloud is a patient monitor connected with the Bambi Belt to wirelessly monitor the vital signs, the monitor can alarm the nurse if needed. Key advantages of the Care Cloud include early infection detection, reassurance between visits, a parent-friendly design, seamless data access, enhanced workflow, and portability of the design. Furthermore, this project underscores the importance of integrating diverse stakeholders' perspectives and amplifying the voice of nurses to drive innovation in the medical field.
To ensure the successful implementation of the project results, a strategic roadmap was developed. The roadmap consists of three horizons that outline specific goals, with assigned responsibilities for the necessary actions. This strategic approach helps achieve the projects' vision and implementing continuous monitoring with the Care Cloud effectively.

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Glossary

Adhesive electrodes: These sticky patches are placed on the skin of the neonate to detect electrical signals from the body, commonly used for continuous monitoring of heart activity or muscle function.

Care professional: Every person with a job focused on human health care. In this project it is used as a collective term for the nurses at different wards, the pediatrician, obstetrician, assistants, and other care professionals working within the hospital.

CTG: Cardiotocogram, measures the heartbeat of an unborn child, which is still in the womb.

Early-onset neonatal sepsis: To describe sepsis that develops within the first 72 hours of life (Cleveland Clinic, 2024).

EHR: Electronic Health Record: Allow healthcare providers to pull comprehensive data on a patient's history, lab results and treatments.
Intermittent visits.

MMC: Maxima Medical Center in Veldhoven

Neonate: A neonate is also called a newborn. The neonatal period is the first 4 weeks of a child's life.
NICU: Neonatal Intensive Care Unit

Rdgg: Reinier de Graaf Gasthuis, hospital in Delft.

Sepsis: Sepsis is a life-threatening condition that occurs when the body damages its own tissues and organs in response to an infection. Sepsis can lead to septic shock, organ failure and even death if it's not diagnosed and treated early (Healthdirect Australia, 2022).

Socio-technical system: This is a complex system in which social elements and technical elements interact and influence each other within a specific context or environment (Carayon, et al., 2011).

INTRODUCTION

Problem definition
Approach
Methodology

INTRODUCTION

An infection in a neonate must be identified as quickly as possible, making close monitoring essential. This project began with the proposition to improve this critical observation period. **The initial vision for this project is to implement a form of continuous monitoring at the maternity ward to improve the observation period of identification of infection.** This approach aims to provide a continuous flow of data, which can provide insights between the intermittent visits of care professionals. Continuous monitoring can help facilitating the detection of trends. It can potentially help identify early signs of infections in neonates, improving response times and patient outcomes.

At the maternity ward there are different stakeholders; neonates, nurses, parents, and pediatricians. These stakeholders have different needs and wishes. A key aspect of this project is to carefully consider the needs and wishes of all stakeholders. The solution designed at the conclusion of this graduation project must align closely with their requirements and preferences. To achieve this, the project starts with a research phase—phase 1 and phase 2—focused on identifying these needs, as well as uncovering potential opportunities and barriers. The project focusses on human-centered design, there is close collaboration with stakeholders to refine how the vision of continuous monitoring can be practically implemented to support in early infection detection at the neonatal ward.

Problem definition
Close monitoring of neonates at the maternity ward is essential. If an infection is detected, prompt action is critical to ensure effective treatment. Antibiotics, however, should only be administered when truly necessary to avoid potential harm. Overuse of antibiotics has major drawbacks for the risk of developing antibiotic-resistant bacteria and its negative impact on the neonate's immune system. To avoid this, the neonates are currently closely monitored. Nurses physically check on neonates every three hours, but significant changes can occur within these intervals, particularly when there is a risk of life-threatening bacterial infections. This unnoticed decline in health can cause a delay in starting the treatment.

To improve medical outcomes, by detecting signs of infection as early as possible, the possibility of continuous monitoring is explored. The previously developed wireless monitoring device Bambi Belt could be introduced as part of the solution (Bambi Belt is explained in chapter 1.3.2). However, the challenge lies in the fact that the maternity ward is not yet equipped or used to continuous monitoring, thus needing further adaption. Any monitoring approach must remain parent-friendly and should not affect the current interaction between neonates, parents, and care professionals. This project aims to explore how continuous monitoring with the Bambi Belt as a use case can be implemented in a way that addresses these needs and challenges. The problem definition is further developed throughout the project and redefined at chapter 2.1.

Disclaimer quotes
Most quotes in this report are written in Dutch, due to Dutch speaking interviewees. By translating the quotes to English a nuance of the intentional meaning can get lost, as a consequence it has been decided to keep most quotes in Dutch. The same accounts for some Dutch visualizations, these visualizations are validated by nurses who prefer the Dutch language.

Aproach

This project followed a structured methodology to ensure a successful outcome. The project's structure was based on the double diamond concept (Design Council, 2015), which divides the process into two distinct diamonds: research and design (figure 0.1).

Research phase (first diamond)
The first diamond focuses on research, starting with phase 1, where the problem and its context are explored in depth. This phase involves diverging—broadening the perspective to gather as much information as possible. For this project, this included studying theories related to early-onset neonatal infection, conducting hospital observations and interviews, consulting experts, and delving deeper into the core problem. In phase 2, the findings from phase 1 are converged and synthesized into an overview of the main problems. This process resulted in a redefined problem definition, the design goal, and the future vision, which serve as the starting point for the second diamond.

Design phase (second diamond)
The second diamond emphasizes ideation and design. In phase 3, ideas were generated to address the design goal and future vision. These ideas were evaluated against the established design requirements, ultimately leading from six to three concepts. These concepts were discussed during co-creation sessions with nurses and lead to the one chosen concept, the development of the Care Cloud.
As a result of phase 4, the strategic roadmap is delivered. The roadmap outlines the steps that are needed to implement the Care Cloud and achieve the future vision.

The phases are illustrated in figure 0.1, and the report itself is structured according to these stages.

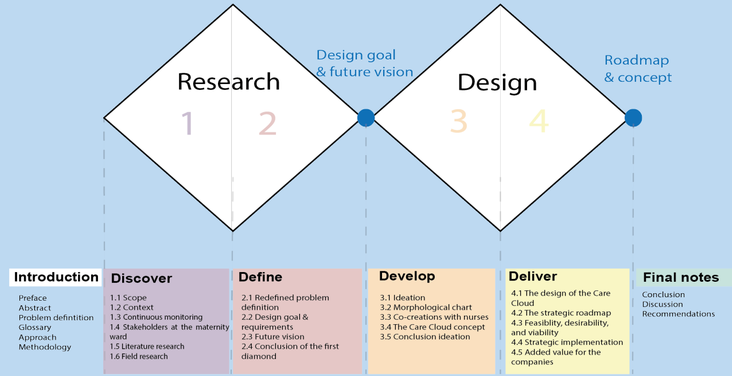


Figure 0.1: Double diamond phases for this project.

Methodology

To ensure robust findings and results, a diverse range of methods was employed throughout this project. These methods are divided into those utilized during the *research phase* and the *design phase*. The project primarily focused on generating in-depth and context-specific insights. Beyond these insights, additional methods such as literature research, various interview techniques, observations, and other investigative approaches were employed.

The **research phase** was designed to comprehensively explore the context and gather actionable insights: this is done with multiple methods like interviewing, observations, generative research design, literature research and more (table table 0.1). The data collected from these observations and interviews was transcribed, systematically analyzed, and organized through abductive analysis with coding and categorization. The software Atlas.ti was used to assist with coding, enabling the identification and clustering the focus areas and patterns. From this analysis, several key findings emerged.

These findings were subsequently validated with nurses through a co-creation session, ensuring that the interpretations aligned with their practical experiences and professional insights. This abductive analysis categorized the findings into three focus areas: medical aspects, nurses, and parents, that were recurrent throughout the project. These focus areas provided a structured framework for transitioning research insights into actionable design requirements, to bridge the research and design phases.

During the **design phase**, several established methods were used to ensure a rigorous and structured approach. These methods were chosen to align with the insights gained during the research phase and included: co-creations, morphological chart, brainstorming, concept designing and more (see table 0.1 for details).

This systematic combination of research and design methodologies ensured that the project was both comprehensive and contextually relevant.

Research activity	Abbre-viation	Goal of activity	Chapter
Literature research on early onset neonatal infection protocols and forms of monitoring.	LR	To gather existing knowledge and protocols on early onset neonatal infections and monitoring methods.	1.5
Observations at maternity ward, obstetric and neonatology ward, 7 days in total. - Rdgg - MMC	OBS	To observe and document practices and interactions at the maternity, obstetric and neonatology wards.	1.6.1
Unstructured interview with parents at the neonatology and maternity ward - 2 parents at Rdgg, maternity and neonatology ward. - 1 parent at MMC neonatology - 1 nurse at MMC neonatology	UI	To collect personal experiences and insights form parents and nurses in neonatology and maternity wards.	1.6.1
Semi-structured interviews with stakeholders. Different interviews with experts; 2 parents (Rdgg, prior research) 1 pediatrician (Rdgg, prior research) 2 nurses from neonatology ward (Rdgg, prior research) 2 parents from other hospital in NL 1 nurse at MMC neonatology 1 employee Bambi Medical (prior) 1 IT specialist EMC (prior)1 obstetric nurse Jeroen Bosch hospital	SSI	To gain insights and perspectives from various stakeholders involved in this thesis.	1.6.1
Generative design research with use of self-created booklet to generate written information from participants - 7 nurses from Rdgg maternity/obstetric ward - 2 managers Rdgg	GDR	To generate detailed written experiences, feedback and ideas from nurses, using a self-created booklet.	1.6.1
Context mapping interviews - 7 nurses from maternity/obstetric ward Rdgg - 2 managers Rdgg	CMI	The interviews that came after the filled in booklets. To gain deeper understanding of what is filled in and explanations through interviews.	1.6.1
Abductive analysis to analyze all transcripts and found information from the field research into findings	TA	To systematically analyze and identify main focus areas and categories from the collected data.	1.6.2

Table 0.1: Activities during the research phase.

Design activity	Abbre-viation	Goal of activity	Chapter
Stakeholder mapping for the stakeholders of this thesis.	SM	To identify and understand all relevant stakeholders involved in the project, their roles, and their influence. Ensuring their needs and expectations are considered throughout the design process.	1.4
Problem definition to define the problem.	PD	To clearly define the problem that needs to be addressed. This well-defined problem statement guides the design process.	2.1
Brainstorming	BS	To generate a diverse range of ideas and solutions.	3.1-4.1
Ideation for multiple phases to create several ideas.	ID	To generate a wide range of ideas and potential solutions through creative thinking. This activity encourages out-of-the box thinking and exploration of various possibilities.	3.1
Story telling to emerge the IDE students into their roles during the co-creation session.	ST	During the co-creation with IDE student this activity is used to let them emerge in their role of parent or nurse.	3.1.2
Co-creation session with the IDE **students**.	CC-S	Collaborating with IDE students to develop ideas during the co-creation session. This activity leverages the fresh perspectives and creativity of ide students.	3.1.2
Morphological chart to create ideas for the subproblems.	MC	To systematically explore different combinations of design elements and features by breaking down the problem into its components. This led to the 6 initial designs, which became concepts.	3.2.1
Concept Design for designing concepts in different phases.	CD	Concept development based on the ideas from previous activities. The 6 initial designs that came forward from the morphological chart became 6 concepts in this phase.	3.3-4.1
Harris profile to chose the 3 best concepts out of the 6 concepts.	HP	To evaluate and compare different design concepts using a set of predefined criteria. This brought the 6 concepts to 3 concepts.	3.2.2
Co-creation session with the **nurses** from Reinier de Graaf hospital	CC-N	To involve nurses in the design process and ensure the solutions meet their needs and are practical at the maternity ward. Their end-users' perspectives are incorporated, leading to more user-friendly and effective designs.	3.3
Strategic roadmap to explain the steps towards the end goal.	RM	To create a strategic plan outlining the steps and timeline for implementing the design solutions.	4.2
Future visioning	FV	To envision and plan for the long-term impact of the design solutions. Thinking ahead about the future needs, possibilities and challenges over time.	2.3

Table 0.2: Activities during the design phase.

1.Discover

The first phase is about discovering the underlying problems. This phase is explorative and focuses on diverging. The goal is to seek possible areas or themes to improve (Marin-Garcia, Garcia-Sabater, Garcia-Sabater, & Maheut, 2020). There are many areas to be considered when exploring possible problems. During this phase the theory about neonatal infections, observations and interviews with care professionals, practical and theoretical context are explored and reported.

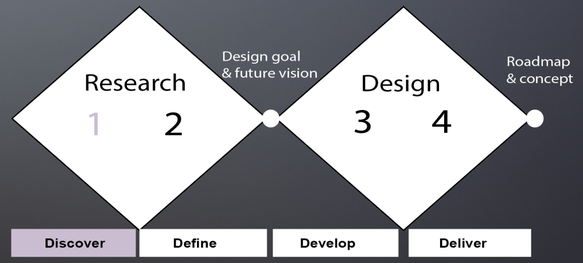


Figure 1.1 Phase 1 highlited in the double diamond

1.1 Scope

This project focuses on introducing continuous monitoring for neonates at increased risk of infection in the maternity. Currently, nurses manually monitor vital signs every three hours, a process that can be uncomfortable for neonates and parents (HaaglandenMC, 2024). The intermittent time between the intervals can also delay the detection of acute deterioration (Fieselmann, Hendryx, M.S., & Wakefields, 1993). The new approach of continuous monitoring aims to improve monitoring while considering both technical and social aspects and the needs of different stakeholders (nurses, parents, pediatricians, and neonates). To thoroughly develop an understanding of these aspects and needs, the research includes observations and interviews with care professionals and parents to ensure the technology aligns with their needs. The experience of the care professionals and parents are highly valued. Most activities took place at the Reinier de Graaf hospital.

Socio-technical systems
Within this project there has to be dealt with socio-technical systems. This is a complex system in which social elements (such as people, organizations, cultures, and communities) and technical elements (in this project monitors, sensor and alarms) interact and influence each other within a specific context or environment (Carayon, et al., 2011). During this project the focus is on how these social and technical elements can be optimized to achieve the desired goals while considering human factors and social dynamics. The desired goals of this project can be simplified to a well-functioning interaction between the social and technical elements. The social element is issue of improving the experience of the parents, neonates, and care professionals at the maternity ward. Whereas the technical elements are about improving the use of the system and faster recognition of the infection.

To reach this goal both social and technical aspects will be improved. For the social aspects there will be interviews and co-creation sessions and literature research. The decisions for the technical aspects will be based on literature research and interviews with experts.

Project background
A 12-week research project was conducted prior to this graduation project to investigate the monitoring possibilities for neonates at risk of infection. This involved in-depth interviews, observations, and analysis to identify the current situation and explore the potential benefits of using a Bambi Belt in these cases. The research included participation in nurses' and pediatricians' workdays and conversations with parents to gain insights and experience. Additionally, interviews with obstetrician, maternity care at home, IT specialists and other disciplines have been conducted. All the insights were combined into a report (appendix J).

The research and analysis for possibilities of continuous monitoring with the Bambi Belt was done for three different future use cases.

Use case 1:
Newborns who are treated with antibiotic due to suspected infection are admitted to a neonatology ward: Cordless continue monitoring with the Bambi Belt instead of monitoring with wires.
Use case 2: Newborns at increased risk of infection without antibiotic treatment, located at the maternity ward. Using Bambi Belt instead of a nurse manually monitoring the neonate every three hours.
Use case 3: Bambi Belt in the home situation instead of nursing checks every 3 hours at the maternity ward.

Findings:
The research revealed both benefits and barriers of using the Bambi Belt in these scenarios (figure 1.2). These barriers were categorized into research questions, outlining areas for further study. Before implementing the Bambi Belt in any of these use cases, additional research is necessary. This graduation project delves deeper into the second use case, exploring ways to improve continuous monitoring at the maternity ward. The prior research gave a first step for developing possibilities for continuous neonate monitoring at the maternity ward. This vision is explored and developed further during this graduation project.

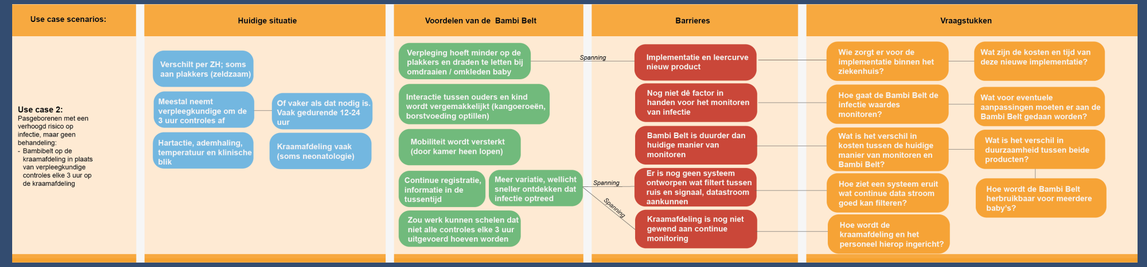


Figure 1.2: Prior research about current situation, problem, advantages of Bambi Belt, barriers, and research questions. More explanation can be found in appendix J.

1.2 Context

To gain a thorough understanding of this project, its context has been explored, including an analysis of the practical setting to ascertain existing knowledge and identify key stakeholders. This section also delves into the rationale for implementing continuous monitoring and the associated challenges. This comprehensive contextual investigation aims to develop a holistic view of the project's operating environment.

1.2.1 Hospital context

This project focuses on the maternity wards. To ensure an effective investigation and possible implementation, the decision was made to concentrate on a single hospital: the Reinier de Graaf Hospital in Delft. Focusing on one physical location allows for in-depth research and close collaboration with care professionals, fostering clarity and precision in the development process. In the future, the outcomes can be adapted for use in other hospitals, recognizing that while minor differences may exist, the overall findings should be broadly applicable across other maternity wards in hospitals.

Figure 1.3: Room at the maternity ward at Reinier de Graaf hospital.

Maternity ward
The maternity ward is one of the three wards located within the hospital where the neonate and its mother can stay. Figure 1.4 shows when a mother and neonate go to the maternity ward. This is based on their health situation.

Sequence of different rooms
The order of rooms is shown in figure 1.4.

1. **Obstetric ward:** It usually starts at the obstetric ward; the mother is there during labor and often a few hours after the neonate is born. After those few hours there are 3 options, depending on the health situation of the neonate and its mother.
2. **Maternity ward:** This is the following room when the hospital wants to keep one of them, or both, for further observation, or to strengthen a bit more before going home. They are transferred together to the maternity ward. Depending on how the situation develops there they can either go home, or the neonate gets transferred to the neonatology ward.
3. **Neonatology ward:** When the neonate is in really bad condition, for example infection, the neonate is sent directly from the obstetric ward to the neonatology ward. The mother can go with the neonate but will not receive care there. Or she can stay at the maternity ward in the case that she also needs a bit more care. In that case they are split up in different rooms.
4. **Home:** The third option that can follow after the obstetric ward is that mother and neonatal can go home after a few hours if both their conditions are capable of doing so.

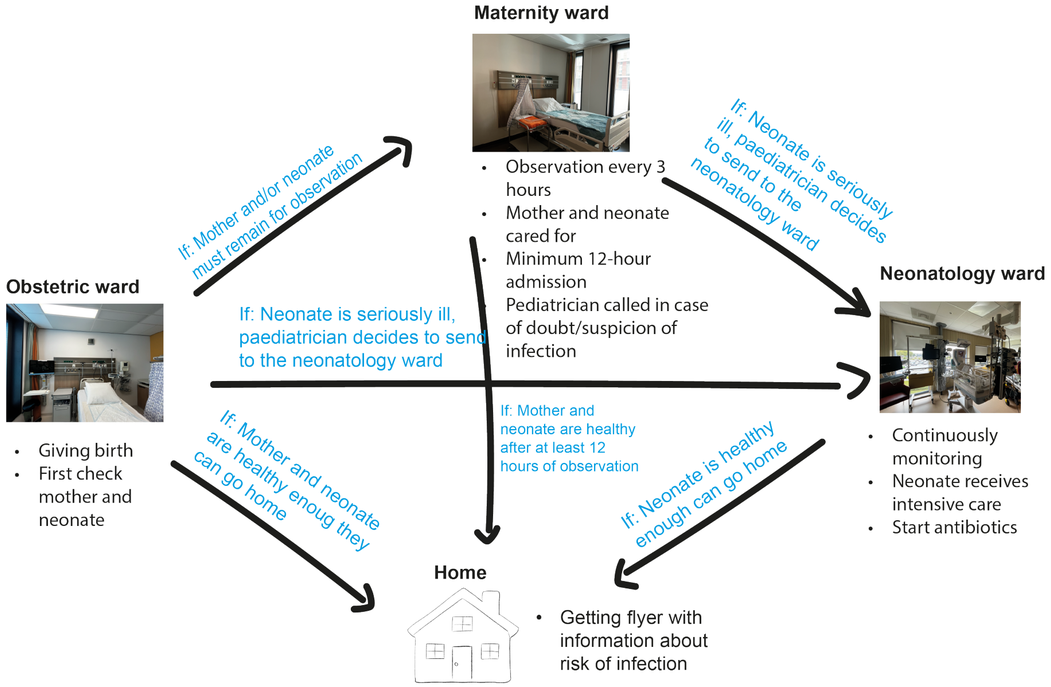


Figure 1.4: Sequence of different rooms.

Different wards in Reinier de Graaf hospital

The project focused on the maternity ward, although, the other wards around it are also important to gain knowledge of, this creates a broader overview about what is already used or standard at other wards. The three departments that are important for this project are the obstetric ward, maternity ward, and the neonatology ward. The rooms in these departments have differences between them. First of all, the presence of monitors. At the obstetric ward there is one monitor and one screen and a tv. Here the cardiotocography (heart activity of the neonatal) is monitored. This is visible at the bed-side screen and in the central monitor room. This is different than at the maternity ward, where are no monitors in the room. And as a contrast, the neonatology ward is equipped with a high number of monitors. Here the heart rate, breathing, oxygen levels, temperature and blood pressure are measured. The difference between the rooms also influences what care professionals see, hear and how they work. This can also affect the parents in the room. The different environments are shown in figure 1.5.

Obstetric ward

Continuous monitoring: Yes
Central monitoring: Yes
Bedside monitor: Yes
Automatic alarm: Yes
What is continyously measured: CTG (heartbeat of baby in the womb)
When in this room: Admission before delivery, during delivery and ofter few hours after delivery. If all goes well, home after few hours **Caring for:** Mother and child
Active: Gynaecologist, clinical midwives, nurses, physician assistants, maternity nurse, lactation consultant, medical social workers, paediatrician on request

Maternity ward

Continuous monitoring: No
Central monitoring: No
Bedside monitor: No
Automatic alarm: No
What is continuously measured: Nothing
When in this room: Admission after the delivery, if mother of neonate is not feeling well. When both are fine, they can go home
Caring for: Mother and child
Active: Maternity nurse, lactation consultant, gynaecologists and clinical obstetrician, medical social workers, paediatrician on request
Note: Optional using saturation monitor for manual use

Neonatology ward

Continuous monitoring: Yes
Central monitoring: Yes
Bedside monitor: Yes
Automatic alarm: Yes
What is continuously measured: Heart rate, breathing, blood oxygen level, temperature, sometimes blood pressure,
When in this room: When neonate is seriously ill
Caring for: Neonate
Active: Neonatologists, nurses, nursing specialists, physician assistants, physiotherapists, sometimes maternity nurses, lactation consultants, medical social workers

Figure 1.5: Different appearances of rooms at the obstetric ward, maternity ward, and the neonatology ward.

1.2.2 Current way of monitoring at the maternity ward

To improve the way of monitoring at the maternity ward it is important to answer the question of how monitoring is currently performed at this ward. To answer this question the graduate student has conducted literature research and field research. The main guideline of the protocol is that a neonate with risk of infection needs to stay a minimum of 12 hours for observation. This can be extended if needed. The pediatrician decides this. Every three hours the nurse goes to the personal room to check on the neonate.

Figure 1.6 illustrates how a common observation period at the maternity ward by risk of infection can proceed. The nurse introduces herself and checks the neonate. In the protocol is written down what to check (temperature, color of skin, breathing, behavior, etc.). This is done with an interval of 3 hours, for a minimum of twelve hours. When there are risk factors apparent (abnormal temperature, color of skin, etc.) or when the nurse does not trust the condition of the neonate, based on their clinical gaze, the pediatrician will be called. The reasons of doubt will be explained and if needed the pediatrician will check the neonate.
Based on the advice of the pediatrician, the following steps will be planned. This can be direct admission to the neonatology ward or a shorter interval between the checks of the nurse, for example, every hour. This observation keeps going until the situation changes. The decisions are made together with the pediatrician. At the end of the observation period (minimum of twelve hours but can be extended if needed) the neonate can go home or to the neonatology if extra care, treatment, or continuous monitoring is needed.

Observation period at the maternity ward, with neonate at risk of infection

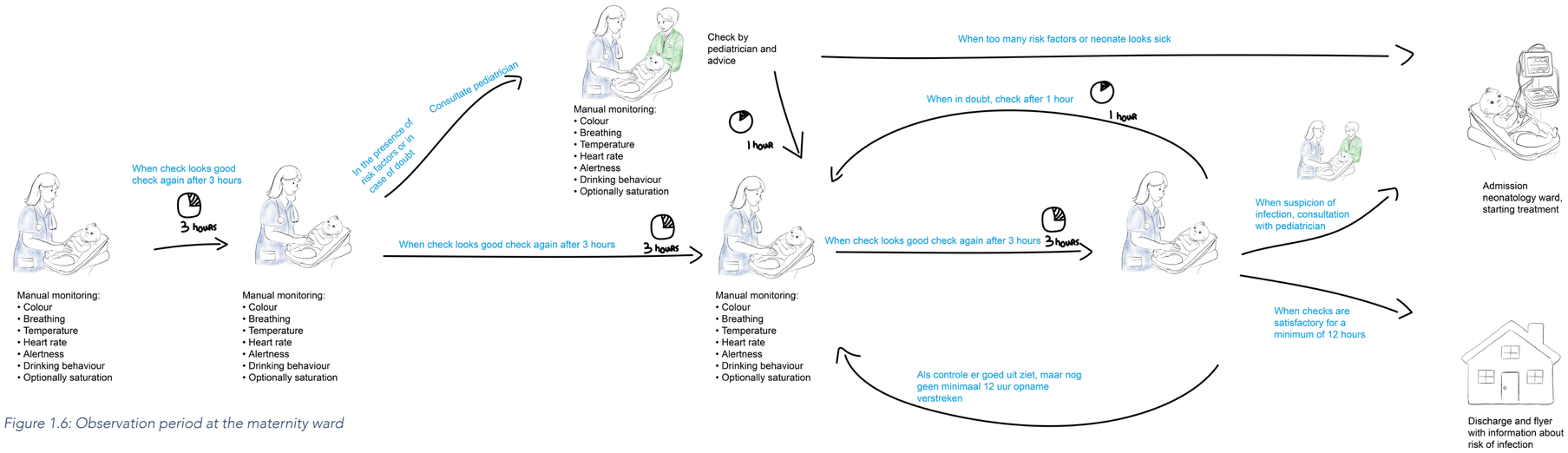


Figure 1.6: Observation period at the maternity ward

1.2.3 Monitoring screens at the different wards

Maternity ward:
As described before, at the maternity ward there are no screens used for monitoring.

Obstetric ward:
At the obstetric department they use personal bedside screens and central screens to observe the CTG (cardiotocogram) scans from baby's that are still in the womb. At the obstetric department in Reinier de Graaf hospital, the central screens were placed in the 'vissenkom' (Dutch translation for fishbowl because of the glass walls (figure 1.7)). This is the central base where care professionals sit in between checks. Although no one is specifically assigned to these screens, there is almost always someone present to monitor the centralized screens and patient data (fieldnotes).

When the CTG measured a deviating value it sends out an alarm, this is noticeable in the personal room, the central monitor, and the handheld of the nurses.

Figure 1.7: The 'vissenkom' at the obstetric ward, central screens with CTG's from different rooms (not visible due to privacy).

Neonatology ward:
At the neonatology ward there are both personal bedside screens and central screens. These central screens were being watched by neonatology nurses. At the neonatology ward multiple vital signs are measured; hearth rate, breathing, blood oxygen level, and temperature. The personal bedside screens provided the healthcare professionals with an easy way to interpret why the alarm went off when they were already in the room. There is no need to reach for their handheld (fieldnotes).

Those fieldnotes point out the differences of the current way of monitoring at the three different wards.

Current way of warning nurses
At Reinier de Graaf hospital, all care professionals in the maternity, obstetric and neonatology wards carry handheld devices, similar in size to smartphones. These devices receive alarms per ward, indicating which rooms require attention. Fieldnotes reveal that during a conversation, a nurse's handheld device beeped multiple times. The nurse promptly checked the device and explained, "it is not my room," referring to the room number displayed on the screen. This indicates that parents in a specific room pressed the call button for nurse assistance. Nurses are assigned to 'personal rooms' each morning, with a buddy system in place for backup in case the assigned nurse is busy and does not answer to the alarm of that room.

Figure 1.8: Handheld at the maternity ward.

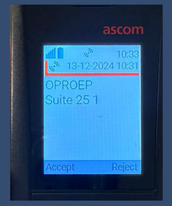


Figure 1.9: Warning on handhelt for suite 25.

1.3 Continuous monitoring

This project aims to design an effective form of continuous monitoring for the maternity ward, for neonates with risk of infection. Improving this experience is essential, as significant time gaps between visits can allow a neonates' condition to deteriorate without the awareness of care professionals or parents, potentially leading to delayed treatment.
This potential delayed treatment is explained by nurse 6: "Nu lopen we soms achter de feiten aan. Er kan in de tussentijd (tussen de controles) het een en ander gebeuren wat de ouders ook niet in de gaten hebben. Hierdoor kan het zo zijn dat de baby verlaat wordt doorgestuurd voor behandeling."

This project explores how continuous monitoring could help address this issue. The needs, wishes and requirements will be researched and explored for possible implementing continuous monitoring.

1.3.1 What is continuous monitoring?

Continuous monitoring for neonates involves the ongoing assessment of vital signs and other health indicators, such as heart rate, respiratory rate, oxygen saturations, and temperature, using specialized medical equipment (Kumar, Akangire, Sullivan, Fairchild, & Sampath, 2019).

Importance of monitoring vital signs by risk of infection

The aim of this project is to improve monitoring neonates with risk of infection. Continuous monitoring plays a crucial role in improving observation during this critical period, as rapid detection of infections is essential. According to Sullivan & Fairchild (2021): "The response to sepsis, (..), manifests as changes in body temperature, respiratory drive and oxygenation, heart rate characteristics and blood pressure." Therefore, it is important to closely monitor the vital signs of neonates at risk of infection. More information about infection by neonates can be found in chapter 1.5.

Use case: The Bambi Belt

Different forms of continuous monitoring are available. An option for continuous monitoring is the previously developed wireless monitoring device Bambi Belt (explained in chapter 1.3.2). This product is initially developed for the Neonatal Intensive Care Unit (NICU), but it could give opportunities for other wards. For this project, the Bambi Belt is used as a use case, serving as both a starting point and a tool for designing a suitable monitoring solution for the maternity ward.

1.3.2 The Bambi Belt

Value

The Bambi Belt is a device to continuously measure body data of a neonate, it offers a substitute for the adhesive electrodes that are mostly used to collect data of vital signs. Bambi Belt is a product of the company Bambi Medical, located in Eindhoven, the Netherlands (Bambi Medical, 2023). It is designed to reduce parental stress and physical discomfort of babies in the Neonatal Intensive Care Unit (NICU).

Bambi Belt offers reliable monitoring of neonatal vital signs without all the wires. The current way of monitoring is performed with wires and adhesive electrodes. Eliminating these wires and adhesive electrodes will reduce stress, pain, and possible skin damage for the baby (Bambi Medical, 2023). The substituting of those wires gives advantages for parents, NICU staff and the neonate itself. Without wires it is easier to pick up the neonate from the incubator, since there is no need to disentangle the wires. The wires are also what makes parents insecure (interview mother NICU): *"Ik vond de draden in het begin ook wel een dingetje, ik durfde haar niet zelf te pakken."* Research showed that skin-to-skin moments are important for the strong mother child bond which can help reduce anxieties (Cheng, et al., 2019). Without wires this is less scary and easier to perform.

Figure 1.10: Elimination of wires through use of the Bambi Belt (Bambi Medical, 2023).

Figure 1.11: Neonate at the NICU wearing the Bambi Belt (Bambi Medical, 2023).

Functioning
The Bambi Belt system consists of a silicone belt around the chest of the neonate, the Bambi Bridge, and the Bambi Interface (figure 1.11). The belt monitors the heart rate (ECG) and dEMG for apnea detection of babies (apnea is a disorder that causes brief interruptions in breathings, often occurring while asleep). This belt sends the data to the Bambi Interface, which is connected to the patient monitor and the alarm management system of the ward (currently only NICU). The belt uses a Bambi Bridge to connect over Bluetooth with the Bambi interface. The Bambi Bridge has a duration of approximately 2 days without charging, it can be charged by plugging into the Bambi Interface. The Bluetooth signal gives the opportunity for wireless monitoring. The Bambi Belt makes wireless monitoring possible for both single room care and open-bay NICUs.

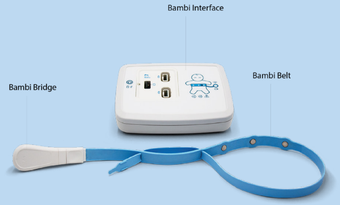


Figure 1.11: The Bambi Belt system (Bambi Medical, 2023)

Bambi Belt placement and measurement
The Bambi Belt is placed below the ribcage of the neonatal patient, the left and right electrodes need to be in a vertical line under the nipples, placed on the diaphragm muscle, this is the primary respiratory muscle located at the base of the lungs (figure 1.10). The Bambi Belt makes use of diaphragmatic electromyography to monitor breathing. This dEMG technology can be more accurate in detecting central apnea when used for respiratory monitoring in premature babies (Bambi Medical, 2023).

The second vital value that the belt can measure is the heart rate (ECG). The Bambi Interface is connected with a wire to the Philips monitor (figure 1.12. This is the current monitor that is already in use for monitoring at the NICU. There are no setting changes needed within the monitor when the Bambi Belt is connected, Bambi Medical calls it ‘plug and play‘.

Figure 1.12 illustrates how the Bambi Belt system (within the dotted line) can replace the current way of monitoring with adhesive electrodes. The signal will go through the Bambi Interface, and this will be connected to the monitor.

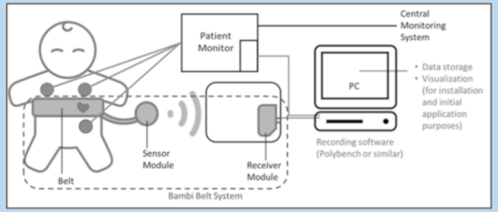


Figure 1.12: The measurement setup. Bambi Belt within the dotted line (Scholten, et al., 2022).

Boundaries of Bambi Belt as use case
For this project the functioning of the Bambi Belt will be assumed to perform as claimed by the company, scientific studies, and research. Analyzing the technical functioning of the Bambi Belt is outside of the scope of this project. In Maxima Medisch Centrum Veldhoven (MMC), studies are performed and will continue during and after this project to test the performance of the Bambi Belt.

Take aways context:
- **Vision about introducing continuous monitoring:** This project aims to introduce a form of continuous monitoring for neonates with risk of infection at the maternity ward, ensuring timely detection of potential issues by reducing the risks associated with time gaps between manual checks.
- **Bambi Belt use case:** The Bambi Belt, a wireless device for monitoring vital signs like heart rate and respiratory function, is used as a use case to explore the feasibility and benefits of continuous monitoring in providing uninterrupted data for neonatal care at the maternity ward.
- **Benefits of wireless monitoring:** The Bambi Belt eliminates wires and adhesives, reducing physical discomfort for neonates and stress for parents, and making it easier to hold and bond with their baby.
- **High precision beyond NICU:** Although designed for the NICU, the Bambi Belt’s high accuracy can also benefit maternity wards, offering the same level of precision for early detection of issues in a less intensive setting.

1.4 Stakeholders at the maternity ward

With the project vision, the context and Bambi Belt thoroughly explained, the next step is to outline the stakeholders involved in this process at the maternity ward. Understanding the key stakeholders and their roles will help direct the focus of the project.

The key stakeholders present in the maternity ward are illustrated in figure 1.13. The central circle represents the core focus: the neonate at risk of infection. The closer a stakeholder is to the center of the circle, the more 'important' their role is in the context of this project. Relationships between stakeholders are indicated by arrows, showing direct interactions.

The key stakeholders closest to the neonate, are the nurses and the parents. These key stakeholders, along with the overarching medical aspect—representing the goal of ensuring the neonate's health—form the three focus areas throughout this project. Each of these focus areas is represented by a specific symbol and color, making them easily identifiable.

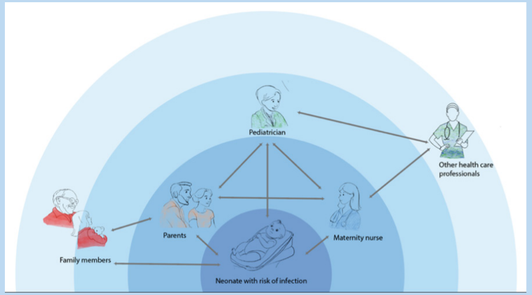


Figure 1.13: Stakeholder overview of key stakeholders at the maternity ward.

Three focus areas:

1. Medical aspects

This focus area reflects the overarching goal: improving the time and experience to identify the infection at neonate. This focus area guides the project and is translated into specific requirements. This focus ensures that the eventual solution contributes to improving the observation of infection risks at neonates.

2. Nurses

As shown in the stakeholder map, maternity nurses are positioned close to the inner circle. This indicates that they are a crucial focus area throughout the project. They care for the neonate and mother at the maternity ward. The wishes and needs of the nurses are carefully studied through shadowing in the hospital, generative design methods, interviews, and co-creation sessions to develop a solution that aligns well with this stakeholder group. Nurses are actively engaged throughout the project, and their input and influence plays a significant role in shaping the process and outcomes.

3. Parents

The third focus area is the parents. They are also positioned close to the neonate at risk of infection, both figuratively and physically, as they sleep in the same room and are deeply emotionally involved in everything that happens. It is crucial to consider their wishes and needs throughout the project and to ensure that the solution aligns with their expectations and experiences. Observations and interviews with parents are conducted to capture their perspective and making their needs visible.

Other stakeholders at the maternity ward

The other stakeholders visualized in figure 1.13 are the pediatricians, family members and other health care professionals. They also play a role and are occasionally present during the stay at the maternity ward. Their wishes and needs are also included during the project. Pediatricians and other health care professionals are interviewed during this project and the prior research. These insights have been considered during the whole project. Next to the parents, other family members have not directly been interviewed. Their wishes and needs are based on indirect insights coming forward from other interviews and research.

Conclusion stakeholders

The focus of this project is at the stakeholders at the maternity ward. The stakeholder analysis translates into the three focus areas: **medical aspects, nurses,** and **parents.** Each focus area plays a crucial role, with medical aspects guiding the overall goal of improving the observation, nurses ensuring practical and effective implementation based on their experiences and opinions, and parents bringing emotional and experiential insights. By focusing on these focus areas and addressing external factors, the project ensures a holistic and collaborative approach to designing solutions that improve neonatal care when there is risk of infection.

To ensure the project meets the requirements of the focus areas, thorough research is essential. For the medical aspects, literature research was conducted to delve into current protocols and theory about early-onset neonatal infection, which is further explained in the next chapter.

1.5 Literature research

This chapter is used for a deeper dive into the literature to discover knowledge. Throughout this project, several key research questions emerged, prompting further investigation to better understand the current situation and identify potential gaps and areas for improvement.

The main research questions addressed:

1. What is early-onset infection, what are the associated risks and what is the protocol for monitoring neonates at risk of infection?
2. What are the advantages and disadvantages of current forms of monitoring?
3. How is data currently being presented and interpreted?

To provide comprehensive answers, this chapter delves into each topic, drawing upon relevant literature and existing research to offer a well-rounded perspective on current practices.

1.5.1 Early-onset neonatal infection

What is early-onset neonatal infection?

For some neonates there is a higher change of becoming unwell due to infection, this occurs in 0.5-8.0/1000 births (Tesini, 2022). This is called **early-onset neonatal infection**, which refers to bacterial infection within the first 72 hours after birth. Early-onset neonatal infections can be life-threatening and must be recognized quickly. According to (WHO, 2020), 84% of neonatal deaths from infections could be prevented with early diagnosis and timely treatment. It is important to recognize the infection as soon as possible because the delay of starting treatment can lead to serious complications. One of these complications is sepsis (blood poisoning), this is a severe and potentially life-threatening condition that arises when the body's response to an infection causes widespread inflammation. Sepsis occurs when the body's response to infection harms its own tissues and organs (Cambridge University Hospitals, 2022).

The symptoms of infection vary widely. This makes it quite difficult to identify the infection in its early stages. As a pediatrician (interview pediatrician 1) said: "*We don't have THE factor in hands which tells us if there is an infection.*" Some neonates with an infection or sepsis can become very unwell in a short time. To try to identify it as soon as possible, it is important to monitor neonates who are most at risk of developing infection or sepsis closely.

Antibiotics treatment

When a neonate is suspected of having an infection, close monitoring is crucial to identify it quickly (interview pediatrician 1). Although antibiotics are not administered immediately due to their negative effects, they must be started rapidly once an infection is confirmed to prevent further deteriorations and complications like sepsis, a potentially life-threatening condition (Cambridge University Hospitals, 2022). Treatment decisions follow established frameworks, and antibiotics should only be used, when necessary, as overuse can harm both the infant and public health (Tarrant, et al., 2020).

The decision to not directly start treatment with antibiotics is because the disadvantages do not outweigh the advantages when there is only a suspicion of infection. Excessive or unnecessary use of antibiotics can lead to significant problems such as:

1. **Antimicrobial resistance (AMR):** Excessive use of antibiotics, especially those with a broad spectrum, accelerates the development resistant bacteria. This poses a danger not just to individual patients, but also to public health by reducing future treatment possibilities (Tarrant, et al., 2020).
2. **Disruption of the neonatal microbiome:** Early exposure to antibiotics can negatively impact the neonate's immune system (Shekhar & Petersen, 2020). Early exposure to antibiotics is associated with an increased risk of conditions such as atopic dermatitis and asthma, likely due to disruption of the gut microbiome (Räty, et al., 2024).
3. **Unnecessary medicalization:** Starting antibiotics treatment happens at the neonatology ward, it leads to unnecessary medicalization and separation from the mother (interview care professional 10).

These points underscore the importance of using antibiotics for neonates only when absolutely necessary. Effective antibiotic stewardship programs can help reducing inappropriate use of antibiotics globally (Tarrant, et al., 2020). For this project the aim is to improve close monitoring to identify the infection, which can also help in reducing unnecessary use of antibiotics.

Risk factors and clinical indicators

Identifying the need for antibiotics in neonates is crucial and relies on established protocols, which can vary by hospital. To explain how a protocol can look like, there is an explanation based on the guideline for neonatal antibiotic policy (Dixon & Fellows, 2022). This is for explanatory basis, the protocols and working methods can slightly differ per hospital. But this is broadly how things are going.

There is a framework for risk factors and for clinical indicators (table 1.1 and 1.2). Some of these rows have a red flag. Based on the framework direct antibiotic management decisions will be made. For example, "In babies who are less than 34 weeks' gestation, with any red flags, or with two or more amber risk factors or clinical indicators, perform a septic screen and commence antibiotics". So based on the framework the decision to either withhold antibiotics and whether it is necessary to monitor the neonates' vital signs or to start the protocol for antibiotics can be made.

Risk Factors	Red Flags
Suspected or confirmed infection in another baby in the case of a multiple pregnancy	Yes
Preterm birth following spontaneous labour (before 37 weeks' gestation)	
Confirmed rupture of membranes for more than 18 hours before a preterm birth	
Confirmed prelabour rupture of membranes at term for more than 24h hours before onset of labour	
Intrapartum fever higher than 38°C, if there is suspected or confirmed bacterial infection	
Confirmed or suspected chorioamnionitis	
Invasive GBS in previous baby or maternal GBS colonisation, bacteriuria or infection in current pregnancy	

Table 1.1: Risk factors for early-onset neonatal infection, including 'red flags' (Dixon & Fellows, 2022).

Clinical Signs	Red Flag
Apnoea	Yes
Seizures	Yes
Need for cardiopulmonary resuscitation	Yes
Need for mechanical ventilation	Yes
Signs of shock	Yes
Altered behaviour or responsiveness	
Altered muscle tone (eg floppiness)	
Feeding difficulties (eg feed refusal)	
Feed intolerance, including vomiting, gastric aspirates and abdominal distension	
Abnormal heart rate (bradycardia or tachycardia)	
Signs of respiratory distress	
Hypoxia (eg central cyanosis or reduced oxygen saturation level)	
Persistent pulmonary hypertension of newborns	
Jaundice within 24 hours of birth	
Signs of neonatal encephalopathy	
Temperature abnormality (less than 36°C or higher than 38°C) not environmental	

Table 1.2: Clinical indicators of possible early-onset neonatal infection (observations and events in the baby), including 'red flags' (Dixon & Fellows, 2022).

The protocol
When the increased risk suspicion is identified, the first step is to inform the parents. The health care providers explain why there is cause for concern and provide information about the infection. Depending on when this increased risk occurs, the advice on following steps can differ. The parents get informed about contacting medical help when they observe certain symptoms. Such as abnormal behavior (inconsolable crying or lethargy), poor drinking, gray skin color, groaning breathing, hypothermia, or fever (NVK , 2017). An important part of this protocol is to verify if the parents really understood the instructions and are able to follow this advice.

Two options based on the framework
Based on the outcome of above-named framework, there are two potential actions:
Start antibiotics: If there is one red flag or multiple amber flags, laboratory research and antibiotic treatment start immediately, even before lab results are available (NVK , 2017). Blood cultures are taken prior to treatment, with antibiotics adjusted based on the clinical condition and culture results. Treated neonates are usually monitored continuously at the neonatology ward.
Monitor without antibiotics: If there are no red flags and only one amber factor, antibiotics may be withheld, and the neonates' vital signs are monitored manually. In the Netherlands, this monitoring typically lasts 12-48 hours, with checks every three hours by a nurse.

Conclusion about literature early-onset neonatal infection
Early-onset neonatal infection is a serious condition requiring prompt recognition and appropriate intervention to prevent severe complications. However, identifying this infection in its early stages remains challenging due to its varied symptoms, which requires close monitoring of at-risk neonates. Given the potential negative impacts of antibiotics—such as immune system disruption, antibiotic resistance, and increased risk of future health issues—treatment is approached with caution. Decisions are guided by frameworks assessing risk factors and clinical indicators, ensuring antibiotics are used only when absolutely necessary.
Overall, while antibiotics can be lifesaving, they must be used properly, underscoring the importance of early, accurate identification of infections and thoughtful treatment approaches.
This information is used to emphasize the wishes of the stakeholder category medical aspects.

Take aways theory early-onset neonatal infection:
- **Prompt recognition is critical:** Early-onset neonatal infection must be identified as soon as possible to avoid severe complications like sepsis.
- **Challenges in early detection:** Due to the varied symptoms of neonatal infections, identifying them in early stages is often difficult, requiring vigilant observation.
- **Close monitoring is essential:** Neonates at risk of infection should be closely monitored to detect signs of infection quickly, allowing for timely intervention.
- **Antibiotic treatment has significant risks:** While antibiotics are necessary for confirmed infections, they can negatively impact a neonate's immune system, increase the risk of certain health issues later in life, and contribute to antibiotic resistance.
- **Antibiotics should be used only when necessary:** Decisions to initiate antibiotics are based on specific frameworks with risk- and clinical indicators to minimize unnecessary exposure.

1.5.2 Different forms of monitoring

The described literature research above emphasizes the importance of monitoring neonates at risk of early-onset infection. Hence there has been researched what ways of monitoring already exists and what their advantages, limitations and impact are.

Monitoring in hospitals is crucial for ensuring patient safety, detecting early signs of deterioration, and supporting clinical decision-making. There are various forms of monitoring used in hospitals, ranging from traditional manual methods to advanced continuous systems that integrate alarms, screens and sometimes even algorithms. The order of this sequence is based on functionalities and futures of the named forms of monitoring, ranging to more technical.

Impact on parents and care professionals

Rapid advancements in technology have enabled various forms of patient monitoring, from manual observation to continuously monitoring with algorithms. Each type affects patients, their parents, and care professionals differently. The analysis covers the impact of all three types of continuous monitoring, as shown in table 1.3.

1. Clinical gaze

The term clinical gaze refers to the general clinical experience of care professionals, to observe and interpret subtle signs and symptoms in neonates that may indicate underlying health issues. Experienced clinicians can often detect early signs of illness or distress that might not be immediately apparent through standard monitoring equipment. This early detection can be critical in preventing the progression of potentially serious conditions (Simple Nursing, 2023).

When a nurse closely observes the neonate, they assess several factors, such as appearance (skin color), behavior, breathing and reflexes. They do that by relying on their own observations, experience, and intuition. This form of monitoring is done with set intervals, typically every few hours.
Sometimes it can be difficult to explain this intangible feeling, it can be described as their gut feeling. This intuitive aspect of clinical gaze is crucial in pediatric care, where early signs of illness can be subtle (Chin-Yee & Fuller, 2018). Healthcare professionals use their clinical gaze to integrate all these observations into a comprehensive assessment of the patient's health. Development of the clinical gaze includes physical presence with the patient combined with learning activities (Källestedt, Asp, Letterstål, & Widarsson, 2022).

2. Manual monitoring

Manual monitoring is the traditional method that is used in hospitals. Care professionals regularly check the vital signs of the patients. The vital signs that are measured in a neonate are heart rate, temperature, saturation, and respiratory rate. These signs are measured by the neonate with manual instruments like the stethoscope, thermometer, or saturation meter. This form of monitoring relies heavily on human intervention, requiring nurses or other medical staff to physically measure and record data at set intervals, typically every few hours (Kellett & Sebat, 2017). This form of monitoring provides numbers and values.

3. Continuous monitoring

Continuous monitoring with alarms is an advanced form of patient surveillance that involves the continuous tracking of vital signs using electronic devices. Equipped with sensors, these systems can monitor parameters such as heart rate, oxygen saturation, and respiratory rate in real time (Downey, Chapman, Randell, Brown, & Jayne, 2018). If patients' vital signs fall outside predetermined safe ranges, alarms are triggered. These alarms can be auditory or visual, such as lights turning red, ensuring immediate attention.

A detailed comparison of all three forms of monitoring is provided in table 1.3, highlighting their advantages, limitations, and the impact on nurses, and parents.

Three categories in the tables:
The table is organized into categroies based on the three focus areas.

1.Medical aspects: This category will focus on the functioning of the form of monitoring. This will be evaluated in the column advantages and limits.

2. Impact on nurses and other care professionals: this column will represent what the impact of the form of monitoring is on care professionals, especially nurses, regarding the literature. It is called nurses and other care professionals because the impact also effects the colleagues of the nurses, for example the pediatricians might hear the alarms or need to use the same monitors.

3. Impact on parents: this column contains information from literature research about the impact on parents. Sometimes the research is based on impact on adult patients, but the project centers on the experiences of the parents, since neonates (0-28 days old) are the patients. Consequently, the form of monitoring affects parents the most as they experience the impact such as alarms and screens.

Different forms of monitoring with their advantages, limitations and impact on nurses and parents.

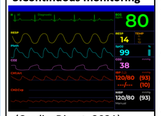
Form of monitoring	Advantages	Limitations	Impact on nurses and other care professionals	Impact on parents
1.Clinical gaze  (Gelre ziekenhuizen, 2019)	Experienced nurses can often detect subtle signs of distress or illness early, based on their observations and instincts (Tanner, 2006). The clinical assessment can be used next to all the other forms of monitoring. In addition, it enables for personalized care, considering factors like feeding patterns, family dynamics and behavior of the patient (Parreira, et al., 2021). Another advantage is that this way of monitoring is non-invasive, it does not cause any discomfort to the baby (Sanders, 2024).	A primary drawback of clinical gaze is that it can be subjective and vary between different nurses and other healthcare professionals. This can lead to inconsistencies in assessments and care. Next to that, the accuracy and effectiveness is heavily dependent on the nurse's experience and intuition (Tanner, 2006). Less experienced nurses might miss subtle signs. There is always a human error possible. Another limitation is that a thorough clinical assessment can be time-consuming. Potential gaps between the visits are possible (see next column for explanation). To properly see the neonate (without clothes and or blanket) it needs to be disturbed. This is a disadvantage for the rest of the neonate.	Direct observation and assessment require critical thinking and clinical judgement. This asks for an increasing cognitive demand on nurses which makes it labor-intensive and can increase the workload (Connor, Flenady, Massey, & Dwyer, 2022). Despite the challenges, many nurses find clinical monitoring rewarding, the ability to make a direct impact on patient care gives a professional fulfillment.	The face-to-face interaction with the care professionals during observations fosters trust and reassurance. Parents often feel more secure knowing that a trained professional is directly observing their baby, it feels more personal (Parreira, et al., 2021). The presence of a nurse can also provide emotional support to parents. The nurse can answer questions or provide comfort.
2.Manual monitoring  (Enurse.nl, 2024)	Manual monitoring is straightforward and can be done with minimal equipment (Kellett & Sebat, 2017). It allows for personal interaction between patients and healthcare providers, which can be reassuring for patients. Furthermore, it has the same advantages as clinical assessment.	The primary drawback is the potential for gaps in monitoring, as it provides only periodic snapshots of a patient's condition. This intermittent time between manually monitoring intervals can delay the detection of acute deterioration, making it less suitable for critically ill patients (Fieselmann, Hendryx, M.S., & Wakefields, 1993). This results in data measured on a snapshot basis, where for example heartbeat can be different once one wakes up a neonate. It can be difficult to monitor some vital signs precisely, such as heart rate. Counting the heartbeats while listening and timing can be deviating (Kellett & Sebat, 2017).	Manual monitoring is labor-intensive, contributing to staff fatigue and increased workloads (Dye, et al., 2023). On the positive side, manual monitoring helps maintain clinical judgement, as healthcare professionals rely on direct observation and assessment.	Manual monitoring maintains face-to-face interaction between healthcare providers and patients, which can foster trust and reassurance. Personal contact often helps to reduce anxiety for the parents, as they feel more engaged in the care for their child. On the other hand, the gaps in monitoring between checks (scheduled monitoring intervals) may lead to potential risks in the condition of the patient. This intermittent approach may leave some parents feeling vulnerable or worried, especially those in unstable conditions (Alasad & Abu Tabar, 2003).
3.Continuous monitoring  (CardiacDirect, 2021)	Continuous monitoring provides real-time data, enabling immediate response to critical changes in a patient's condition (Downey, Chapman, Randell, Brown, & Jayne, 2018). Another advantage is that neonates are not able to talk about their pain, which can make continuous monitoring crucial. Next to that, there is no need to continuously watch the monitor, the alarm will go off to attract attention (Sanders, 2024).	A significant challenge with continuous monitoring is the phenomenon of alarm fatigue. Healthcare providers may become desensitized to frequent alarms, particularly if many are false positives, leading to delayed responses to genuine emergencies (Kuznetsova, et al., 2023)	Healthcare professionals often face alarm fatigue due to the high frequency of false or non-actionable alarms. This desensitization to alarms can delay responses to true emergencies, posing serious risks to patient safety (Sendelbach & Funk, 2013). Despite alarm fatigue, continuous monitoring with alarms can significantly improve response times when alarms are accurate and actionable. When properly calibrated, these systems allow for faster interventions in critical situations, ultimately improving patient outcomes (Downey, Chapman, Randell, Brown, & Jayne, 2018).	Patients and/or parents exposed to frequent alarms often experience sensory overload, which can contribute to sleep deprivation and increased stress. The constant sound of alarms can provoke fear and confusion among patients, who may interpret every beep as a sign of imminent danger. This can exacerbate feelings of helplessness, especially in patients who are unfamiliar with how the monitoring system works (Cvach, 2012). The positive impact of continuous monitoring is the reassurance that there is always a care professional monitoring the patient, this can give a reassuring feeling to parents (Prgomet, et al., 2016).

Table 1.3: Forms of monitoring with their advantages, limitations and impact on nurses and parents.

Besides these three forms of monitoring, the location of these monitors by continuous monitoring also plays a role. There are two main locations for the monitors:

Location of the monitors

A. Centralized screens

In some hospital settings, continuous monitoring is integrated with centralized screens that display the vital signs of multiple patients simultaneously. In centralized monitoring, patient data from various beds or units is displayed on large screens at centralized stations (Michikata, et al., 2016). These screens typically show critical data such as heart rate, oxygen saturation, blood pressure, and respiratory rate. The system is connected to sensors attached to the patient, continuously updating the display with the latest readings. These screens are typically located at nursing stations or central monitoring rooms, where care professionals can oversee several patients at once.

B. Personal bedside screens

Next to centralized screens with continuous monitoring, there can also be added personal bedside screens. In terms of content, it works the same as the continuous monitoring with centralized screens, but there is an extra personal bedside screen located next to the patient's bed. (Gardner, Clemmer, Evans, & Mark, 2013). The bedside display can easily be viewed by the patients and the care providers.

Table 1.4 provides an overview of the different locations, highlighting their advantages, limitations and the impact on nurses and parents.

Different locations of monitoring with their advantages, limitations and impact on nurses and parents

Location of monitor	Advantages	Limitations	Impact on nurses and other care professionals	Impact on parents
A. Centralized screens  (RGB, 2017)	Centralized monitoring allows for the efficient supervision of multiple patients, enabling rapid intervention when necessary. It is particularly effective in high-acuity settings like Intensive Care Units (ICU's) and emergency departments, where continuous oversight is essential (Ramnath & Khazeni, 2014).	The effectiveness of centralized monitoring depends on the staff-to-patient ratio and the ability of healthcare providers to quickly interpret and act on the data displayed. There is also the risk that important changes in a patient's condition may be missed if the staff is overwhelmed by information from multiple screens (Michikata, et al., 2016). And the risk of less physical visits, where the behavior of the patient is checked. Another limitation is that there is not always someone near the screens, nurses spend more time at the bedside of the patients. Data might be missed.	Centralized screens allow healthcare providers to monitor multiple patients simultaneously, improving the efficiency of care. This system also reduces the need for continuous bedside presence, allowing staff to manage high patient volumes more effectively (Sowan, Tarriela, Gomez, Reed, & Paper, 2015) . However, centralized systems can reduce direct patient interaction, leading to a potential disconnect between patient needs and clinical care. When nurses rely primarily on data, important aspects of patient well-being, such as emotional and psychological health, may be overlooked (Prgomet, et al., 2016).	From the patient's and/or parents' perspective, centralized monitoring can feel detached. The absence of regular bedside visits may make patients or parents feel neglected or less personally cared for, which can have psychological repercussions, particularly for patients who require emotional support in addition to physical care (Parreira, et al., 2021). The knowledge that they are being monitored remotely may also foster feelings of being under constant surveillance, which some patients may find uncomfortable or invasive. On the other hand, the patient and/or parents may feel more comfortable knowing that there is a constant surveillance, even when the patient goes to sleep or in between visits from the care provider (Alasad & Abu Tabar, 2003).
B. Bedside screens  (DC_Studio, 2022)	Bedside screens offer healthcare providers instant access to real-time data without the need to check centralized monitors or separate device. This can improve response time (Gardner, Clemmer, Evans, & Mark, 2013). Another advantage is that there is enhanced patient engagement, the patients have direct access to their vital signs. This empowers them to be more involved in their own care (Prgomet, et al., 2016).	While personal bedside screens provide valuable data, there is a risk of information overload for both patients and caregivers. The problem of alarm management has been widely recognized as a critical patient safety issue (Durbin, 2016).	For healthcare providers, personal bedside screens offer immediate access to data, supporting quick, informed decision-making without the need to rely on centralized systems (Cvach, 2012). This can enhance both the accuracy and speed of interventions, particularly in time-sensitive situations. On the downside, the visibility of health data may lead to frequent patient queries, requiring staff to explain fluctuations or address concerns. This can disrupt workflow and add to workload of caregivers (D'Costa, Kuhn, & Fritz, 2020).	Bedside screens can offer empowerment to patients and/or parents by providing them direct access to their own health data. This transparency can foster trust and help patients feel more in control of their situation (Prgomet, et al., 2016). However, constant exposure to health metrics can also increase patient anxiety, especially if they misunderstand or misinterpret the data presented. Some patients may become fixated on minor fluctuations, leading to unnecessary worry (Gross, Dahl, & Nielsen, 2011). Patients or parents might become anxious if they do not fully understand the readings or if they misinterpret normal fluctuations in vital signs as concerning (Prgomet, et al., 2016).

Table 1.4: Monitoring locations with their advantages, limitations and impact on nurses and parents.

Monitoring with the Bambi Belt
During this project, the focus is on how (wireless) continuous monitoring could be used at the maternity ward, where the Bambi Belt is used as a use case. The Bambi Belt is a product that continuously measures vital signs in a wireless manner (explanation in chapter 1.3.2). It is important to understand how the Bambi Belt relates to the other forms of monitoring described in table 1.5.

To begin with, the Bambi Belt is a form of **continuous monitoring**, which makes it most comparable to continuous monitoring in the table. Whether it aligns more with subcategory “a (centralized screen)” or “b (bedside screen)” depends on the design of this project. This project aimed to explore what (new) form of continuous monitoring is most suitable and how it can be implemented on the maternity ward.

Bambi Belt monitoring device with its advantages, limitations and impact on nurses and parents

Form of monitoring	Advantages	Limitations	Impact on nurses and other care professionals	Impact on parents
Bambi Belt  (Bambi Medical, 2023)	Wireless monitoring means there are no issues with wires and adhesives, both for freedom of movement and skin this is an advantage. According to (Bambi Medical, 2023), the likelihood of false alarms is reduced, as the adhesives sometimes become loose, triggering false alarms. A problem that does not occur with the wireless Bambi Belt (Bambi Medical, 2023). Additionally, all the benefits associated with continuous monitoring are retained.	The limitations of continuous monitoring with the Bambi Belt remain the same as with current methods. However, there is an added challenge of familiarizing staff with the new product, especially since the maternity ward is not accustomed to using such technology (field research). Another limitation is that the Bambi Belt is designed for one time usage only. Next to that it only measures heart rate and respiration, this might be a limited quantity of vital parameters.	The impact on care professionals will largely remain the same as outlined in the table for general continuous monitoring. However, a key consideration is that care professionals on the maternity ward are not currently familiar with continuous monitoring (field research). Therefore, special attention must be given when introducing the Bambi Belt in this setting. The experience and impact on care professionals should be carefully considered in the design process. This adaption might take some time and has impact on the nurses and other care professionals that need to get used to working with the Bambi Belt.	The impact on parents is largely similar to the impact of general continuous monitoring as shown in the table. Compared to the current way of continuous monitoring parents can experience more freedom of movement and independence interacting with their child (Bambi Medical, 2023). However, parents on the maternity ward are not currently accustomed to this type of monitoring. It is important that their experience and the potential impact on parents be thoroughly considered in the design of the system.

Table 1.5: Bambi Belt as form of monitoring with its advantages, limitations and impact on nurses and parents.

Conclusion different forms of monitoring
Continuous monitoring technologies bring possibilities for enhanced patient care, improving early detection and intervention capabilities. However, the impact on patients, their parents, and care professionals are complex and multifaceted. While continuous monitoring can offer reassurance, improved outcomes, and more efficient care, it can also contribute to sensory overload, alarm fatigue, and increased stress. **The balance between technology and human interaction is critical, as over-reliance on machines can lead to a decrease in clinical skills and patient engagement.** It is important that there is a balance between the clinical gaze and instrumental monitoring. They both fulfill different purposes and can be used well in combination.

This chapter presented the different forms of monitoring and how the use case Bambi Belt relates to them. This was done to gain a deeper understanding of the various monitoring forms and to apply this knowledge to the project effectively. Another aspect of monitoring is presenting the output of monitoring, knowledge about how this data is presented is explored hereafter.

Take aways theory early-onset neonatal infection:
- **Clinical gaze supports monitoring:** Clinical gaze is a foundational element and usually used alongside other monitoring types. It is essential for personalized care, as it incorporates the healthcare professional’s intuition and experience.
- **Manual monitoring gaps:** Intermittent time between manually monitoring intervals can delay the detection of acute deterioration, making it less suitable for critically ill patients (Fieselmann, Hendryx, M.S., & Wakefields, 1993).
- **Real-time response with continuous monitoring:** Continuous monitoring provides real-time data and quick alerts, enabling prompt intervention for critical changes in a patient’s condition.
- **Centralized vs. bedside monitoring:** Centralized monitoring improves efficiency by displaying multiple patients’ data in one location but may reduce direct caregiver-patient interaction. Bedside screens, however, allow for quicker, personalized response but can lead to information overload and patient anxiety.
- **Bambi Belt as continuous monitoring:** The Bambi Belt is a form of continuous monitoring. It has roughly the same features as the current way of wired continuous monitoring, but it brings advantages for freedom of movement and interaction.

1.5.3 Presenting patient data

Next to the different forms of monitoring, there are also different possibilities how to translate and show patient data. Translation can be with raw information, that you see exactly what the values of the vital signs are, or it can be translated into graphics. How the data is presented is based on the situation.
The most important take aways about presenting patient data are discussed here. More information about monitoring can be found in appendix C.

Effective translation and visualization of patient data are crucial in hospital settings to improve decision-making and patient care. As healthcare becomes increasingly digitized through systems like Electronic Health Records (EHRs), clinical dashboards, and telemedicine platforms, these tools help care professionals gain actionable insights from raw data. EHR systems centralize patient information and enable real-time updates on patient conditions (CMS, 2024). Clinical dashboards aggregate vital health measures, supporting rapid assessments in critical care environments, while telemedicine platforms allow for remote monitoring (figure 1.14), particularly beneficial in chronic disease management (Halaxy, 2024). There are different remote monitoring devices that can be used for example for heartrate, blood sugar or other vital signs. However, several challenges persist, such as poorly designed user interfaces, data standardization issues, and mismatched workflows between care providers and the system they used. This can all lead to errors in care and increased cognitive load (Foster, et al., 2022). The previous chapter also pointed out that constant exposure to health metrics can also increase patient anxiety, especially if they misunderstand or misinterpret the data presented. **Some patients may become fixated on minor fluctuations, leading to unnecessary worry** (Gross, Dahl, & Nielsen, 2011).

Figure 1.14: Different remote patient monitoring devices (Khaled, 2024).

Monitor used for Bambi Belt data
Currently used for the Bambi Belt to present data is a Philips patient monitor. This presents the patient data with numbers and graphs, continuously displaying the current values. For example the IntelliVue MX800 from Philips (figure 1.15).

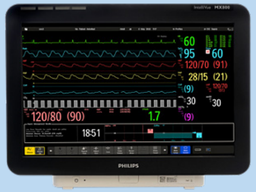


Figure 1.15: IntelliVue MX800 patient monitor (Philips, 2024).

Design Considerations:
When designing healthcare data systems, it is essential to prioritize user-**friendly interfaces that minimize complexity and cognitive load.** Systems should align with the natural workflow of care providers, reducing the time spent interacting with the system and increasing the time available for patient care. Moreover, data should be integrated seamlessly from various sources, maintaining consistency and standardization to improve decision-making. It is important to learn from these design considerations and optimize this for each focus area.

Medical aspects: Data seamlessly integrated from various sources, consistency, and standardization to improve decision-making.

Nurses: User friendly interface, minimize complexity and cognitive load. Aligning with natural workflow.

Parents: Avoid overload of information, unnecessary alarms and disturbing which is leading to unnecessary worry (Gross, Dahl, & Nielsen, 2011).

Next step
All the insights from the literature research underscore the need to balance human assessment with technological monitoring for comprehensive and effective patient care. This highlights the importance of the socio-technical system and taking both perspective in mind during the project.

All insights gained from the literature gave a good foundation for consideration for the next phase. To validate this literature information, prioritize problems and supplement it with personal experiences, field research is conducted.

1.6 Field research

Field research is used to gather practical insights and personal opinions from care professionals and parents. It outlines the context exploration, methods, findings, and visualizations. By presenting this information, the chapter offers a comprehensive overview of all the insights gathered during the first phase.

1.6.1 Field exploration

To gain a deeper understanding of the physical field of this project various activities were conducted to explore the field.

Besides verbal insights from stakeholders, an exploration took place in the physical context as well. Several days were spend at the Reinier de Graaf hospital in Delft. Observations took place at the maternity ward, obstetric department, and the neonatology. The focus was to research the current way of monitoring and the experience of care professionals and parents. This provided insights in specific challenges and dynamics unique to this environment, for the current way of monitoring as for potential continuous monitoring.
There were also observations and interviews at the Maxima Medical Center in Veldhoven. Here the context for working with the Bambi Belt was explored. Besides the interviews and observations at Reinier de Graaf hospital and MMC Veldhoven, the other interviews (table 1.6) were conducted online.

Reinier de Graaf hospital Delft
During the research days at the Reinier de Graaf hospital observations took place during visits, regular checks, team meetings and collegial consultation. During the observations, the care professionals explained what they were doing and there was room for asking questions to the parents. Providing an overview of how monitoring a neonate with risk of infection is currently performed. Besides that, 12 care professionals were interviewed, including maternity ward nurses, obstetricians, (some work at both departments), neonatology nurses, pediatricians, and managers.

Hospital	Who?	How?
Reinier de Graaf hospital	Nurse 1-9 from maternity / obstetric / neonatology ward Pedicatrician 1 (prior) Manager 1&2 Parent 1,2 &3 (1&2 from prior)	Observations, generative research and interviews
Other hospital in NL (privacy)	Parent 4&5	Interviews
Maxima Medical Center Velhdhoven	Parent 6 Nurse 10&11	Observations, and interviews
Erasmus Medical Center	IT specialilst 1 (prior)	Interview
Jeroen Bosch hospital	Obstetric nurse 12	Interview

Table 1.6: Overview of observations and interviews

Generative design research
During the research phase generative design research was used. It provides participants with a tool where they can imagine and express their ideas and dreams for future experience (Sanders & Stappers, 2020). Generative design research can have different approaches. In this case, the method context mapping is used.

According to Sanders & Stappers (2020): *"Context mapping is a technic that aims to inform and inspire design teams, where users and stakeholders actively participate in the design process to ensure a good fit between the design and the use of a future product or service."* The name 'context mapping' illustrates two main elements about the information or understanding that the design team needs:
First of all, the context of a specific product use or situation with all factors which influence the interaction between user and product will be explored.

The second main element is to map this out, this is a tool to help access the terrain of experience.

This method was used to gain a better understanding about the context of this project. This is important to gain empathy with users, to avoid fixation on preset assumptions and to create innovative concepts (Visser, Stappers, Van Der Lugt, & Sanders, 2005). To empower this generative technique there was a booklet created. This booklet was handed over a week before the interviews. Filling in the booklet helps to sensitize with their own experiences, which is a good preparation for the interview. It helps to easier recall experiences during the interview. The care professionals could fill in this booklet at their own pace. A booklet and the absence of pressure helps to gain deeper insight of what people, know, feel, and dream. This is also called latent knowledge (figure 1.16). For this instance, it was used at the maternity ward and the obstetric ward to explore the current situation, thoughts, and experiences at a deeper level. Other interviews were without booklet, for example with the parents, due to no prior meeting and time for filling out the booklet.

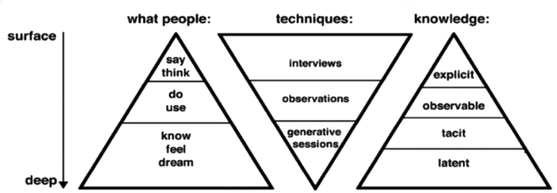


Figure 1.16: Different techniques revealing different levels of knowledge (Sleeswijk Visser et al., 2005).

Booklet
The booklet (appendix D) was handed out a week before the interviews, allowing participants to draw, write, and use stickers to express thoughts and feelings in a personal way. It was designed in a specific order: starting with questions about the current situation to understand experiences with observing neonates at risk of infection and interaction with parents. Next, participants were asked about their opinions on continuous monitoring and its potential impact on their work experience. The final section invited them to describe their ideal approach to managing neonates with infection risks, with space at the end for extra remarks or questions.
During the interviews, the booklet was guiding. The graduate student went through the participants' self-created answers in their booklets and asked for further explanation and examples where needed. If topics were not covered thoroughly, additional questions from the prepared expert interview topic guide (appendix E) were asked. Most questions, however, were addressed through the booklet.

Participants responded positively to the booklet, noting that the stickers made it enjoyable and helped express feelings more easily. They also appreciated having time to reflect before the interview.

Figure 1.17: Stickers provided with the booklets.

Figure 1.18: Booklet and sticker package for one participant.

Maxima Medisch Centrum Veldhoven
At Maxima Medical Center in Veldhoven (MMC), the functioning and interaction with the Bambi Belt was observed and questioned. The graduate student talked with care professionals, product expert and parents. The observations were located at the NICU, with premature neonates in private, separate rooms. The Bambi Interface is connected to each individual monitor and visible for both parents and care professionals. The same data visualized at the individual monitor is also displayed at a central monitor, which is also under observation. The nurses explained a lot what they were doing and thinking, while observing and checking the Bambi Belt.

Conclusion conducting field research
In preparation for the field research, careful consideration was given to its design and execution. Using generative design methods, such as context mapping with booklets, as well as interviews and observations, the research was conducted effectively. The locations were discussed and picked on forehand. Finding participants, especially parents was difficult. Hospitals are busy and their priority is on immediate healthcare. Luckily spending enough time at the hospital helped with interviews between care moments. The gathered data was analyzed by using thematic analysis and categorized into three focus areas, focusing on either the current monitoring practices or continuous monitoring.

Findings from the field research are presented in the next chapter, structured around the three key stakeholder categories: medical aspects, nurses, and parents. This approach ensures that insights are aligned with the project's central focus and form a strong foundation for the design process.

Figure 1.19: Main entrance of Maxima Medical Center Veldhoven.

1.6.2 Analysis from field research to findings
All findings from the field research—interviews, field notes, observations, and other studies—were analyzed using abductive analysis. Abductive analysis is a qualitative research approach that involves iteratively moving between empirical data and theory to develop new insights or refine existing theories. In practice, abductive analysis allows researchers to explore unexpected findings by revisiting and adjusting theoretical assumptions, thereby enhancing the depth and applicability of qualitative research (Hulst & Visser, 2024).

Abductive analysis
To conduct a thorough abductive analysis, the software program Atlas.ti was utilized. The process began with transcribing all interviews, documenting field notes, and compiling other relevant findings. These transcripts were then imported into Atlas.ti for analysis. The texts were reviewed multiple times within the program, and significant, notable, or frequently occurring excerpts were coded. These codes served as labels and were systematically organized into the three focus areas. A combination of deductive analysis (to address the predefined focus areas) and inductive analysis (to identify emerging categories) guided the labeling process. This approach ensured that specific quotes were accurately linked to their corresponding codes.
The identified codes were grouped into the three focus areas.
1. Medical aspects
2. Nurse perspectives
3. Parent perspectives

Both *care professionals* and *parents* were interviewed to gather their unique perspectives. Interestingly, these two viewpoints frequently overlapped during field research and interviews. For instance, medical staff often reflected on the experiences and concerns of families, while families shared their impressions of medical practices and staff interactions. This interplay underscored the importance of considering both perspectives equally within the project's framework.
Each of these three focus areas was further divided into two newly created categories per focus area: findings related to the current method of monitoring (A) and findings related to continuous monitoring (B).

By categorizing the results into these three focus areas, the research ensures a comprehensive exploration and guided structure. The detailed findings within these three focus areas are presented in the following chapter.

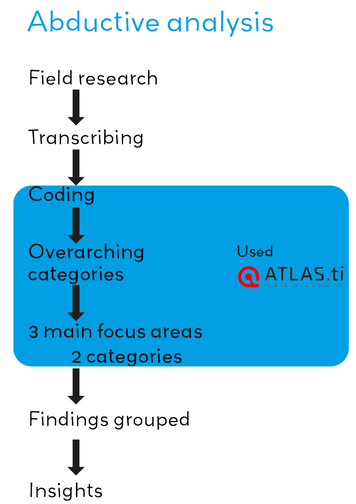


Figure 1.20: Abductive analysis from field research to findings

1.6.3 Findings

The findings from the field research are detailed in this chapter, grouped under the category where they have the most significant impact, even if some overlap. The named insights were mentioned or observed multiple times during the field research, the insights are illustrated with a specific quote from interviews or fieldnotes (table 1.6) in the previous chapter).

Additionally, the research explored the layout and design of rooms across various departments, including furnishings, types of monitors present, and parameters being measured. These contextual descriptions are detailed in earlier chapters, but key aspects relevant to the three focus areas are highlighted here. These insights are valuable for the continuation of the project and the design.

1.Medical aspects

The first focus area is medical aspects, particularly early-onset neonatal infection, the use of antibiotics, technical aspects of monitoring, and the specific use case of Bambi Belt. These topics were primarily explored and explained during the literature review (chapter 1.5). This paragraph illustrates insights combined with this literature about medical aspects.

1.A: Medical aspects about current way of monitoring

Subjectivity with clinical judgement:

Nurses mention that they experience subjectivity as a primary drawback with clinical gaze, which was also mentioned in literature by (Tanner, 2006). Nurses think that this subjectivity could be improved by a monitoring system.

"Als je kijkt naar bijvoorbeeld de kleur, dat kan iedereen soms anders zien, de ademhaling ook, dat tel je natuurlijk. Maar ja dat is niet zo nauwkeurig he. Als je dat door een systeem laat doen, dan is dat natuurlijk beter." Nurse 7

Measuring:

Another drawback of manual monitoring is highlighted by several care professionals. They said that it is difficult to measure the heartbeat. They need to watch the clock for 30 seconds and count the heartbeat, which is fast in general for neonates. This matches what was also found in literature about difficulties monitoring vital signs precisely (Kellett & Sebat, 2017).

1.B: Medical aspects about continuous monitoring

Care for both mother and neonate:

Regardless of different forms of monitoring, in a lot of interviews and during observations it came forward that both the mother and child are important at the obstetric and maternity ward. Care professionals are afraid that the focus will shift to the neonate when continuous monitoring is introduced, although the mother also needs care.

"Ik ben dan heel erg bang dat er heel veel tijd naar de baby'tjes toe gaat, wat soms ook ten onrechte is. En dat daardoor de moeder minder aandacht krijgt, terwijl ze verblijven juist op de kraamafdeling omdat moeder ook zorg nodig heeft." Nurse 1

2. Maternity nurse perspectives

The second focus area is the perspective of maternity nurses. Insights related to care professionals were gathered through observations and interviews. These findings are summarized here, offering a detailed understanding of the care professionals' perspectives and practices.

2.A: Maternity nurses' perspectives about current way of monitoring

Worries in between visits: and snapshots:

During the field research it came forward that care professionals identified the major disadvantage of manual monitoring the inability to know what is happening behind closed doors, when they are not present. An interval of three hours between checks can sometimes be considered too long, as situations of children can deteriorate quickly. The quote below illustrates the problem that nurses can encounter when they have no vision in the room for a longer time.

"Je hebt niet altijd zicht op de kamers. Je bent van de kamer af en hebt er geen zicht meer op. Het kan best zijn dat je een uur of misschien zelfs wel eens langer niet op een kamer bent." Nurse 7

The condition of the patient can differ just after that check. It would help to spot abnormal values when there is continuous monitoring. It could also prevent that a neonate deteriorates right after the visit of the nurse. The current visit is a snapshot, the situation can change right after that visit, which is a worry that came forward from multiple interviews.

"Met continue monitoren onderschep je sneller afwijkende waardes (..). Het zijn niet momentopnames. Maar het is gewoon continu dat je het beeld hebt, dus je kan er sneller op handelen. Want het kan nu goed zijn als een minuut later na mijn controle dat kind in kachelt. Ja, dan kom ik pas 3 uur later weer op de kamer. Ligt dat kind daar al een soort van 3 uur naar adem te happen en zijn best te doen." Nurse 4

This finding reinforces the theory about intermittent time between manually monitoring intervals can delay detection of acute deterioration (Fieselmann, Hendryx, M.S., & Wakefields, 1993).

Another disadvantages that came forward from the observations and interviews is that with the current way of monitoring (manual monitoring) the pediatrician only measures the heart rate once in 24 hours. A deviation in heart rate can be easily measured with continuously monitoring.

"De hartslag is wel vaak een van de eerste dingen die op de monitor ziet afwijken. Dat is wat de kinderarts komt luisteren. Dat is één keer per 24 uur. Dat zo'n kind wordt nagekeken en dan denk ik, ja een moment opname. Ja als dat dan net even iets anders in staan dan een uur daarna." Nurse 4

Importance of clinical judgement and personal contact:

The field research revealed that care professionals consider clinical gaze to be extremely important. This is particularly crucial in detecting infections. Sometimes they rely more on the clinical gaze than the values indicated by monitoring. It can be difficult to put their finger on the factor which gives them the feeling that something is wrong. This intuitive aspect of clinical judgement is crucial in pediatric care, where signs of illness can be subtle (Chin-Yee & Fuller, 2018).

"Maar daarbij wil ik ook wel de aandacht geven aan de andere factoren. Ik weet dat monitoren de nieuwe manier ook is van verplegen. (..) Maar ik vind je klinische blik ook heel belangrijk. Dat dit altijd zwaarder weegt dan de monitor." Nurse 3

Additionally, personal contact with the patient is highly valued, as it is an aspect of their work that nurses enjoy. It was emphasized that they wish to maintain this personal contact, regardless of the form of monitoring used.

"Ik vind zelf het persoonlijke contact het leukste en ook erg belangrijk in mijn werk. Dit zou ik altijd willen houden, ongeacht de vorm van monitoring." Nurse 4

Clinical gaze
It emerged that nurses are disappointed when their intuition and clinical gaze about a neonate's condition are not immediately trusted by pediatricians. Despite observing a neonate for a long period, when nurses called for pediatric evaluations, the short assessments by pediatricians often delayed critical decisions. Nurses expressed frustration with the time it took for pediatricians to act on their concerns.

"Ik heb het idee dat wij hier heel erg moeten zeuren zeg maar. Als wij een soort onderbuikgevoel hebben dat het kindje moet worden opgenomen. Maar de kinderarts ziet dat nog niet en dan duurt het vaak wel eventjes voordat het kindje echt opgenomen wordt (..) en voor mijn gevoel duurt dat soms toch net een beetje te lang. Dan willen de kinderartsen het toch blijven aankijken. Want misschien lukt het toch wel." Nurse 8

2.B: Maternity nurses' perspectives about continuous monitoring

Worries about staff and workload:
During the interviews at the maternity ward and obstetrics ward it became evident that there are a lot of worries about the capacity of the staff in combination with continuous monitoring. The concerns are about increased workload, and that continuous monitoring doesn't belong to the maternity and/or obstetrics ward.

The quote below points out how alarms can possibly influence the increased workload.

"Er gaan meer alarmen af, dus er gaan ook meer bellen van ouders af, dus je moet vaker heen en weer naar de kamers lopen." Nurse 3

One of the things that was in contrast with the theory is alarm fatigue (Kuznetsova, et al., 2023). Observation and interview findings pointed out that the care professionals experience a higher workload because of all the alarms, because they want, and do response to all the alarms. Even if they think it can be a false alarm, they go for every alarm. This was reassuring for parents, they looked relieved every time a care professional answered to their alarm (field notes observation Reinier de Graaf).

A concern from the maternity ward that came forward during the interviews is that there is not enough staff to always have someone looking at the screens and that this will add tasks to their workload.

"Ja er moet ook geobserveerd worden bij de schermen, en je hebt niet altijd een mankracht dat die ook continu naar het scherm kunnen kijken of dat er iemand is die daar continu zit. Dat is het nadeel denk ik. Denk dat er weer meer werkzaamheden voor ons bijkomen." Nurse 7

Worries about shifting to maternity ward:
Another significant concern that emerged during the field research is the need to ensure that not all neonates requiring monitoring are shifted to the maternity ward.

"Eerder oppikken van infectie en doorsturen ben ik best een voorstander van, maar niet als we alles gaan verleggen naar de kraamafdeling." Nurse 6

Another concern is that not all babies should be monitored. There are also healthy neonates at the maternity ward, who do not need monitoring. Overly monitoring is unnecessary and this would also lead to a higher workload.

"We moeten niet alle gezonde zuigelingen gaan monitoren, die werkdruk kunnen wij ook niet aan en het is niet nodig." Nurse 5

Rapid detection infection:
Opinions about using continuous monitoring to identify infections at neonates at the maternity ward were also positive from health care professionals. Most of the reactions came down to seeing the deterioration earlier. More information over a longer period and that it is easier to intercept a trend than a snapshot.

"Een trend is eigenlijk veel beter te onderscheppen dan een tussentijdse controle." Pediatrician 1

"Continue monitoring kan zorgen dat je uiteindelijk een minder ziek kind krijgt. Omdat je er eerder bij bent." Nurse 6

These findings strengthen the literature about faster interventions with continuous monitoring (Downey, Chapman, Randell, Brown, & Jayne, 2018).

3. Parent perspectives

The third main theme is about the perspectives of the parents, and other possible family members, this third main theme is called parents perspectives. Parent related insights emerged both from direct interviews with parents and from the perspectives shared by care professionals during their interviews. These findings provide a comprehensive view of the parents' experience and are detailed below.

3.A: Parents perspectives about current way of monitoring

Personal contact:
Parents appreciate personal contact with medical staff, possibility to ask questions and enjoy helping with caring for the neonate.

> *"Ik vind het erg fijn dat het medische personeel zo vaak langskwam, hierdoor kon ik al mijn vragen stellen en hielpen ze mij bij dingen die ik spannend vond."* Parent 3

Parents prefer to see what is happing during the check conducted by the care professional. As emerges from the following fieldnotes: When the nurse picked up the neonate to undress him and check his behavior, both parents walked with her every step. They looked over her shoulder. The mom could stand next to the nurse and help with holding the neonates' hand when the nurse undressed him. Both parents pay attention at what the nurse is doing.

3.B: Parents perspectives about continuous monitoring

Medical appearance:
The impact of continuous monitoring on parents can result in a way that the neonate looks more ill when there are wires and adhesive electrodes. It will appear more medical. This was a worry that came forward from multiple care professionals, for example nurse 4 said:

> *"Met draden oogt zieker. Dan dat je gewoon een gezonde pasgeboren hebt met net even een aandachtspuntje. Het oogt gelijk heftiger voor foto's, broertjes, zusjes, wat dan ook al die plakkers oogt gewoon meer medisch."* Nurse 4

Central screens monitoring:
One of the big advantages of centralized screens in comparison with personal bedside screens is the impact on the people in the room. Since there are no screens in the room the parents cannot get fixed on the monitor. Nurse 8 explains that she prefers not having screens in the personal rooms, but only central screen monitoring.

> *"Dat je uitlegt van we monitoren uit voorzorg, dit doen we via een centraal scherm in onze kamer. En dan hebben ouders niet een scherm waar ze zelf continue naar zitten te kijken met "oh ik zie dit, oh wat is dat?"* Nurse 8

The comfortable feeling of knowing that there is constant surveillance (Alasad & Abu Tabar, 2003), also proved to be true in practice. The presence of centralized screens also gives a secure feeling to parents. They know that we also look at the central screens, there is always someone keeping an eye on them and their baby. Nurse7 illustrated that giving clear explanation to parents helps to not let them panic, because they know that someone else is watching as well.

> *"Vaak als je ze dan wel goed instrueert dan weten ze: Oh, ze zien het toch wel, zeg maar, en dan bellen ze niet meteen. En soms krijg je een collega aan de telefoon die de registratie ziet en dan ga je even naar de kamer toe. En dan kom je op de kamer aan en dan gaan er bellen en piepjes af maar zijn de ouders niet in paniek, want ze weten dat er ook nog iemand buiten de kamer op let".* Nurse 7

From observations it came forward that when the monitor beeps, most parents directly look at the screen. This may lead to the fixation on minor fluctuations (Gross, Dahl, & Nielsen, 2011).

Fieldnotes: Sometimes they ask why the alarm went off, or they just stare at the screen and then look back at their baby. The monitor seemed to have impact on the parents, they reacted to most alarms.

Alarms and parents:
The tension between both positive and negative impact on patients and/or parents that was found in literature was also found in practice. The transparency of having a personal bedside screen can foster trust and empower the parents by direct access to their health data. But the constant exposure can also increase anxiety (Gross, Dahl, & Nielsen, 2011). The interviews revealed that care professionals are indeed worried about the rest and stress of the parents, especially at night. Nurse 8 explains both sides of bed side monitoring in the following quote.

> *"Aan de ene kant is het fijn dat de ouders zo kunnen meekijken. Aan de andere kant kan ik me ook voorstellen dat het ouders stress en onrust kan geven, want je ligt daar te slapen en al die toeters en bellen gaan wel een keer in de zoveel tijd. Dan merk je heel erg die onrust natuurlijk."* Nurse 8

> *"Vooral wat je hoort inderdaad in de nacht, de ouders slapen en schrik je wakker als het alarm gaat. Ook al ademt de baby daarna weer goed, de monitor blijft piepen, dus je maakt je weer opnieuw zorgen."* Nurse 4

Alarms can continue beeping, even when the neonate starts breathing normal again. This can scare and wake the parents, also during the night. This is a worry from nurse 4, about continuous monitoring with alarms in the personal room.

Independence of parents with wireless monitoring:
The current wires are scary and make parents less dependent. Parent 2 explains that because of the wires she did not dare to pick up her daughter in the beginning. Non-wired monitoring devices, like the Bambi Belt make it easier for parents to care for their baby (Bambi Medical, 2023). In the literature it was highlighted that remote monitoring allows patients to maintain their independence, while still benefiting from continuous healthcare oversight (Tan, Sumner, Wang, & Yip, 2024).

> *"Ik vond de draden in het begin ook wel een dingetje, ik durfde haar niet zelf te pakken."* Parent 2

The care professionals address the importance of parents easily helping to care. Wires and adhesive electrodes make this more difficult, which will lead to a higher workload for nurses.

> *"Werkdruk zou dan echt intens toenemen en ik denk dat je alles uit handen neemt voor zelfzorg voor de ouders".* Nurse 5

Nurse 4 addresses that wireless continuous monitoring can be a solution for this, making it easier to independently care for their child.

> *"Met de draadloze belt wordt het wel gewoon makkelijker, want dan kunnen ouders die zelfstandigheid behouden".* Nurse 4

This independence is also mentioned in the literature about advantages of remote monitoring (Tan, Sumner, Wang, & Yip, 2024). The advantage of wireless monitoring was evident from the interviews and observations during the field research. From interviews it appeared that parents would feel more secure to pick up and cuddle with their baby without the wires. The Bambi Belt could help with sustaining this independence for parents.

Next to that, wireless monitoring with the belt is seen as a low-threshold solution, it looks less medical than wires and adhesive electrodes. The lower threshold and still have continuous data for the breathing for example is an advantage.

> *"Het is ook wat laagdrempeliger. Het ziet er minder medisch uit en zodat we toch alles kunnen checken. Ja, zeker die ademhaling inderdaad".* Nurse 7

Showing data from monitoring:
From interviews with parents, it became evident that they sometimes prefer not to see everything themselves. The idea of monitoring appeals to them—knowing that their baby is in good hands and being observed in a control room provides reassurance. Parent 4 explained how he would like central monitoring, so he knows that someone is looking at the monitor at another place.

> *"Ik zou liever hebben dat er gemonitord wordt en dat ik weet dat er in een centrale controle kamer naar gekeken wordt en dat ik weet dat hij in goede handen is."* Parent 4

However, they would rather not have full visibility themselves. Without medical expertise, it can be difficult for them to interpret what they see, leading to unnecessary worry. For parents without medical knowledge, it would be good to set boundaries, according to parent 5.

> *"Heel duidelijk grenzen stellen, ouders kunnen in paniek schieten als ze alles zien, als je geen medisch inzicht hebt lijkt dat me lastig inschatten of er iets aan de hand is of niet."* Parent 5

Additionally, parents find it challenging to determine whether a situation requires concern or not. They do not want to see the values, to not have unnecessary stress, according to parent 4.

> *"Ik wil liever de waardes niet zien, je weet dat het een keer dipt en omhoog gaat, dan maak je je onnodig zorgen, word je wakker van en wil je kijken. Ik denk wat niet weet wat niet deert."* Parent 4

During the observations the difference between wires and adhesive electrodes and the Bambi Belt were visible.

> *"Ik vind het fijn dat ik nu zelf mijn kindje kan wassen, dat durfde ik niet met de draden."* Parent 6

1.6.4 Visual overview of findings:
The findings that emerged during the research (literature and field research) are summarized and visually presented in different visual overviews. The difference in rooms, sequence of rooms, the period of observation at the maternity ward and a user journey of the experience are created. This is based on the observations and interviews combined. The visualized user journey is elaborated here.

User journey
In the user journey (figure 1.21) a possible chronological observation process at the maternity ward is visualized from left to right, illustrating how an admission might proceed. This user journey is based on observations and interviews conducted at Reinier de Graaf Hospital in Delft, though it is generalized and may vary depending on the specific situation.

Sections
Starting at the top, the grey sections represent events, the blue sections indicate activities, the lighter blue sections show what equipment is used during that activity, and the interactions between parents and nurses are highlighted.

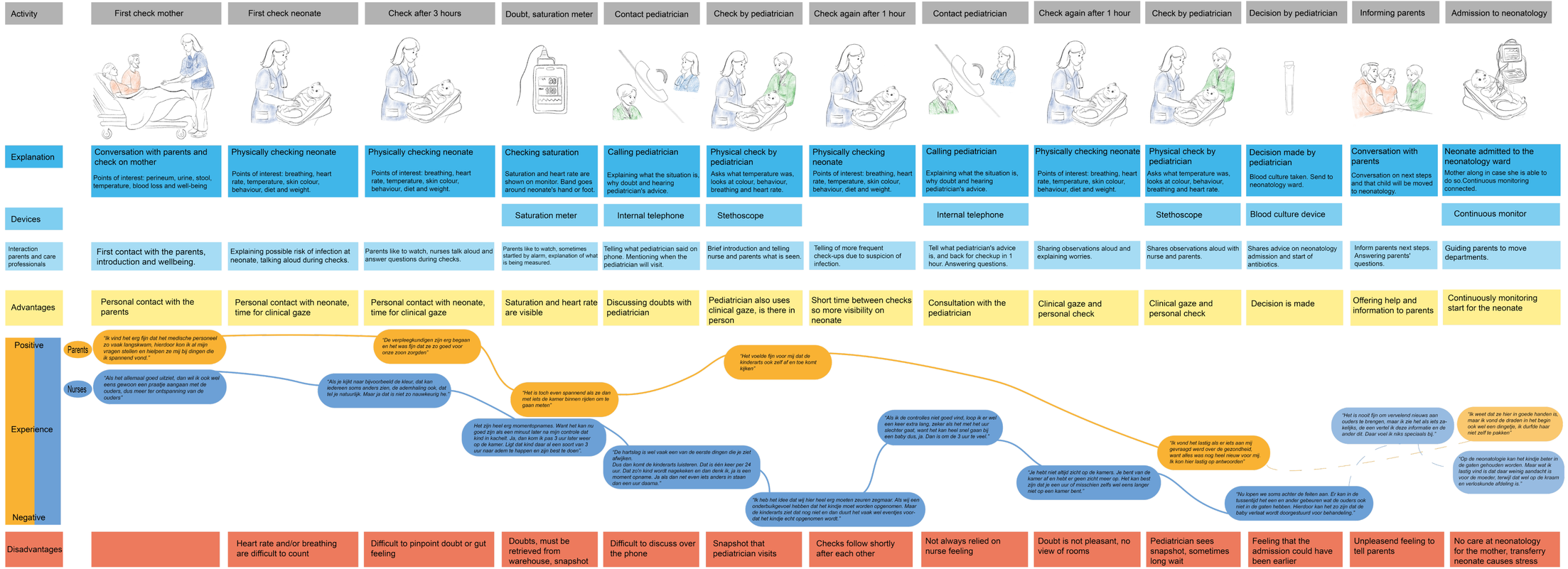
The experience lines, shown in blue and orange, represent the common experiences reported by nurses from Reinier de Graaf Hospital's maternity ward (blue line) and the experience of parents (orange line). This experience focuses on a case involving a neonate at risk of infection, illustrating the process from observation to admission. The line moves from positive (at the top) to negative (at the bottom) experiences, this is determined based on input from nurses and parents, with specific moments illustrated with quotes. For instance, nurses reported enjoying their initial contact with parents and examining the neonate, which started with positive feelings. However, as they faced challenges in accurately monitoring the neonates' breathing and waiting for updates between monitoring intervals, their experience declined. A key frustration was the "snapshot" observation, where pediatricians only assess the neonate briefly, not fully capturing the child's condition over time. This led to nurses feeling that important signs might be missed.

The experience line is lowering when nurses feel their instincts and insights about a neonate's condition are not immediately trusted by pediatricians. Despite closely monitoring a neonate for an extended period, the brief evaluations by pediatricians often delayed crucial decisions when nurses requested their involvement. Nurses voiced their frustration with the time it took for pediatricians to respond to their concerns.

This situation, although not experienced by every nurse, highlights a common challenge. Nurses feel they are often behind in responding, with critical moments potentially unnoticed by parents, who are unaware of what is happening behind the scenes. The sense of delay in transferring the neonate to a neonatal department where proper monitoring can occur is a significant stress point. At the same time, the shift of focus from the mother's care to the neonate's health often leads to concerns about the mother's well-being, an aspect nurses feel is under-addressed in the current system.
In the same diagram the experience of the parents is also visualized, this experience is also drawn with positive experiences at the top and negative on the bottom. Quotes from parents are shown in the user journey to explain the height of the experience line in that moment.

While this user journey reflects one potential scenario, it is important to note that not all nurses have the same experience, and some may feel more positive about the process. This user journey is a representation of a typical situation and aims to highlight the key challenges (where the experience line is negative) and emotional journey experienced by nurses and parents. The end of the journey can differ per neonate, it might start treatment at the neonatology ward (as visualized in this user journey), or it can go home after the checks, or it will be stay longer at the maternity ward. Due to these different possible outcomes, the illustrated experience line leading to the neonatology ward is dotted.

Figure 1.12: User journey of obstervation period at the maternity ward with neonate at risk of infection.



1.7 Conclusion findings

The insights from the field research are valuable for the continuation of the project. Along with the literature research, they provide information about the current situation and the opinions and experiences of stakeholders. These findings are categorized into three focus areas: medical aspects, perspectives of nurses and parent perspectives, each divided into findings about A. current monitoring practices and B. continuous monitoring. The field research, together with the literature research, is translated into visual overviews of the findings. These visual representations serve as a foundation for translating the research into the problem definition and will continue to play a central role throughout the project. Additional insights, such as those noted in the context section of this report, support the project's development and understanding.

The main takeaways from the field research are summarized below. These conclusions mark the end of the first phase, which focused on the exploration of the research. Moving forward, the insights from both the literature- and field research will be utilized to redefine the main problem, the design goal, and the future vision in the next phase of the project.

Take aways findings field research:

- **Challenges in current monitoring:** There are long intervals between checks, making it hard to know what happens in between. Nurses also struggle to explain their gut feelings to pediatricians when they sense something is wrong.
- **Improved trend detection with continuous monitoring:** Continuous monitoring provides more data over time, making it easier to identify trends and detect deterioration earlier compared to single snapshots during manual checks.
- **Balancing focus between mother and neonate:** Nurses worry that continuous monitoring might shift attention solely to the neonate, neglecting the mother's needs in maternity wards.
- **Staffing challenges with continuous monitoring:** Continuous monitoring might require more resources, and care professionals fear they lack enough staff to manage central screens and extra tasks effectively.
- **Parents' perspective on data transparency:** Parents appreciate knowing their baby is being monitored but often prefer not to see all the data themselves, as it can lead to unnecessary worry.
- **Importance of personal interaction:** Both parents and care professionals value personal contact during monitoring. This interaction reassures families and helps healthcare workers maintain a human connection despite technological advances.

2.Define

The second phase of the first diamond is used to define the main problems. This phase is focused on converging, where the issues identified in the previous phase are prioritized. To continue in the right direction the main problem is redefined. This is done with the problem definition method from the Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

The outcome is a structured description of the redefined design problem, leading to the design goal with elaborated design requirements and the future vision.

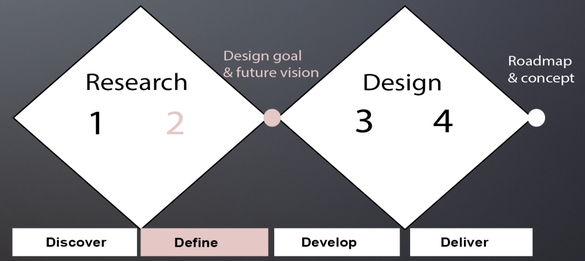


Figure 2.1 Phase 2 highlited in the double diamond

Based on the main insights from the research phase, the initial problem definition and the insights led to the redefined problem definition. The summarized version of the main take aways from phase 1 are repeated, the comprehensive overview can be found in appendix G.

Take aways early onset neonatal infection.
- Prompt recognition is critical.
- There are challenges in identifying early detection.
- Close monitoring is essential.
- Antibiotic treatment has significant risks.
- Antibiotics should be used only when necessary.

Take aways forms of monitoring.
- Clinical gaze is a foundational element of monitoring.
- Intermittent time between manual monitoring can delay detection of deterioration.
- The different forms of monitoring each have different advantages, limitations, and impact.
- Real-time response with continuous monitoring.
- Centralized vs. bedside monitoring both have advantages and limitations.
- Use case of Bambi Belt as wireless continuous monitoring device.

Take aways findings field research.
- There are challenges in current monitoring; intervals and explaining clinical gaze and gut feeling.
- Improved trend detection with continuous monitoring.
- Balancing focus between mother and neonate:
- Staff workload challenges with continuous monitoring.
- Parents' perspective on data transparency, can lead to unnecessary worry.
- Parents and care professionals value personal contact during monitoring.

2.1 Redefined problem definition

Using those insides, the redefined problem definition is created based the problem definition method from the Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

Context of problem

Early-onset neonatal infections can be life-threatening and must be recognized quickly. According to (WHO, 2020), 84% of neonatal deaths from infections could be prevented with early diagnosis and timely treatment. However, detecting infections early is challenging, so close monitoring is essential. Treatment decisions follow established frameworks, and antibiotics should only be used when necessary, as overuse can harm both the infant and public health (Tarrant, et al., 2020).

Current monitoring methods have drawbacks. Nurses check the neonates' vital signs every 3 hours for at least 12 hours, leaving gaps between visits where deterioration can occur unnoticed. Pediatricians' short visits provide limited data, discussing with nurses is often relayed on their clinical gaze, which can be hard to explain. This can delay necessary treatments and worsen outcomes for the neonate, increasing stress on care professionals and parents.

Problem definition

The current way of monitoring in this context raises concerns among care professionals about potential unnoticed deterioration in neonates due to intervals/gaps between visits. More frequent visits are not always possible. Pediatricians only get brief snapshots of the situation, which can frustrate nurses, as they struggle to convey earlier observations based on gut-feeling. This can delay treatment, worsen outcomes for neonates, and increase stress for both care professionals and parents.

A potential strategy to address this problem is to introduce a system of continuous monitoring. Currently, this approach is not being implemented in the maternity ward. To ensure smooth implementation, it is essential to carefully consider any potential challenges and limitations during the design phase. To guide this process, a specific design goal has been established.

2.2 Design goal

The goal of this project is to create a nurse- and parent-friendly system for continuous neonate monitoring at the maternity ward, improving response time and patient outcomes. The strategic roadmap explains the steps that should be taken to reach this way of monitoring.

What is meant by nurse-friendly and parent-friendly?

Nurse-friendly:

Nurse-friendly means that the design should offer support to nurses clinical gaze, without interrupting personal contact with patients, which most nurses love most about their job. The continuous monitoring should allow nurses to better support their clinical gaze and observations from earlier visits. Pediatricians will have access to a consistent flow of data. All without the environment feeling overly clinical.

Parent-friendly:

Parent-friendly means that the design should allow parents freedom of movement and autonomy in interacting with their baby and that the design should not put (extra) stress on parents (e.g. by an overly clinical appearance). The goal is to create a setting that feels comfortable and reassured, without adding extra stress. Providing parents with the reassurance that a care professional is regularly overseeing their baby's wellbeing. While the environment should not appear overly clinical.

Design requirements:
To reach the design goal, there are requirements which the final design should meet. These requirements came forward from the research during this project and are also divided into the three focus areas. These requirements will guide the designing phase to a fitting design. The design is regularly checked if it meets with the design requirements.

Medical requirements:
1. The design should provide a clear overview of continuous data, with possibility to see the history of data.
2. The design should provide a stable flow of continuous data that makes spotting trends possible.
3. The design should improve response time to detect the infection.
4. The design should decrease time to start treatment when there is an infection, which helps preventing deterioration.
5. The maternity ward is for providing care for both mother and neonate, the design should help remain this.

Nurse-friendly requirements:
1. The design should reinforce the gut feeling as part of the clinical gaze.
2. The design should provide reassurance between visits.
3. The design should avoid extra shifting from the neonatology ward to the maternity ward because of monitoring possibilities.
4. The design should avoid unnecessary interruption of the environment at the ward due to alarms.

Parents-friendly requirements:
1. The design should not look to medical with cables or monitors.
2. The design should not affect the current possible parent child interaction.
3. The design should not restrict the parents' freedom of movement.
4. The design should avoid giving parents extra stress.
5. The design should avoid a clinical appearance in the room, which changes the 'family ambiance'.

An elaborated version of the design requirements can be found in appendix H.

2.3 Future vision

A future vision has been developed to ensure that this project ultimately achieves its intended goals. This is based on the initial vision of the project: "The initial vision for this project is to implement a form of continuous monitoring at the maternity ward." As the project evolved, this vision has been further refined, integrating the redefined problem definition and all established requirements. As a result, the future vision has become more specific and focused.

Future Vision
Neonates with higher risk of infection will be continuously monitored in maternity wards with a nurse-and parent-friendly system. This system ensures that care professionals are empowered to detect potential signs of neonatal deterioration at early stages, addressing critical gaps between visits. It enhances the clinical gaze and helps nurses to support explaining their gut feelings with consistent data while maintaining a parent- friendly experience.

The importance of the future vision is aptly described (Simonse, 2024):
"On a design roadmap, the future vision points to the destination. As an expression of a desired future, the vision provides a strategic reference point – a focused direction that leads to stronger motivation. Turning the vision into reality."

The goal of this project is to bring this future vision to fruition. To support this endeavor, a strategic roadmap has been developed, offering a comprehensive overview of the necessary steps to move towards this future vision, this roadmap is further detailed in phase 4.

2.4 Conclusion of the first diamond

The first two phases provided an extensive understanding of the context, stakeholders, existing literature, the current monitoring practices, insights into continuous monitoring, the potential use case of the Bambi Belt, and the identified challenges. These findings from the research phase were translated in the second phase into a redefined problem definition, the design goal with its requirements and the future vision. These requirements will guide the development of the solution in the next phase and ultimately lead to a strategic roadmap which explains the steps to reach the future vision.

3. Develop

The third phase is about developing solutions based on the design goal established in the previous diamond. To reach this goal, the main problem was divided into different subproblems. This approach is carried out based on the method of the morphological chart. The ideas for these subproblems were generated during two activities. Alle ideas were assessed and combined with the morphological chart, leading to 6 concepts. These were narrowed down to 3 concepts, discussed during co-creation sessions with nurses. Eventually one concept was chosen and further iterated into the Care Cloud. The design of the Care Cloud is a fundamental step of the roadmap, complementarily leading to the future vision.

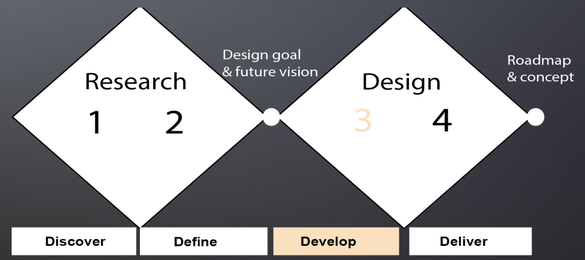


Figure 3.1 Phase 3 highlited in the double diamond

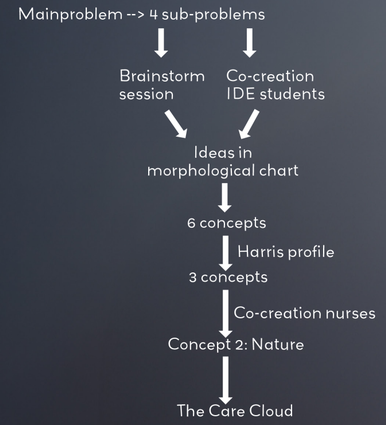


Figure 3.2: Steps that are taken in phase 3 develop.

3.1 Ideation

To achieve the future vision of the roadmap and the design goal, several ideas were generated during the ideation phase, each addressing specific subproblems within the larger challenge. These subproblems are defined based on the method morphological chart from Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).The main problem is composed of multiple aspects, including the need for a monitoring device that is easily readable by care professionals without being intrusive for parents. Key factors influencing this experience on the maternity ward are the monitor's location, its appearance, and the way alarms or notifications are conveyed. These factors must be balanced to ensure both functionality and comfort for everyone involved.

The Bambi Belt as use case is a given part of the solutions during the ideation. The Bambi Belt can be seen as one of the starting points, this is the only product that needs to be in the room.
The Bambi Belt will be used as the starting point of the solution since this monitoring device enables wireless continuous monitoring and with that provides the base for nurse- and parents-friendly optimized neonate monitoring. To further respond to the goal, needs, requirements and create the intended vision, multiple aspects still require ideation.

Subproblems
To develop an effective complete solution, a morphological chart was created to break down the main problem into manageable subproblems. This project has to deal with a socio-technical system. This is a complex system in which social elements (in this case: people, hospital organization, and culture) and technical elements (the monitors and the Bambi Belt) interact and influence each other (Carayon, et al., 2011) at the maternity ward.
The social element is issue of improving the experience of the parents and nurses at the maternity ward, whereas the technical elements are about improving the use of the system and possible faster recognition of the infection.

To address the main problem while meeting these diverse needs and wishes, it was divided into four subproblems. These subproblems were identified based on the research conducted in the first diamond, making the issue more manageable. Each subproblem is solved individually first, and the sub-solutions are combined into six comprehensive solutions. This approach is based on the method of the morphological chart (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

Subproblems:
1. How can the nurse be warned?
2. How can the data be shown?
3. How to translate the data?
4. What is the location of this solution?

Ideas for the subproblems
To generate multiple ideas for each subproblem, there are two different activities conducted. The first activity was the initial brainstorm session of the graduate student, the second activity was a co-creation session with Industrial Design Students. The ideas that emerged from this co-creation session were combined with the graduate students' own preliminary ideas, creating a comprehensive set of options for addressing each aspect of the design. This combined approach, summarizing the insights and ideas, is presented in chapter 3.2.

3.1.1 Brainstorm sessions
After identifying the main- and subproblems the graduate student brainstormed on ideas for these problems. The ideas were mostly sketches or small notes, generated based on the "how to ...." method from the Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013). The graduate student wrote down questions about how to solve these subproblems, several ideas were generated and later on combined with the ideas form the co-creation session with Industrial Design Engineering students.

3.1.2 Co-creation session Industrial Design Engineering students:
A creative co-creation session was conducted with Industrial Design Engineering (IDE) students to generate solutions for the subproblems, leveraging their fresh perspectives to bring innovative ideas and added value to the process.
The session focused on three subproblems (the initial second and third subproblem are combined during this session for time saving).
1. How to warn the nurse?
2. How can you display/translate the data?
3. Where can you place this 'solution?

The aim was to brainstorm various approaches to address challenges such as alerting the nurse, determining an optimal placement for the 'solution', visualizing data in an intuitive format, and designing the 'solutions' appearance. During the session, four IDE students were involved, with two representing the perspective of nurses and two embodying the role of parents. Through the use of storytelling, visual aids, and personas, students immersed themselves in the experiences of either nurses or parents. They were tasked with thinking from these perspectives to gain a deeper understanding of the needs and preferences of each stakeholder.

Figure 3.3: Co-creation session with four IDE students.

Immersing participants in the scenario during the co-creation session
Storytelling was used to help the IDE students fully step into the roles of either nurses or parents. According to (Madsen & Nielsen, 2010): "Storytelling supports idea generation for a different target audience by encouraging designers to empathize with users' needs, desires and contexts, enabling more user-centered and relevant solutions."

The graduate student guided the IDE students through a carefully structured exercise. Participants were asked to close their eyes to focus and engage with the storytelling. The session began with the sound of a crying baby. The graduate student narrated a scenario: *the parents had just endured a long, exhausting labor of 32 hours. They hadn't slept for two nights and were emotionally drained. While they were happy, they were also fatigued and sensitive to stimuli. The storytelling was delivered slowly, with faint crying sounds in the background, to help create a realistic environment.*

Next, the nurses' perspective was introduced. *In their story, they began their day on the maternity ward, where they had been working for years. During the handover, they were informed about a baby, Sem, who was at risk of infection. Their task was to monitor Sem to track any signs of the infection developing. However, due to the busy day, they could only check on him every three hours. The time between visits was a source of concern for the nurses, as they worried about what might happen when they weren't in the room. They wanted a solution to stay informed in real time. During their visits they noticed deterioration in Sems health. When they expressed these concerns to the pediatrician, they were advised to wait a little bit longer and see how the situation develops, which left the nurses feeling frustrated because they couldn't adequately convey their instincts and concerns.*

Figure 3.4: Story telling for the parents about the delivery.

After the storytelling, participants were invited to open their eyes. In front of them lay personas that detailed the roles' needs and activities, serving as helpful references for the ideation phase. The graduate student also presented photographs and additional information about the current hospital ward, existing protocols, and introduced the Bambi Belt device. Participants asked questions to deepen their understanding of the context and better immerse themselves in their roles before generating ideas.
The IDE students embraced their roles wholeheartedly. For instance, one student playing the father felt deeply responsible for maintaining calmness in the room. This level of immersion led to insightful ideas and engaging discussions, as participants fully identified with the challenges and emotions of their assigned roles.

Figure 3.5: Persona of the parents to explain the emotions, wishes and activities.

Rounds for subproblems:
The session was structured into multiple rounds per subproblem (table 3.1), each used for different goals, to come closer to solutions for the sub-problems. Each round started with explaining the subproblem for which new solutions are being devised. In figure 3.6 an example of subproblem 1 is shown. The problem is written down in a question starting with the "how to …." method from the Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).
This is used to stimulate the participants to think creatively about how you can solve this subproblem.

Figure 3.6: Round for subproblem 1.

At the beginning of each round, the students representing nurses and parents separately brainstormed ideas and recorded their thoughts on post-it notes. These ideas were then placed on a central sheet to create a visual overview of all thoughts. After this initial brainstorming phase, participants took a moment to re-energize by standing up and then engaged in a group discussion. The group discussion started with sharing the content they wrote on the post-its. This allowed them to hear one another's thoughts and insights, fostering an environment of collaborative exchange. Valuable ideas emerged during these discussions, as both the nurse and parent representatives contributed perspectives that aligned with the needs of both parties, promoting solutions with shared appeal.

Figure 3.7: Clustering post-its during the co-creation session.

Following each discussion, all four participants selected the idea they felt best represented their respective roles. In a silent reflection, they individually developed these ideas further, listing potential advantages and disadvantages. Each participant then presented their idea as an elevator pitch, receiving constructive feedback from the others (figure 3.8). This feedback process sparked fresh inspiration and offered new angles for the next iteration. The session concluded with a rich collection of insights, with each round building upon the previous to produce thoughtful, stakeholder-aligned solutions for the design.

Round	Goal	Output
Round 1: Brainstorming	Writing/drawing ideas and thoughts from nurse / parent perspectives	Ideas and thoughts on post-its
Round 2: Sharing	Telling and inspiring others	Clusters with ideas and thoughts that fit together
Round 3: Discussion	Combining both perspectives together in ideas	New ideas where wishes are combined
Round 4: Choose idea	Defining best ideas from nurse / parent perspectives	Mini poster with idea advantages and disadvantages

Table 3.1: Rounds during the Co-Creation session.

Figure 3.8: Individual ideas developed during the co-creation session, with explanation, advantages, and limitations.

Reflection:
The co-creation session with IDE students generated creative ideas, as they brought a fresh perspective and weren't constrained by practical limitations. Storytelling at the start helped them immerse in their roles by listening attentively and asking follow-up questions. Personas on the table further guided their focus on user needs.

Discussions between "parents" and "nurses" were particularly effective, leading to solutions that addressed both perspectives. Although the students lacked firsthand experience with hospital settings, storytelling and personas helped them empathize well and generate ideas for a different target audience (Madsen & Nielsen, 2010).

A mix of standing and sitting activities kept energy levels high and provided structure. Sitting was used for brainstorming and subgroup discussions, while standing facilitated clustering and full-group debates. This distinction helped maintain engagement and clarity.

At the end of each round, participants pitched ideas individually, responding to each other to refine and deepen concepts. Mini posters supported their elevator pitch presentations, adding clarity and structure.

The IDE students' creative ideas, combined with earlier ideation outputs, were redefined further. Selected ideas were developed using a morphological chart, as detailed in the next chapters.

3.1.3 Evaluating the ideas

All ideas generated from the brainstorm session and the co-creation session have been merged, this resulted in approximately 10 ideas per sub-problem, about 40 ideas in total. These ideas were assessed based on the design requirements from the first diamond. The six ideas per subproblem that scored highest were chosen and organized within the morphological chart (figure 3.11).

Each idea for the subproblems was individually assessed against the design requirements established in the first diamond, receiving a score out of 5. Medical requirements were excluded from this assessment, as they represent broader goals that all ideas will contribute to in the overall concept.

For nurse- and parent-friendliness, four symbols were used to evaluate the ideas:

- ✅ = (1) Meets /solves requirement
- ➖ = (0) Does not meet requirement
- ❌ = (0) Has no influence on requirement
- 🔄 = (0,5) 50/50 – partially meets requirement

If an idea met the requirement, it was awarded 1 point. If it did not meet the requirement or had no influence, it received 0 points. In cases of uncertainty—where the idea might meet the requirement, depending on the design —it was given 0.5 points.
Ultimately, each idea received a total score out of 5.

An example of how this evaluation looks is shown in figure 3.9.
The tables with the evaluation of the ideas can be found in appendix I.

Figure 3.9: A part of the evaluation of ideas for warning nurse, scoring on the requirements.

Idea for warning nurses	Explanation	Staff friendly score	Family friendly score
Vibration wearable	A smartwatch or wristband gives a subtle but distinct vibration pulse pattern unique to the type of alert, such as a faster pattern for breathing issues or a steady, slower pulse if the parents press the call button. option: ripple / heartbeat vibration different rhytm, check screen after	- Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting ✅ Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Color-Coded Lamp with Gentle Flashing: In room	A small, color-coded light in the room softly pulses in different colors for different issues (e.g., red for a breathing alert, blue for a call button) and doesn't flash continuously to avoid causing stress	- Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting ❌ Not interrupting environment 1/4	🔄 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress 🔄 Avoid clinical look 3/5

Remark 'no influence on requirement'

As shown in the table, some ideas are marked with a ❌ for certain requirements, such as "The design should reinforce the gut feeling as part of the clinical gase" under the nurse-friendly category (figure 3.9). While this policy protects nurses' preferences, it is sometimes unrelated to the ideas themselves, which is why some requirements with the same issue are scored as ➖.

Figure 3.10: Sketches of some ideas for the subproblems.

3.2 Morphological chart

The six highest scoring ideas per subproblem were visualized in the morphological chart. The purpose of this chart is to create a matrix containing ideas for the subproblems, these ideas can be combined into principal solutions. In the left column, each subproblem is listed, followed by six optional ideas across the row, each representing a potential idea. The first score above the idea reflects how many **nurse-friendly** requirements the idea meets, while the second score represents the **parent-friendly** requirements.

This structured approach facilitates the identification of optimal configurations by comparing and merging key elements from each sub-solution, guiding the design process toward well-rounded and effective outcomes (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

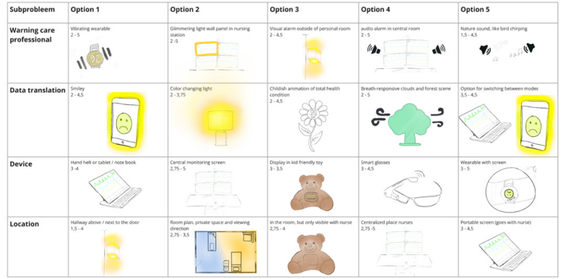


Figure 3.11: Morphological chart with sketches for each chosen sub-idea.

Principal solutions:

The morphological chart gives an overview of the chosen ideas per subproblem. To create principal solutions, there must be combinations made from selecting one idea per row for each subproblem (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

In order to do this, several combinations were tried out on sketching paper, to explore which combinations could work. Some combinations were not possible due to overlap or greater disparities between ideas. Ultimately, six combinations were possible, resulting in promising principal solutions aggregated from the sub-ideas.

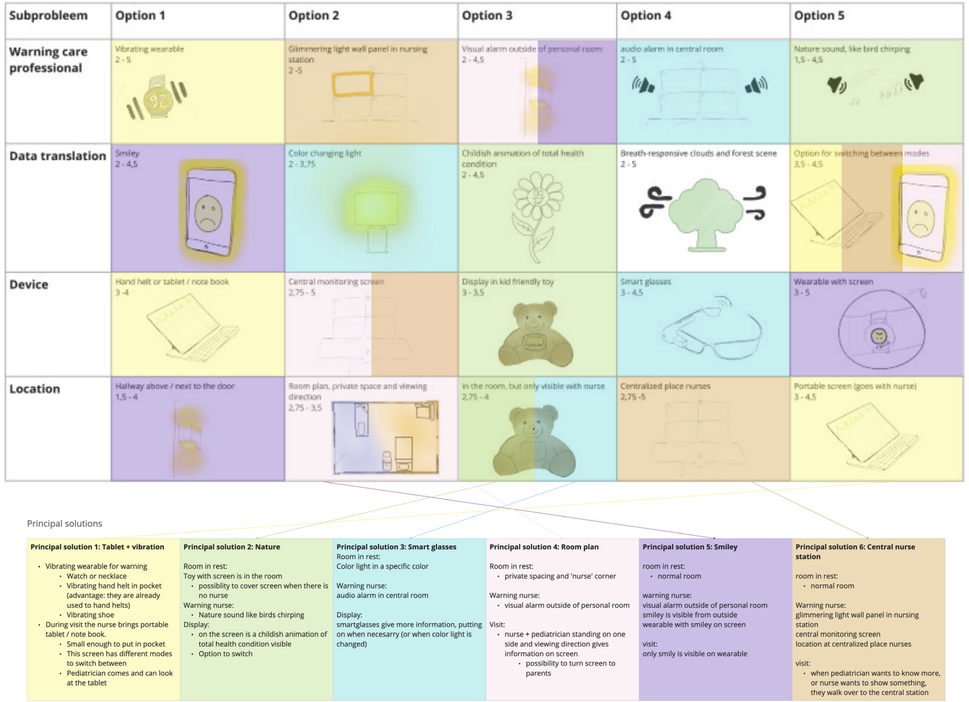


Figure 3.12: filled out morphological chart, leading to six principal solutions.

From principal solutions to concepts

The six principal solutions created with the morphological chart were developed into six concepts. The difference between the principal solution is that this an aggregation from the four sub-ideas next to each other, the concept is a holistic overview of how these (sub-) ideas work together. Problem 2 (data translation) and 3 (device) were often taken together in the creative sessions and concepts, because the translation of data often involves the display of this data.

This ultimately led to the development of six unique concepts. Significant effort went into ensuring that these concepts were distinct from one another while incorporating most of the ideas generated using the morphological chart. One exception was the breath-responsive clouds and forest idea, which did not integrate well into the final concepts.
All other chosen sub-ideas were utilized, forming the basis of different concepts. These six concepts were developed further to be both feasible and varied in complexity, ranging from simpler to more challenging implementations. This careful approach ensured that the resulting concepts offered diverse perspectives while remaining practical.

3.2.1 The six concepts

The six concepts are visualized in short comic strips. Each concept is based on three scenarios. How these scenarios look like can differ per concept. These three scenarios are about: The six concepts, with each visualizing what happens for each scenario:

1. Time between visits	2. Notifying the nurse	3. Pediatrician consultation
Between visits, the neonate is monitored using a Bambi Belt system, allowing continuous health tracking. During this time, parents can rest in the room.	In this scenario, the nurse is alerted either by parents pressing a call button or by an alarm triggered by the monitoring system.	The pediatrician arrives after being called by the nurse, ready to assess the neonate's condition. Together, they review past health data using the monitoring system, enabling them to analyze trends and make informed decisions.

Figure 3.12: Template comic strip concept.

Concept 1 vibration and tablet: Focused on mobility, this concept ensures that only the nurse is alerted with a vibrating notification that does not disturb the environment. During consultations with the pediatrician, a mobile tablet can be used for additional information.

Concept 2 nature: Inspired by natural sounds and objects, this concept integrates the screen into a child-friendly product, like a teddy bear. The notification sound mimics nature, such as birdsong, offering a calming atmosphere. When data is needed, the belly of the teddy bear can be opened, and the monitoring screen is visible.

Concept 3 smart glasses: A futuristic concept where a lamp in the room changes color to indicate the child's condition, visible to parents. Sound notifications are played in the central room, and both pediatricians and nurses can view the neonates' data through their smart glasses. Parents, however, do not see the data.

Concept 4 room plan: Focused on the direction of eyesight, this concept addresses the privacy of parents and care professionals. In the new room layout, care professionals remain in a "blue zone" for consultations, where the data screen faces them. Parents, located in the private (orange) zone, are unable to see the screen. To warn the nurse there is a colored light visible in the hallway, directly outside of the room.

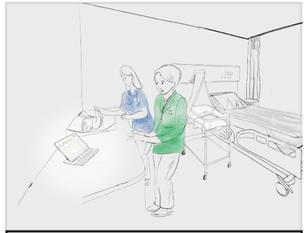
Concept 5 smiley: Based on a smiley face, this concept uses an algorithm to indicate the child's condition. The smiley is displayed outside the room and on a wearable device, accompanied by a text explanation, such as an abnormal heart rate, to provide quick and easy understanding.

Concept 6 central nurse station: Located in the central nurse station, this concept keeps the individual rooms unchanged except for the Bambi Belt on the neonate. All notifications and communications occur at the central monitoring station, ensuring that the data stays within the designated professional space.

1 Vibration and tablet

1.1: Between check-ups, the room remains as it is in the current setup, with the exception of the neonate wearing a blue monitoring band. This allows for discreet observation without disturbing the parents.

1.2: Nurses receive notifications through vibrations, either via a wearable device or a handheld device, ensuring that the room's atmosphere remains undisturbed.

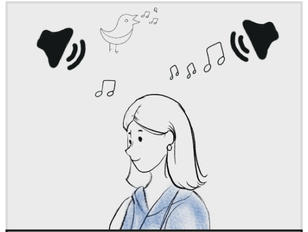


1.3: Nurses carry a tablet, enabling them and the pediatrician to review past health data and identify trends collaboratively.

Figure 3.13: Concept 1 vibration and tablet.

2 Nature

2.1: A teddy bear with a hidden screen is always present in the room, with a flap covering the screen to prevent unnecessary distractions for the parents.



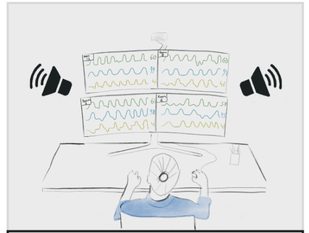
2.2: Nurses are alerted with natural sounds, such as bird songs, based on their location, allowing notifications to be subtle and localized.

2.3: When the pediatrician joins the nurse for a consultation, they can open the bear's flap to access data, review trends, and discuss the neonate's condition.

Figure 3.14: Concept 2 nature.

3 Smart glasses

3.1: An ambient light in the room changes color depending on the neonate's condition, signaling improvements or concerns discreetly.

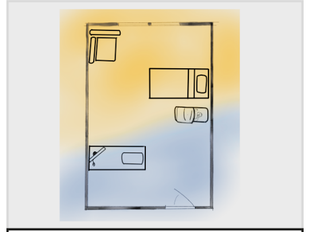


3.2: In the central monitoring room, a sound notification alerts nurses to changes, keeping parents unaware of these alarms.

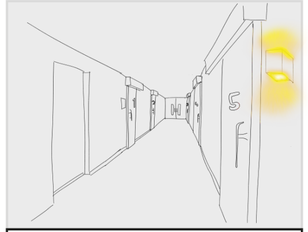
3.3: Pediatricians and nurses can use smart glasses stored in their pockets to view real-time and historical health data, aiding in quick assessments.

Figure 3.15: Concept 3 smart glasses.

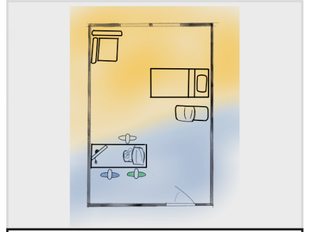
4 Room plan



4.1: The room features a restructured layout with a dedicated private space for the family. A changing table marks the boundary between private and staff zones, with a screen activated only by staff for data review. Parents do not see or hear these displays unless staff are present.



4.2: Outside the room, in the hallway, a light turns on to notify staff, ensuring parents inside remain undisturbed.



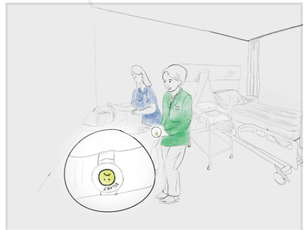
4.3: When the pediatrician joins the nurse for a consultation, they can analyze the data on the screen. While staff and parents generally stay in their respective zones, the boundaries are flexible. Screens can be turned to share information with parents when appropriate.

Figure 3.16: Concept 4 room plan.

5 Smiley

5.1: Between check-ups, the room remains as it is in the current setup, with the exception of the neonate wearing a blue monitoring band. This allows for discreet observation without disturbing the parents.

5.2: A tablet in the hallway displays a smiley face that lights up during alerts, representing the neonate's condition and keeping parents uninvolved.

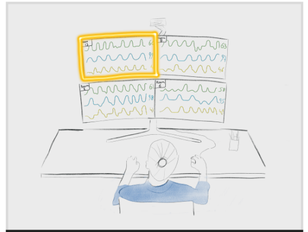


5.3: Care professionals see the same smiley on their smartwatches, accompanied by specific data like heart rate for immediate context.

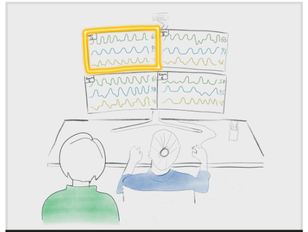
Figure 3.17: concept 5 smiley.

6 Nurse station

6.1: Between check-ups, the room remains as it is in the current setup, with the exception of the neonate wearing a blue monitoring band. This allows for discreet observation without disturbing the parents.



6.2: In the central monitoring room, a light strip around the relevant screen highlights the neonate's room and displays the room number for clarity. Parents cannot access this area.



6.3: When further discussion is needed, the nurse and pediatrician meet in the control room to review data and trends collaboratively, ensuring a thorough analysis of the neonate's condition.

Figure 3.18: Concept 6 central nurse station.

Harris profile

Visualizing the six concepts provided a valuable opportunity to critically evaluate their strengths and weaknesses. It allowed for deeper consideration of how the sub-ideas worked together and their impact on the three focus areas: medical aspects, nurses, and parents. This process led to iterations of the concepts.

The next step was to engage nurses in reviewing the concepts to gather specific and practical feedback. To make this step more focused and take time and concentration into considering, the six initial concepts were narrowed down to three, using the Harris profile method from the Delft Design Guide (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013).

This method was used to evaluate each concept based on overarching requirements. These requirements are listed alongside the Harris profiles, ordered from most important at the top to less important at the bottom. The evaluations are relative, comparing the performance of the different concepts for each criterion (van Boeijen, Daalhuizen, Zijlstra, & van der Schoor, 2013). A four-point scale is used to score the concepts.

-- is bad
- is below moderated
+ is above moderate
++ is good.

Concept 1 vibration and tablet, concept 2 nature, and concept 4 room plan, were chosen based on this analysis. Compared to other concepts, they scored higher on the important criteria. They stand out in fostering a calm environment for parents, maintaining personal contact, requiring minimal effort from nurses, and providing a clear overview of the data.

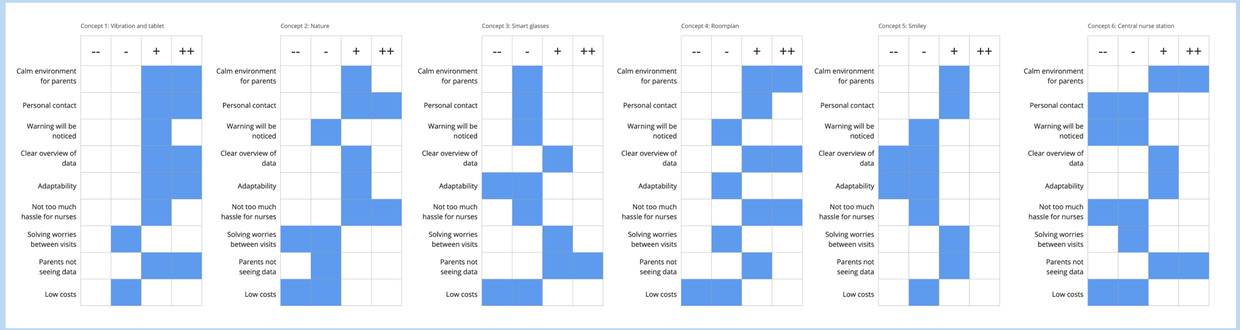


Figure 3.19: Harris profile for concept 1, 2 and 3.

Figure 3.20: Harris profile for concept 4,5 and 6.

Further explanation flaws

Concepts 3 smart glasses, concept 5 smiley and concept 6 central nurse station are not chosen based on the Harris profile method, and this is also explained by their flaws.
Concept 3 smart glasses scores below average (-) on all three most important categories. Next to that de adaptability, hustle, and costs are very low scoring. This concept might be too futuristic and not fitting for this environment.
Concept 5 smiley has flaws when it comes to the overview of data and adaptability. It does not give obvious warnings and it will be a subjective opinion on how to interpret the smiley.
Concept 6 central nurse station creates a calm environment for parents, because they do not see any monitoring device. But on the other hand, this concept discourages personal contact, the nurse needs to go to a different location to see the data or discuss with the pediatrician.

Next step

The three chosen concepts (concept 1 vibration and tablet, concept 2 nature, and concept 4 room plan) are taken to the co-creation sessions with nurses to gather feedback on them.

3.3 Co-creations with nurses

To involve nurses in the design process, ensure the solutions meet their needs even more and are practical at the maternity ward, multiple co-creation sessions were held with nurses. These sessions had two main objectives: **validating the information from previous phases** and **gathering feedback on the concepts** while brainstorming additional ideas for the problems or subproblems.
During the introduction of the co-creation sessions, the graduate student explained the vision and goal of this project. Further, it was clarified that the project includes the Bambi Belt as a use case (demo model was shown), serving as an example of wireless continuous monitoring, and that the concepts were still flexible in terms of their final appearance and functionality. This openness encouraged participants to freely express their thoughts and ask questions, contributing to further iteration and development of the direction and concepts. The three concepts were printed out on multiple a3 pages to invite participants to draw, write, or attach post-it notes with their feedback.

Objective 1: Validating the results from previous phases, the conclusions from the research phase (chapter 2.1) were discussed with the nurses to see if they recognized and agreed with them. The graduate student presented the results (main insights, user journey, observation period risk of infection) and closely observed the nurses' reactions, asking if they identified the issues familiar. The nurses recognized all the problems; some identified with them personally, while others noted that their colleagues faced these issues. The feedback of the nurses helped prioritize focus point for the further development of the concept, making the validation of research results very effective.

Objective 2: Gathering feedback on the concepts. The second and largest part of the session involved presenting the three chosen concepts, the first round started with concept 1 vibration and tablet, then concept 2 nature and as third concept 4 room plan.

Each concept proposal included 4 rounds:

1. The graduate student presenting the concept by handing out a3 papers with the comic strip of the concept to each participant and explaining the concept in further detail.
2. Taking time for questions or clarifications about the concept.
3. Participants individually placing post-its with feedback, opinions, or ideas on the printed concept.
4. A group discussion about the thoughts of the participants.

*Additionally, during co-creation session 3, the cloud concept was discussed.

Figure 3.21: Co-creation session 1.

The group discussions in step 4 were particularly fruitful, as participants debated and reasoned out their views, sometimes arriving at new solutions together. These new ideas were noted down by both the participants on post-its and the graduate student in their notes. Many new ideas emerged during these discussions.

Co-creation session	Participants
Session 1	2 nurses
Session 2	1 nurse
Session 3	2 nurses

Table 3.2: Overview of the co-creation sessions with number of nurses.

Participants creating own ideas
After discussing all three concepts, the final part of the session focused on nurses creating their own ideas. Each participant received a blank template (figure X) to design their desired ideas for the three scenarios. They were encouraged to draw, write, use stickers, or cut out and paste drawings provided by the graduate student. The participants' ideas were then discussed in the group, fostering a collaborative environment for developing practical and user-friendly designs. The input from the nurses largely echoed the feedback and ideas they had shared during earlier stages of the concept discussions. As such, their contributions have been integrated into the broader insights from the entire session.

Figure 3.22: Template to create own ideas for participants during the session.

3.3.1 Between session 2 and 3

Between the first two co-creation sessions and the third session there was time for the graduate student to iterate one concept and discuss this iterated concept during the third session. The preference of the first two sessions leaned towards concept 2: nature. Nurses appreciated the parent-friendly design, with a screen that can be hidden when not in use. Distinguishing alerts with was also a highlighted feature.

Evaluation of concept 2 nature in the first two sessions
This concept was favored by nurses due to its alignment with key considerations:

- A screen in the room allows for quick access to data.
- It prevents parents from viewing the screen when no nurse is present.
- The pediatrician and nurse can watch the screen together.
- It esthetically fits in the maternity ward rooms.
- It is a family friendly design, also for young brothers and sisters.
- Differentiated alert sounds provide clarity.

However, despite these advantages, the concept revealed several limitations:

- It lacked hygienic features suitable for a hospital environment.
- There was no secure attachment mechanism.
- The design is overly childish.
- Parents could easily open the bear's compartment, seeing the screen when there is no nurse in the room.

In response to these considerations and limitations, the graduate student started to iterate further on this concept and brainstormed about ideas for solving the limitations from the nature concept. The graduate student explored alternative objects suitable for a child's room while incorporating a screen. Some of these ideas are illustrated as sketches below.

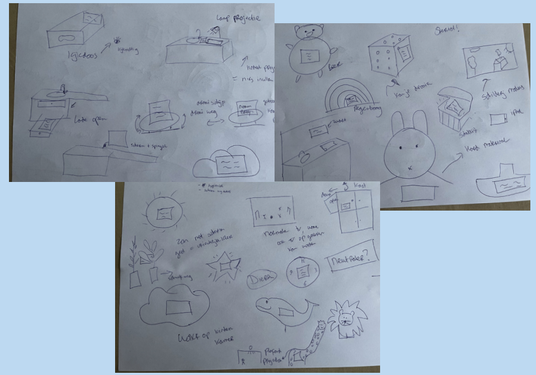


Figure 3.23: Sketches for iteration.

3.3.2 Iteration towards the promising concept

From these sketches and more brainstorming, the cloud emerged as the most viable solution. It was chosen because the cloud addressed the limitations of the concept 2 nature and fulfilled the requirements identified earlier in the project, linking back to the problem statement (chapter 2.1). The cloud concept was based on concept 2 nature, with the teddy bear with screen, but now meeting all the requirements and solving the limitations. The cloud has a screen in it that is invisible for parents but can be visible for care professionals, when they unlock it with their ID. The alarms are not noticeable in the room, they are sent to the handheld of the nurses. Below are illustrated the first renders of this cloud concept. These renders are made before the third co-creation session, to discuss the cloud concept with the nurses.

Figure 3.24: First renders of the cloud concept with possibility to hide monitor screen.

3.3.3 Third co-creation session:

The third co-creation session started with the same rounds and concepts as the first two sessions. Additionally, the concept of the cloud was also discussed towards the end of the session. This was an extra addition to gain their feedback on the cloud concept, after discussing the three concepts like was done in the first two sessions.

The cloud design was validated with three nurses, who provided essential feedback. They highlighted the importance of a screen that could be turned off when not in use, preventing parents from staring at the screen and reducing unnecessary disturbs. Additionally, they appreciated the functionality of using the screen to input data directly, eliminating the need to leave the room for documentation.

The opinion of the participants in the third co-creation session was as follows:
Participant 4: *"The cloud seems like a good idea to me, it looks good, and it can hang on the wall of the room."*
Participant 5: *"This looks better than the teddy bear, this is more for adults as well."*

Additionally, there was a discussion about the appearance of the cloud concept. The conclusion of the nurses was that the design should look clean, blend in with the room and should not look too childish. It is still a hospital and according to participant 5: *"Parents are not crazy; they can see the screen too."*

3.3.4 Key insights co-creation nurses

The co-creation sessions have provided important outcomes, which are elaborated upon per idea.

Figure 3.25: Overview of post-its on proposed concepts and created concepts during the co-creation session.

One concept was evaluated most positive along all three co-creation sessions. That was concept 2 nature, with the teddy bear that has a screen in his belly and alarming sounds based on nature sounds. The possibility to hide the screen, parent-friendly looks and calming sounds were positive scoring aspects of this concept. But this concept had its limitations as well, coming forward during the discussion in the co-creation sessions. This concept was further developed into the cloud concept, which is discussed with nurses in the third session, after the original three concepts.

Key insights from the co-creation sessions with nurses:

Clinical gaze:
- Clinical gaze should still be first priority.
- The concept should not hinder the clinical gaze.
- The continuous data should be a support for the clinical gaze, and not the other way around.
- Pediatricians prefer to examine the child first before relying on backup screens.

Hygiene and environment:
- The object must be hygienic (a teddy bear with soft fabric is not ideal).
- Maintaining a calm and familiar environment in the room is preferred.
- Parents should not access the screen themselves when alone to avoid "self-doctoring."

Alarm systems:
- Alarms need to be obviously noticeable.
- Alarms should be on the handheld of the nurse, not in the room with the parents.
- Keeping the currently used handheld is preferred.

Distinctive alerts:
- Having distinctive sounds for each type of alert helps in quick identification and action.
- Alerts should be manageable and not visible to parents to avoid unnecessary worry.
- Efficient alarm management contributes to a calm and controlled environment.

Location and looks:
- Positive reception of a child-friendly teddy bear concept, also appreciated by visiting family members.
- A black screen does not look friendly in the room.
- The best location for these interactions is the table with the sink and changing pad.
- A good location can be on the wall above the weighing scale (this is the wall where the bed of the mother is attached to with the headboard.
- The portable tablet has the advantage of not being in the room when not necessary but as a drawback the nurse can forget to get it, and it takes more time once they are observing the neonate that they need to leave the room to get the tablet.
- The option for a fixed screen in the room has an advantage that the data can always be visible when observing the neonate, but as a drawback that the screen can be interrupting the environment.

Data:
- The lack of in-room computers due to budget cuts has led to nurses forgetting what needs to be inputted when interrupted.
- Having in-room computers would significantly improve data entry accuracy and efficiency.
- Integration with HIX (current documenting system) is an option for seamless data access during patient rounds and consultations.
- Data should be easily accessible on both computers and tablets for efficiency.
- Real-time data monitoring helps in better clinical decision-making.
- The presentation of the data should be well visible for two persons at the same time. When nurse and pediatrician want to discuss and watch the monitor at the same time.

General Recommendations:
- Avoid extensive remodeling of every room; adjust to neonates at risk of infection in different rooms.
- Item security: devices must be securely fixed to prevent theft.
- Training nurses on interpreting and communicating the monitored values is necessary.
- Clinical gaze should remain most important.
- Central monitoring requires sufficient personnel to ensure someone is always available to watch the screens.
- Suggestion from nurses; combine it with the NEWS-score (National Early Warning Score).
- The tablet can be connected to HIX, the system that is used for documenting the dossiers about the patients. This can then be filled in in the room and can be evaluated behind the computer in the nurse post as well.

Figure 3.26: Co-creation session 3.

3.3.5 Insights from co-creation sessions beyond content

Beyond the content insights gathered during the sessions, several other noteworthy points emerged:

- **Appreciation from nurses:** The nurses greatly valued that the graduate student sought their opinions both during the research and now during the design process. Sometimes they have the feeling that other designs are implemented without their input, despite being the end users. But for this project they highly valued the option to give their opinions.
- **Insights from nurses:** Nurses brought up several insights that the graduate student had not previously considered, such as the need for the device to be fixed to prevent theft, integration with the HIX system, and adherence to hygiene regulations.
- **Clarifying presentation:** The initial presentation effectively clarified the goal, vision, and operation of the Bambi Belt. None of the participants were familiar with the Bambi Belt prior to this.
- **Openness graduate student:** Nurses appreciated the graduate student's openness at the start, welcoming all feedback and criticisms. This openness fostered a constructive atmosphere, leading to valuable and critical feedback.
- **Validation from research:** During the sessions the most important insights from the research phases where presented. This was all validated by the nurses.
- **Hosting different co-creation sessions** helped diving deeper into personal opinions of the participants, during sessions they can influence each other with their opinion. Having different sessions helped preventing biased opinions.
- **Positive effects on new design iteration:** The openness and collaborative mindset of the participants positively influenced the new iteration of the design.

3.3.6 Conclusion co-creation nurses

The co-creation sessions with nurses ensured the solutions are practical and meet maternity ward needs by incorporating end-user perspectives. This made the designs more user-friendly and validated earlier research findings, while also providing valuable feedback on clinical priorities, hygiene, alarms, and data integration. Nurses valued being involved, offering insights that shaped the concepts meaningfully.

This process highlighted the importance of collaborative design, as nurses appreciated being included and provided remarks, thoughts, explanations, and ideas from their perspectives that shaped the concepts in unexpected ways. These insights, combined with their feedback, guided from concept 2 nature into the cloud concept, which is further developed and detailed following.

Take aways co-creation sessions nurses:

- **Insights:** Co-creation sessions led to new insights and valuable feedback on conceptual directions.
- **Clinical gaze:** Technology should support, not replace, clinical gaze.
- **Hygiene & environment:** Devices must be hygienic and maintain a calm atmosphere.
- **Alarms:** Clear, distinct alerts for nurses; hidden from parents (as much as possible) to reduce stress.
- **Data access: I**ntegration with HIX and current devices improves efficiency and accuracy.
- **Looks:** The concept should not look too medical, focus on parent friendliness.
- **Protected data:** Parents should be protected and not be able to look at the data without medical personnel.
- **Location preferences:** Portable devices offer flexibility; fixed screens ensure visibility but must blend into the environment.
- **Nurse input:** nurses valued being consulted, which fostered critical insights and design improvements.
- **Design impact:** Sessions inspired better alignment with user needs and generated actionable design updates.

3.3.7 Supplementing design requirements

After the co-creation sessions, the provided insights were reviewed again, these insights are important to ensure that the final design is even better aligned with the needs of the focus areas. These insights were translated to supplementary design requirements.

- The design should provide easy access to the data.
- The design should provide an overview of the data that can be viewed together with the pediatrician.
- The design needs to have hygienic and easy-to-clean surfaces.
- The design needs to have securing features to prevent unauthorized access.
- The design needs to be portable and easily movable between rooms.
- Screen visibility of the design should be optimized for nurses while limiting parental viewing.
- The design should have differentiated alert sounds for clarity in monitoring alarms.

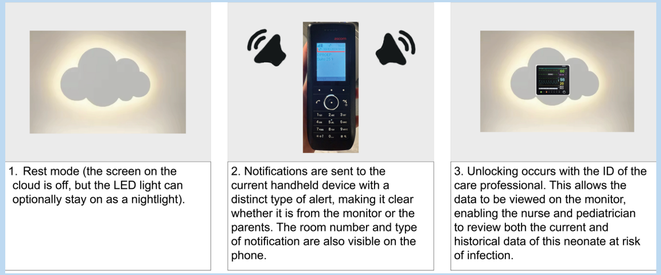
By integrating these supplementing design requirements, the optimized design effectively addresses the needs and preferences of the three focus areas. The design of the cloud, with the supplementing design requirements, is further conceptualized into the Care Cloud.

3.4 The Care Cloud concept

After the co-creation sessions with nurses, preferred *concept 2: nature,* was chosen and further developed into the cloud concept. Also, a name was created for the final concept; The Care Cloud. To further explain the functioning of the Care Cloud, it was visualized in the same comic strips as the other concepts, showcasing the three scenarios and the cloud's functioning. Its functioning is illustrated below in the comic strip.

The Care Cloud in different scenarios

To present the Care Cloud and how it solves the subproblems for this project, the cloud is detailed in to the three scenarios. With elaborated information.



1. Rest mode (the screen on the cloud is off, but the LED light can optionally stay on as a nightlight).

2. Notifications are sent to the current handheld device with a distinct type of alert, making it clear whether it is from the monitor or the parents. The room number and type of notification are also visible on the phone.

3. Unlocking occurs with the ID of the care professional. This allows the data to be viewed on the monitor, enabling the nurse and pediatrician to review both the current and historical data of this neonate at risk of infection.

Figure 3.27: The Care Cloud in the different scenarios explained.

1. Standby mode when no care professional is present

When no care professional is present in the room, the Care Cloud operates in standby mode. In this state, the monitor is not visible, maintaining a calm environment. However, the LED lighting surrounding the Care Cloud can be turned on to serve as a nightlight for parents. Importantly, parents do not have access to view the data. The cloud remains connected to the Bambi Belt worn by the neonate, which continuously measures heart rate and respiration.

2. Alerts for out-of-range values

If the Bambi Belt detects values that fall outside the predefined boundaries, an alert is sent to the nurse via their existing handheld device. These alerts are distinct from other notifications, such as call button alarms from parents, as the Bambi Belt alerts use a different sound. Nurses have expressed appreciation for this differentiation, as it helps them prioritize responses more effectively. Upon receiving an alert, the handheld device displays the room number and the type of notification, allowing the nurse to promptly address the situation by going to the designated room.

3. Accessing data in the room

Upon arriving at the designated room, the nurse can unlock the Care Cloud using their staff ID card. This action makes the front panel of the Care Cloud transparent, revealing the monitor inside. The monitor displays real-time data, enabling the nurse to assess the neonate's condition. Nurses can review vital signs, explore specific data points, or present this information to a pediatrician to support their clinical intuition.

3.5 Conclusion ideation

The ideation phase consolidated all knowledge acquired throughout the project—from research and literature to fieldwork, interviews, and co-creations—into a cohesive concept. The 14 design criteria guided the evaluation process, confirming the concept 2 nature as the most suitable solution. Iterations of this concept led to the development of the Care Cloud. Additional design requirements were established from feedback of nurses. These were integrated and led to a final design of the Care Cloud, with its additional features, which is further detailed in phase 4, where it is directly integrated as a component into the roadmap to support achieving the future vision.

4.Deliver

To achieve the future vision, phase 4 was dedicated to deliver results of this project. The Care Cloud is further detailed and conceptualized into its final design, with a prototype to illustrate this. The strategic roadmap is a visual overview of the steps that need to be taken to achieve the future vision.

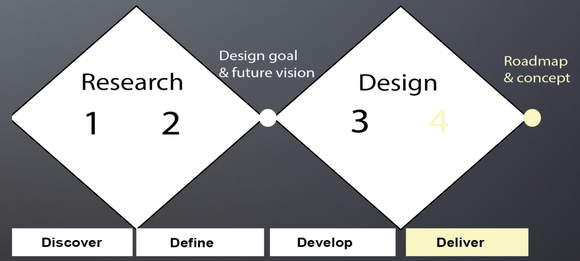


Figure 4.1 Phase 4 highlighted in the double diamond.

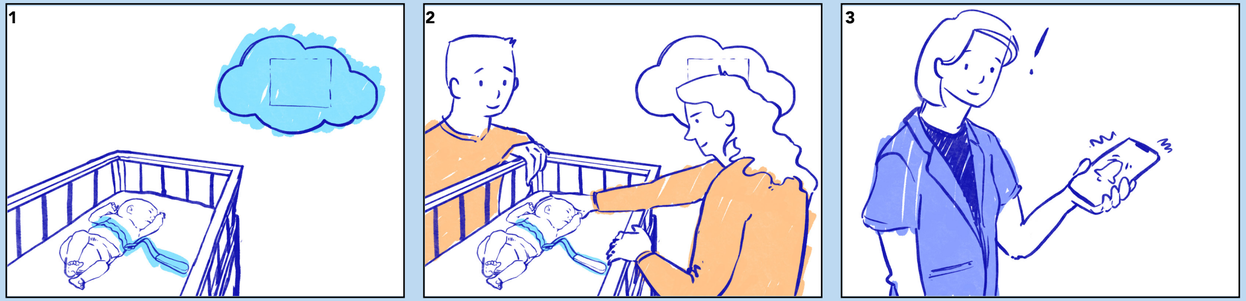
4.1 The design of the Care Cloud

The Care Cloud concept has been further developed through several iterations, the addition of design requirements, and feedback. The final design of the Care Cloud is detailed here.

The Care Cloud is an object in the shape of a cloud that is placed in the maternity room for neonates at risk of infection. The neonate is fitted with the Bambi Belt, which connects to the monitor integrated within the Care Cloud. When a care professional is present in the room, the data from the neonate's vital signs can be viewed on the monitor. This enables the care professional to observe the neonates heart rate and respiration. By continuously monitoring these parameters, trends or deteriorations in the vital signs can be identified quicker. If any vital sign exceeds its boundary value, an alarm will notify the nurse, though this alarm will not be audible from the Care Cloud. Predictive algorithms can be integrated into this in the future, to help predicting the infection at neonates. Additionally, the monitor will not display data when parents are alone in the room, ensuring the family atmosphere and tranquility are maintained. It is essential to emphasize that the Care Cloud supports the highly valued clinical gaze and personal contact, which remain priority (Parreira, et al., 2021).

To illustrate the interaction with the Care Cloud at the maternity ward, a storyboard (figure 4.2) has been created.

Scenario of use of the Care Cloud at the maternity ward



The Care Cloud is being mounted to the wall. A Bambi Belt has been placed on the neonate at risk of infection, which wirelessly sends heart activity and respiration values to the Care Cloud.

Between routine checks, the neonate is countinuously monitored, able to move and sleep freely. Parents can also rest in the room without being disturbed, and they can care for their child.

When an irregular value, or trend, is measured, the Care Cloud sends an alarm to the nurse's phone, displaying the rom number, prompting her to check on the neonate.

The nurse's initial step is to physically assess the neonate using her clinical expertise.

If needed, the nurse can unlock the Care Cloud with her ID to access real-time and historical monitoring data, helping her evaluate trends. Because she remains uncertain about the clinical signs and values, she contacts the pediatrician.

The pediatrician arrives and first conducts a physical examination of the neonate. The nurse can explain her concerns, support them with data, or analyze past trends. Based on this, the pediatrician makes a decision.

Figure 4.2: Storyboard of the Care Cloud at the maternity ward.

4.1.1 How does it work?

The Care Cloud has two operational modes:

'Rest' Mode: Also called the 'parent-friendly mode'. When it is not necessary to view the monitor data, the window with smart PDLC film remains white, making the cloud appear as a decorative object.

The decision to protect the parents is made based on field research and literature research, according to (Gross, Dahl, & Nielsen, 2011): "However, constant exposure to health metrics can also increase patient anxiety, especially if they misunderstand or misinterpret the data presented. Some parents may become fixated on minor fluctuations, leading to unnecessary worry". To prevent this from happening the parent-friendly mode is developed.

Figure 4.3: care cloud in rest mode.

'Active' Mode: When care professionals need to access the data on the monitor, the window can turn transparent. This happens when the care professional taps their employee badge on the authenticator located on the side of the cloud. This action makes the front window with smart PDLC film transparent, revealing the monitor.

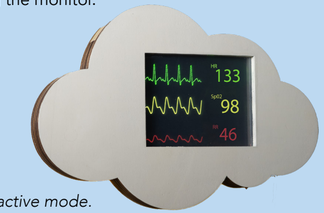


Figure 4.4: Care Cloud in active mode.

System

The functioning of the system is illustrated in the system overview (figure 4.5). It illustrates when monitor within the Care Cloud is visible and when not. Based on the results of exanimating the physical condition and the data, the nurse can decide to either turn the Care Cloud to rest mode when results are satisfactory, or the nurse can call the pediatrician when results are concerning.

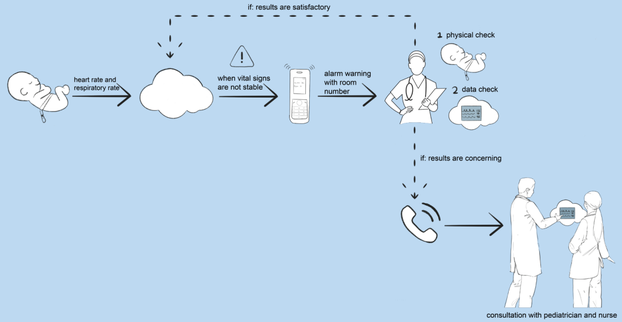


Figure 4.5: System overview of the Care Cloud.

Alarm

The Care Cloud continuously monitors the vital sings of the neonate, it is connected to the current alarm system at the hospital. If a vital sign exceeds its predefined threshold, a distinct alarm is triggered for the nurse, separatable from the alarm used for parent calls. This differentiation is preferred by nurses and ensures that urgent cases are prioritized, according to nurse 5 (co-creation 3): *"Als ik onderscheid zie tussen de alarmen kan ik hier zelf op prioriteren en handelen."*

The nurses will see the room number on their handheld devices, allowing them to quickly locate the neonate. Upon arriving, they can unlock the Care Cloud to view real-time and historical data for better assessment. The alarm is not noticeable in the room, the parents remain in rest and will not be disturbed or worried about possible 'false alarms'.

4.1.2 Key components of the Care Cloud system

Bambi Belt:

The Bambi Belt provides reliable monitoring of neonatal vital signs without wires. It consists of a silicone belt placed around the neonates' chest. The belt monitors heart rate (ECG) and dEMG for apnea detection, sending this data to the Bambi Interface (Bambi Medical, 2023). Currently, the Bambi Belt is designed for single use over ten days with one neonate. Th design must be adapted by Bambi Medical for sterilization and reuse within 10 days, as neonates at risk of infection typically stay in the maternity ward for 12-24 hours, using the Bambi Belt only during that time. Another adaption that Bambi Medical could make to improve the Bambi Belt is by adding a temperature measurement.

Figure 4.6: Bambi Belt.

Bambi Interface:

The Bambi Interface receives Bluetooth signals from the Bambi Belt, converts them, and sends the information to the Philips monitor via an ECG cable. The Bambi Interface is located at the side of the Care Cloud and should provide access form the side, the interface needs to be redesigned to have the Bambi Bridge ports and indicator lights at the side for easier access.

Figure 4.7: Bambi Interface (Bambi Medical, 2024).

Patient monitor:

A standard patient monitor is embedded in the Care Cloud, positioned directly behind the PDLC window. The proposed monitor for this design is the Philips IntelliVue MX800, chosen for its powerful monitoring with flexible portability in once compact unit (Philips, 2024). This is proposed due to already existing experiences with this monitor and Bambi Belt.

Dimensions: h288 x w327 x d182 mm.

To improve compatibility, the suggestion is that Philips could develop a smaller version of this monitor.

Hospitals can also use their existing monitors, the Care Cloud its monitor slot should be adapted to specific dimensions.

Figure 4.8: Philips Intellivue MX800 patient monitor (Philips, 2024).

PDLC Film window:
To hide the patient monitor, PDLC smart film is used, this provides a seamless automatic transition and makes it securable, two important features. The PDLC (Polymer dispersed Liquid Cyrstal) film is a smart film that can switch by applying an electrical current, it enables the Care Cloud to switch between two modes with use of a staff ID: a transparent state for displaying monitor data and an opaque state to maintain the decorative appearance.
The smart film is mounted on an acrylic panel, which is thin enough to allow touch functionality for entering values. The approximate dimensions of the PDLC panel are 200 x 200 mm, depending on the chosen monitor.

Figure 4.9: Example of smart PDLC film (homeguide, 2024).

ID authenticator:
This feature ensures only care professionals can switch the PDLC screen. Parents do not have access to this functionality, ensuring privacy and parent-friendliness. Hospitals can use their existing ID systems for this component.

Figure 4.10: Example of ID authenticator (Allegion, 2025).

Care Cloud frame:
The Care Cloud's casing is constructed from 9mm and 12mm plywood. Layers of laser-cut wood create compartments for the monitor, Bambi Interface, and power cables. These components are accessible from the top, the front layer can be clipped on, facilitating repairs when needed. The front panel includes a cut-out window for the acrylic screen with PDLC film. The wooden exterior is painted white, and LED lighting around the back edge provides a nightlight function.

Figure 4.11: Layer of laser-cut wood in cloud design.

Mounting system:
Designed for easy installation and removal. The Care Cloud has two hooks on its backside and can slide onto the mounting bar on the wall near the examination table in maternity rooms. The mounting bar has rounded edges to prevent hurting, the bar hangs in every room, painted in the same color as the wall behind it, to be as invisible as possible.

Figure 4.12: Suggested wall mount system.

4.1.3 Exploded view renders
To visualize how the monitor and Bambi Interface would be integrated within the Care Cloud, an 3D model is created. There is an opening on the right side of the cloud for the (power)cables. The front layer can be clipped on, facilitating assembling or repairs.

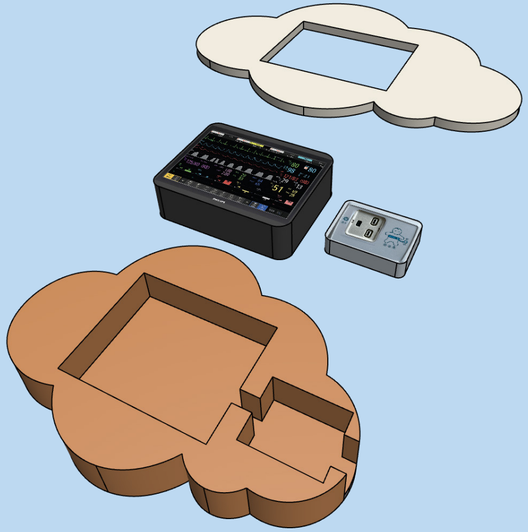


Figure 4.13: Renders of the Care Cloud with the Philips monitor and Bambi Interace inside.

4.1.4 Portability

Given the high cost of equipping every room with a Care Cloud, the design allows for portability. Each room is equipped with the mounting bar on the wall, enabling the Care Cloud to be transferred as needed. All components are integrated and connected to each other within the Care Cloud, it can be simply installed by hanging the Care Cloud on the mounting system, plugging in the power cable, and connecting the Bambi Belt and putting it on the neonate. Every maternity ward can have a few Care Clouds in the storage room, and as soon as a neonate at risk of infection arrives at the maternity ward the Care Cloud and Bambi Belt are brought to the personal room.

Location

The Care Cloud's mounting system is positioned near the examination table in the personal room. Placing the Care Cloud in this location enables the care professionals to simultaneously view the data and interact with the neonate, with the clinical gaze remaining the primary focus. Based on feedback from care professionals, the recommended placement is on the wall behind the mother's bed, next to the headboard which provides power outlets. This location minimizes visual distractions for the parents while maintaining functionality, keeping it within the professionals' line of sight. Additionally, the LED lighting can also serve as a nightlight next to the bed for parents.

Figure 4.14: Maternity room with designated location for the Care Cloud.

To illustrate the location and context better, a visualization with the mother, nurse, pediatrician, and neonate is drawn. It shows that the pediatrician physically checks the neonate and as a support the data on the Care Cloud is being checked, with the possibility to check previous data. The mother faces the same direction as the screen, which helps preventing distraction from data, but in consultation it is possible to see the data for the parents as well.

Figure 4.15: Care Cloud at designated location with mother, nurse, pediatrician and neonate drawn in the room.

4.1.5 Optional visibilty

Based on care professionals' estimation and in consultation with parents there can be decided to make the data visible to parents, also during absence of care professionals. The wish to see the data among parents and situations, this is difficult to tell in advance, which is why there is an option to leave the screen on (the care professional does not turn the Care Cloud to white when leaving). This is decided at the time and only used if it fits the situation, as nurse 8 said: *"Aan de ene kant is het fijn dat de ouders zo kunnen meekijken. Aan de andere kant kan ik me ook voorstellen dat het ouders stress en onrust kan geven."*

4.1.6 Advantages of the Care Cloud

The most important advantages of the Care Cloud are elaborated below.

- **Early detection:** Improves the identification of infections with alarms when values exceed set boundaries, leading to faster intervention and better outcomes. In the future predictive algorithms can be integrated in the continuous monitoring, this will help predicting the infection.
- **Reassurance between visits:** The continuous monitoring helps identifying the infection, also between visits when there is no care professional in the room. It gives a reassured feeling to parents and care professionals that the neonate is continuously monitored.
- **Parent-friendly design:** The parents are protected from the continuous data; it is not visible for them without care professionals. This creates a calmer atmosphere than having their eyes fixed on the monitor. This decision to protect the parents is made based on field research and literature research, according to Gross, Dahl & Nielsen (2011): *"Some patients may become fixated on minor fluctuations, leading to unnecessary worry"*.
  - To prevent this from happening the parent-friendly mode is developed.
  - Resembles a decorative object, maintaining a calm and family- friendly atmosphere, also for (young) brothers and sisters.
  - Wireless monitoring: The Bambi Belt is wireless and promotes family integrated care.
  - Night light: Serves as both a monitoring tool and a nightlight for parents.
- **Seamless data access:** Allows nurses to review data trends and discuss findings with pediatricians. This can support the gut feelings of the nurses and resolves worries between the visits.
  - **Supports gutfeeling:** The data, history and trend spotting support the intuitive decision-making of care professionals. Especially the gutfeeling of nurses, which supports intuitive decision-making.
- **Enhanced workflow:** Integrates with existing alarm systems and reduces manual monitoring efforts. The decision to hide the data from parents also enhances the workflow of the care professionals, since the visibility of health data may lead to frequent patient queries, requiring staff to explain more, which disrupts their workflow (D'Costa, Kuhn, & Fritz, 2020).
- **Portable design:** The Care Cloud is designed to be moved and mounted as one package, the monitor, devices, and cables are inside the Care Cloud, one power cable needs to be plugged in to the power socket.

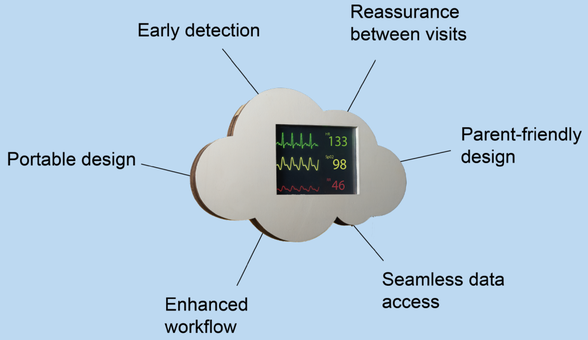


Figure 4.16: Main advantages of the Care Cloud.

4.1.7 Prototype

To provide a tangible impression of the concept, a physical prototype was created to showcase its potential application. The prototype consists of laser-cut wooden layers, designed to accommodate a tablet simulating the monitor (the values in the simulation do not reflect actual clinical condition but are intended for illustrative purposes in the photo). The screen in the top layer is made of acrylic with a layer of PLDC smart film. A LED strip is attached behind the Care Cloud to enable its nightlight function. Additionally, a wall-mounting system prototype was developed to demonstrate the Care Cloud's portability and wall-mounting capability. The prototype is fully functional and illustrates the device operating in two modes: making the monitor visible or invisible. The images below were taken in the photo studio at the IDE faculty.

Figure 4.17: Physical prototype of the Care Cloud when window is white.

Figure 4.18: Physical prototype of the Care Cloud when window is transparent, and monitor is visible.

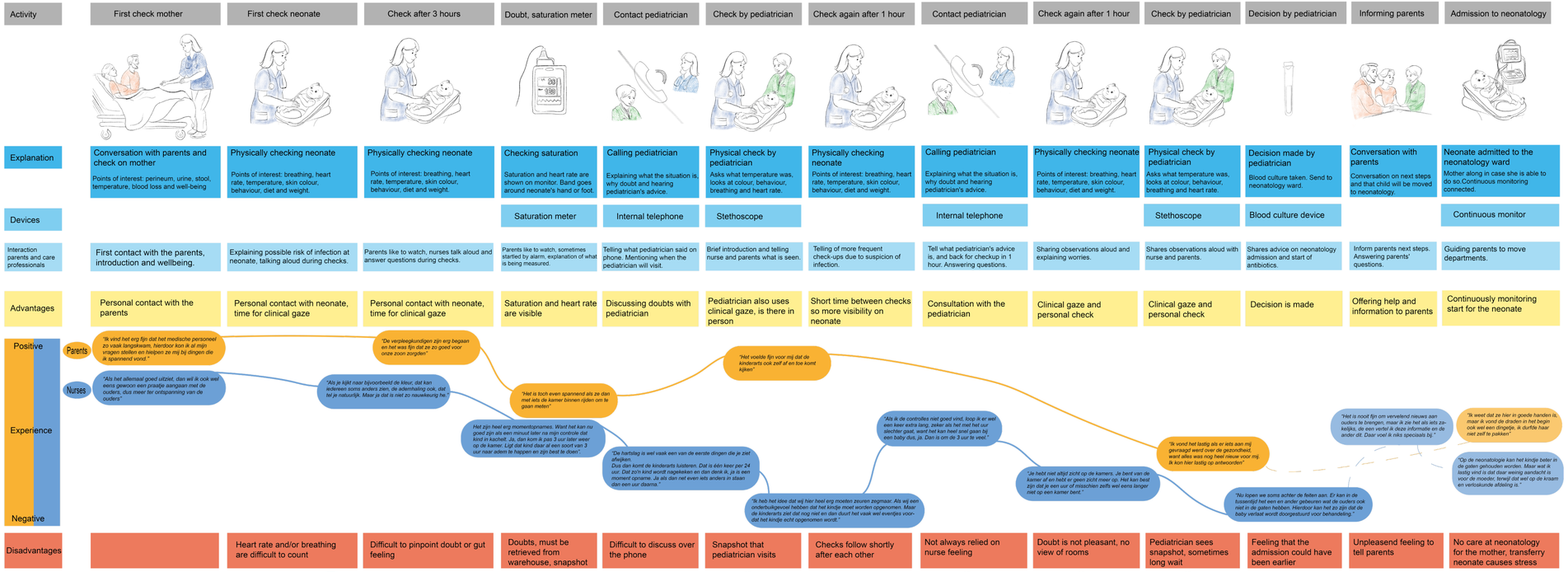
4.1.8 User journey with Care Cloud

To illustrate how the Care Cloud supports the current monitoring process for neonates at risk of infection at maternity wards, it has been integrated into the user journey designed at phase 1 (chapter 1.6.4). The added bottom row details the role of the Care Cloud, including when it is introduced alongside the Bambi Belt in the room, when the screen remains off, and how care professionals interact with the Care Cloud. The workflow remains largely unchanged—since clinical observation remains the primary focus—the Care Cloud serves as a supportive tool.

Additionally, it can help reduce the workload of healthcare professionals. As Dye, et al. (2023) note: *"Manual monitoring is labor-intensive and contributes to staff fatigue and increased workloads."* The Care Cloud can alleviate some of these tasks while ensuring that the clinical gaze remains the top priority.

Moreover, the Care Cloud addresses the challenge of conveying intuitive assessments or gut feelings by providing data to support clinical decisions. In particular, it can help mitigate delays in detecting deteriorating and the limitations of the snapshot visit, while maintaining the parent-friendliness. This will contribute to an improved experience for both nurses and parents, but the new experience line has not been visualized yet, as it can only be accurately defined after observing its impact in practice.

Figure 4.19: User journey with Care Cloud included.



4.1.9 Flyer with information

Parents may feel overwhelmed after the birth of their baby, especially when they learn they need to stay for observation due to a potential risk of infection. Adding to this, a Bambi Belt has been placed on their baby, and the Care Cloud system has been installed and connected in their room. The nurse explains verbally the functioning of the system and how parents can work with it. Understandably, some details about how the system works might slip their minds later.
To support parents in these moments, a flyer has been designed to supplement the verbal explanation they receive. This flyer serves as a concise guide, outlining what has been set up in the room. Information about the infection and the symptoms parents could pay attention to is already covered in a separate flyer that is already distributed in this situation. This new flyer is dedicated solely to explaining the Care Cloud system, ensuring parents feel informed and confident in using it.

Figure 4.20: Flyer for parents with information about the Care Cloud and Bambi Belt.

The Care Cloud

What is it?
The Bambi Belt is a belt around your baby's chest. It wirelessly measures the heartactivity and breathing.

The Care Cloud is used to receive the data from the Bambi Belt. You can use the cloud as a night lamp.

You can hold, feed and cuddly your baby as long as you stay in the room.

Alarms
The vital sings of your baby are constantly being monitored. When there is something that need our attention, we will get an alarm warning us and we will come to your room to check on your baby.

Rest mode
- The vital signs of your baby are continuously monitored.
- The Care Cloud will send an alarm to the nurse when needed.
- To ensure your rest, the monitor in the Care Cloud is not visible.
- You can use the night light in both modes.

Active mode
- The care professionals can unlock the Care Cloud.
- The white screen turns transparent and the monitor is visible.
- The care professionals can view the data of your baby's vital signs,
- with the possibility to go back in history and spot trends.

4.1.10 Conclusion Care Cloud

The final concept of the Care Cloud aligns seamlessly with the insights gathered during the previous phases. The design meets the project's design goal: "**To create a nurse- and parent-friendly system for continuous neonate monitoring in the maternity ward, improving response time and patient outcomes."** For **nurse-friendliness**, the Care Cloud supports the clinical gaze without disrupting personal interactions with patients. It allows nurses and pediatricians to review historical data, providing insights into the neonate's health over time. This can also be integrated with predictive algorithms to better identify potential infections in the future.
For **parent-friendliness**, the wireless Bambi Belt enables parents to maintain autonomy and interact with their baby. The Care Cloud's family-friendly design ensures it blends into the room's environment, offering reassurance without appearing overly clinical.

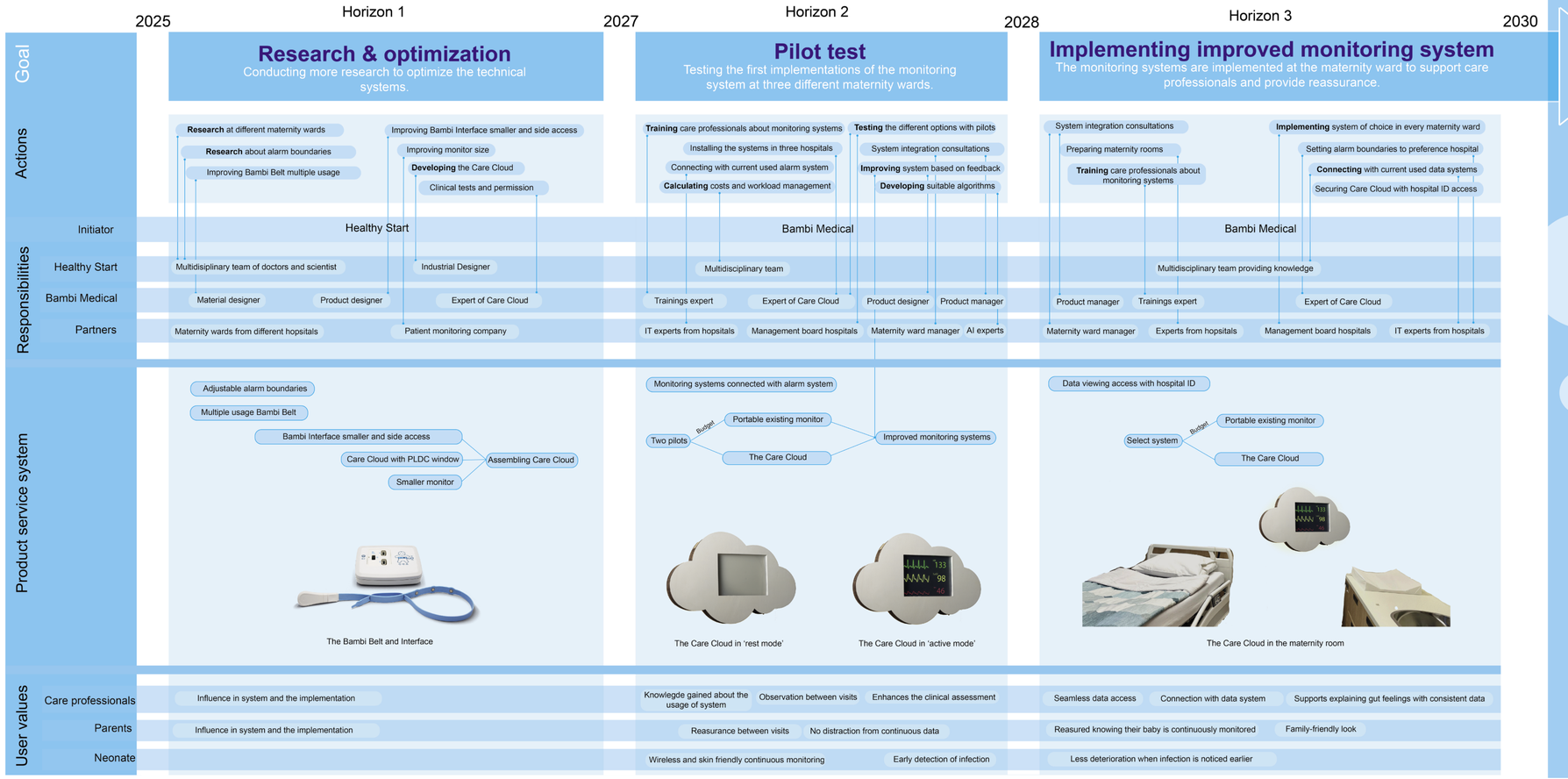
The Care Cloud has been developed as a key component of the roadmap to achieve the future vision and enhance the monitoring of neonates at risk of infection. It incorporates numerous advantages that address the problems and needs identified throughout the project. These include features such as adjustable modes to switch the visibility of the monitor, portability, a parent-friendly design, and other significant benefits. The Care Cloud has been designed with as much detail as possible to ensure its development contribute to the realization of the projects future vision. Additionally, the concept was prototyped to offer a tangible impression of its potential real-world application. Further implementation steps and contribution of the Care Cloud concept are detailed in the roadmap.

Values of the Care Cloud for the three focus areas:

Medical aspects:
- Quicker identification, can be integrated with predictive algorithms, enables timely start of treatment if necessary.
- Avoids unrecognized deterioration of the neonate's condition.

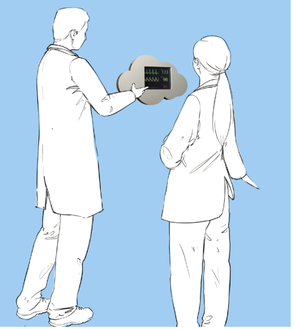
Nurse-friendly:
- The alarm and continuous monitoring alert the nurses if something goes wrong between intermittent visits, which reduces their worries.
- The nurses have the ability to go back in the history of the data on the Care Cloud, which can support their gut feeling when explaining to pediatricians.
- Quick access to patient data to support the clinical gaze.

Parent-friendly:
- The Care Cloud gives the parents a reassuring feeling knowing their child is continuously monitored.
- The 'rest' mode of the Care Cloud prevents parents from fixating on the screens with data.
- The Care Cloud has a parent-friendly design that is not too distracting and also gives a family-friendly look in the room.



Neonates with higher risk of infection will be continuously monitored in maternity wards with a **nurse-** and **parent-friendly system**.
This system ensures that care professionals are empowered to **detect** potential signs of neonatal deterioration at early stages, addressing critical gaps between visits. It **enhances** the clinical assessment and helps nurses to support explaining their gut feelings with **consistent data** while maintaining a **parent-friendly experience.**

Future vision



Strategic roadmap

Figure 4.21: The strategic roadmap.

4.2 The strategic roadmap

To ensure a successful implementation of the results from this project, it is crucial to follow the outlined roadmap. The strategic roadmap details the most important steps that need to be taken and assigns responsibilities to specific stakeholders. Since the project exists within a socio-technical system, it is essential to carefully balance the technical and social aspects. This means having advanced technical systems that are developed in alignment with social needs, practices, and workflows. The roadmap serves as a guide to achieve this balance effectively, to achieve the future vision.

The initial vision of this project was as follow: *"The initial vision for this project is to implement a form of continuous monitoring at the maternity ward."* This vision has been further redefined throughout the various project phases, incorporating the redefined problem definition and all established requirements. As a result, the vision has become more specific and focused, leading to the future vision (chapter 2.3).

Future vision
Neonates with higher risk of infection will be continuously monitored in maternity wards with a nurse-and parent-friendly system. This system ensures that care professionals are empowered to detect potential signs of neonatal deterioration at early stages, addressing critical gaps between visits. It enhances the clinical gaze and helps nurses to support explaining their gut feelings with consistent data while maintaining a parent-friendly experience.

The importance of a future vision is aptly described by Simonse (2024): *"On a design roadmap, the future vision points to the destination. As an expression of a desired future, the vision provides a strategic reference point – a focused direction that leads to stronger motivation. Turning the vision into reality."*

The goal of this project is to bring this vision to fruition. To support this endeavor, a roadmap has been developed, offering a comprehensive overview of the necessary steps to move towards this future vision.

4.2.1 Structure of the roadmap

Vertically
The roadmap progresses from left to right, moving towards the future vision. The roadmap is divided into three horizons, each focused on a specific goal:

Horizon 1: Research & optimization
In this horizon additional research will be conducted, including studies across multiple maternity wards in different hospitals, workflow observations, and alarm boundaries. Optimization is also a key focus, refining the Care Cloud concept and making necessary adjustments to related devices. By the end of this horizon, the Care Cloud will be fully developed and prepared for use.

Horizon 2: Pilot test
The goal of this phase is to pilot the designed monitoring system at three different maternity wards. This pilot test will evaluate the implementation of both the Care Cloud and the interim alternative (chapter 4.2.4) on a manageable scale. Feedback from this pilot will be used to improve the system and its implementation before moving to the next horizon.

Horizon 3: Implementing improved monitoring system
In this final horizon, the improved monitoring system will be implemented across all maternity wards in the Netherlands. The goal is to support care professionals in their work and provide reassurance to parents and nurses between visits.

Horizontally
The roadmap is structured horizontally into categories that outline the necessary steps to achieve the future vision while effectively addressing the identified problems in a user-friendly and impactful way.

Goal: The specific objective being addressed during each horizon, aimed to be achieved by its ending.
Actions: The key steps to be taken during each horizon.
Responsibilities: A clear allocation of tasks, indicating who is responsible for each action. Each horizon also has an initiator who takes the lead and monitors the progress.
Product-service system: Changes or additions to the product-service system, such as modified components, connection options, or new implementations.
User Value: The added value achieved for all three stakeholders—care professionals, parents, and neonates—during each horizon.

Categories that need further explanation are detailed below.

4.2.2 Actions

Some future actions are required for a successful implementation and reaching the future vision. Below, recommendations are presented in detail and in the order of their suggested initiation.

1. Maternity ward research
The project has primarily focused on the maternity ward of Reinier de Graaf Hospital in Delft. To ensure the generalizability of the results, it is recommended to conduct research on a broader scale. This involves examining the needs, workflows, technical systems, and room layouts at multiple hospitals. By gathering these insights, the implementation of the results of this project can be better aligned with the specific requirements of other hospitals and maternity wards.
Who: Healthy Start should take the lead, assembling a multidisciplinary team of care professionals, industrial designers, and students.
When: This should be the first step in the process, as it provides the foundation for future phases.

Further research on maternity wards:
Conduct more quantitative based in-depth research on the differences between various maternity wards before implementing the design. Each ward may have unique requirements, workflows, and challenges that need to be addressed to ensure the concept fits seamlessly into their specific environments.

2. Clinical research
To ensure the system functions effectively and achieves its intended outcomes, further clinical research is necessary.
Alarm boundaries: Research is needed to define appropriate alarm thresholds and trends. Alarms should only be triggered when specific trends occur over a certain period, minimizing unnecessary disturbances in the maternity ward. The exact parameters for triggering alarms and the timeframes for detecting these trends need to be determined.
Key indicators for infections: Identify the vital parameters most crucial for detecting infections (e.g., temperature, heart rate). Current devices, like the Bambi Belt, may need improvement or replacement to monitor these indicators effectively.
Who: Healthy Start should form a research team including medical professionals and scientists.
When: Short-term, during horizon 1, as this research is critical for the subsequent steps.

3. Improving technology
To achieve the future vision, technological improvements are necessary. This involves two approaches, which can either run sequentially or in parallel:
Short-term and budget-friendly approach:
Bambi Belt: Ensure the belt is suitable for multiple uses and can be sterilized effectively for hospital settings.
Monitors: Use existing hospital monitors, ideally those already available. These monitors should be configured with the determined alarm boundaries. To align with the project's vision, the monitors can be placed in enclosed cabinets within patient rooms, preventing parents from directly viewing the screens. This ensures the room maintains a calm and parent-friendly environment.

Long-term and vision-oriented approach:
Bambi Interface: Modify the interface to enhance usability within the Care Cloud. This includes repositioning the Bambi Bridge ports and indicator lights to be accessible and visible from the side of the Care Cloud.
Smaller monitor: To reduce the size and cost of the Care Cloud, consider a smaller, portable monitor. Explore partnerships with companies like Philips to develop a more compact device, potentially transitioning to a tablet-based solution in the future, which also offers greater flexibility and ease of use.
Who: Bambi Medical should take the lead in improving the Bambi Belt and Interface. Collaboration with technology companies, such as Philips, will be necessary for developing the monitor.
When: These improvements should follow the completion of maternity ward and clinical research.

4. Preparing care professionals
Hospitals and staff should be prepared for the implementation of the Care Cloud and the use of the Bambi Belt, as both are new technologies. Comprehensive training should be provided to strengthen adoption.
Who: Training experts from Bambi Medical are responsible for this phase.
When: Medium-term, starting in horizon 2.

5.Calculating outcomes of costs and workload management
To assess the extent to which this system impacts costs and workload management (the balanced distribution of work across systems and personnel), such as training care professionals, purchasing systems, transit times etc., factors will be calculated and evaluated during the pilot tests. The benefits and costs identified through this process can then be incorporated into the business case, which will be presented during the system integration consultation between Bambi Medical and the hospital, showcasing the financial and management outcomes of this solution.
Who: The multidisciplinary team from Healthy start.
When: During the pilot tests in horizon 2.

6. Developing predictive algorithms
To ensure that the Care Cloud also acquires predictive value, collaboration with an external party can be initiated. This party can assist in developing a predictive algorithm. In the future, this will allow us to determine whether a neonate is likely to develop an infection, based on measured values. The development of the predictive algorithm will run parallel to the implementation of the Care Cloud. The Care Cloud will start with the current technology, and once the algorithm is developed, or one from another external party is used, they will be integrated. This will ensure even faster detection of infection risks.
Who: AI experts.
When: Parallel to the pilot test, in horizon 2.

7. System integration consultation
To ensure that hospitals recognize the value of the system and to facilitate effective integration and adoption, it is essential to conduct system integration consultations with hospitals during the end second and third horizon. These consultations serve to initiate collaboration, clarify the benefits, and features of the product-service offering, and establish a designated point of contact. The maternity ward manager is responsible for the adoption and integration within that specific hospital, serving as a contact person for the other care professionals. This approach fosters mutual learning opportunities and accelerates the adoption and implementation process.
Who: Product manager form Bambi Medical and the maternity ward manager per hospital.
When: End of horizon 2 and during horizon 3.

8. Connection with file systems
Research has shown that nurses value having access to file systems directly from the patient room, allowing the data to be accessed on other devices, such as hospital computers. This functionality is particularly useful during shift handovers or consultations conducted away from the patient's room. It is recommended to integrate the Care Cloud with existing electronic health record systems, enabling direct data input. This could be achieved more effectively if the monitor transitions to a tablet-based system in the future.

Who: Bambi Medical is responsible and will have the collaboration with a technology companies, such as Philips.
When: This step should be addressed once the tablet-based monitor is developed and implemented.

4.2.3 Responsibility
The category responsibility is of great importance for the further implementation and development of this project. Knowing who is responsible enlarges the change of succeeding towards this future vision (Simonse, 2024). The actions are connected to the responsible party in the roadmap with connection lines. Complementary to this, there is one initiator responsible for the progress of each horizon, it is expected from the initiator to monitor the progress and provide guidance to other parties where necessary.

The implementation of this roadmap is carried out in a medical environment. This means that there will be multiple stakeholders from different organizations. Within health care there can be complex mutual relations sometimes. Such as diverse interests and priority, mainly about the financial consequences (Albayrak, 2024). Next to that there are resource constraints, conflicts of interest and complex regulations and policies. Those factors can be challenging and should be managed, led by the initiator and responsible parties of each horizon.

4.2.4 Product service system
Particular improvements or adjustments to the product service system are needed before implementation is possible.
Technical adjustments:
The Bambi Belt must be redesigned for reusable use. The belt needs to be cleanable to be sterile for the next neonate.
The Bambi Interface needs to be modified, the Bambi Bridge ports, and connection lights need to move to the side, since it is located on the side of the Care Cloud. To reduce the size of the Care Cloud, the Bambi Interface could be slimmer if possible.
The Care Cloud's housing should be optimized for mass production.
PDLC screen functionality should be seamlessly linked with ID authentication.

Interim budget and time friendly alternative:
Developing the Care Cloud within this time can be a challenge, design and budget wise. Therefore, a budget and time friendly alternative could be as follows: The Philips IntelliVue MX800 and the Care Cloud design can be replaced with a currently available hospital monitor. This monitor can be hidden in a basic enclosure, for example in a cabinet which can be secured. While less aesthetically pleasing, this option meets all design requirements, but this option needs less time to develop and is a more cost-effective because it uses current monitors and does not need the Care Cloud design.
This option is presented as an interim solution, it can reduce time and costs in the second horizon of the roadmap. This interim alternative still solves the problem and contributes to the future vision. Keeping in mind that the ideal goal is to develop the Care Cloud and implement this at every maternity ward. Hospitals can choose which (temporary) system they prefer in the second and third horizon.

4.2.5 Conclusion strategic roadmap
The roadmap outlines the path to achieving the future vision through three structured horizons. It begins with further research and the optimization of the Care Cloud concept, followed by pilot tests to evaluate the system in practice and refine it based on feedback. Finally, the improved monitoring system is implemented across all maternity wards. Each horizon outlines specific goals, with assigned responsibilities for the necessary actions. By incorporating all insights and results from the project, the strategic roadmap ensures a well-informed and strategic approach to successfully realize the future vision.

4.3 Feasibility, desirability, and viability

4.3.1 Feasibility

One of the main questions with any design result is: can it be done? The answer for the results of this project is: yes. The strategic roadmap breaks down the process into small, manageable steps. All necessary technologies already exist; they only need to be iterated or slightly changed to align with the design. An interim solution is also provided as a backup should the Care Cloud not be feasible within time or budget. This alternative also involves implementing the future vision—except for the physical Care Cloud—using an existing monitor without its custom casing, making it even more feasible in short term. However, even with minor adjustments, the Care Cloud is highly achievable. This innovative design introduces a disruptive approach to how monitors are displayed, with two operational modes that offer a new perspective. The prototype demonstrates how the design can work simply and effectively. As an option, even with existing technology, such as the Bambi Interface and current monitors, the system would function without adjusting the devices. The design might be slightly larger, but it remains highly feasible.

4.3.2 Desirability

Another key question is: does it address the key stakeholders' values and needs?
The results are carefully designed to meet the values and needs of all stakeholders. Data collection, stakeholder interviews, literature reviews, and design expertise have all been incorporated into the final outcome. This project goes beyond simply meeting user needs—it introduces a new way of working within the maternity ward by reducing worry between visits, improving workflow, and supporting intuitive decision-making. The close collaboration with stakeholders, particularly incorporating the perspectives of nurses and parents into the design, emphasized the importance of this approach and led to a more suitable design to their values and needs. Nurses highly valued their involvement in the design process, as it ensured their needs and desires were considered and integrated into the final design.

Evaluations revealed that nurses, pediatricians, other care professionals and parents support the idea. Many believe that continuous monitoring can help reduce worries during gaps in visits and ensure timely identification of infections through alarms. This would enable earlier treatment interventions. Parents expressed relief at the thought of their child being monitored, as reflected in interviews.

In addition, it can help reduce the workload of care professionals. According to Dye, et al. (2023): *"Manual monitoring is labor-intensive contribution to staff fatigue and increased workloads"*. This design can take over part of these tasks, while maintaining the clinical gaze as main priority. This design can also be applied on a larger scale and help other departments and conditions. The Care Cloud can be expanded with other indicators, such as temperature, and in the future, with algorithmic risk scores that are being developed.
This creates new value for working with continuous monitoring. As pediatrician 2 mentioned: "I can also see this Care Cloud used in other departments. Sometimes, with adults, we don't want them to see their own continuous data". This designed system could therefore be applied and add value outside its initial scope.

4.3 3 Viability

A critical aspect of any design is its long-term viability. Will it survive and succeed in the long run?
First of all, this design helps with quicker identification while satisfying the needs and wishes at the maternity ward. Infection risk at neonates and the global burden of bacterial antimicrobial resistance is a problem that will persist and grow in the future (Naghavi, et al., 2024). The Care Cloud supports the identification of the infection and reduces unnecessary antibiotic usage, therefor it has a high possibility of surviving and succeeding in long term usage. Besides the long-term usage at the maternity ward, the Care Cloud can also be used at other wards for continuous monitoring, this brings a new development for continuous monitoring to the broader health care domain.

Next to the theoretic long-term viability, it was also researched how the care professionals foresee the usage of this design in the future. Nurses shared varying reactions to the idea of integrating monitoring and screens. Some are already accustomed to continuous monitoring systems in the obstetric ward, while others expressed a need for training, and a few were hesitant about introducing screens to the maternity ward. This training is included in the roadmap to assure the adoption and long-term usage. As nurse 2 mentioned: *"Moet het weer even een soort gewenning worden dat er een scherm bij komt, als je dan eenmaal gewend bent dan denk ik dat je er ook prima mee werkt en mee kan omgaan."* Overall, the reactions of the nurses, pediatrician and parents were positive, and they can imagine the usage of the Care Cloud in the future.

4.4 Strategic implementation of this business case

To ensure the successful implementation and long-term use of the Care Cloud, the roadmap includes the action of system integration consultations. Two key parties—the product manager and the maternity ward manager of the respective hospital—will be appointed to oversee this process. Their division of responsibilities and being the point of contact within the hospital will facilitate the strategic implementation.
During the system integration consultations, discussions will focus on the system's costs, time savings, financial benefits, and impact on workload. These factors will be calculated in horizon 2 and added to the business case for consultations with hospitals. The main goal is to detect infections more quickly and improve the observation period. The associated benefits will be added to the business case, which will be reviewed with hospital management to secure their partnership for implementation. Besides the knowledge and consultations at the management level of the hospital, it is important to train the care professionals that will use this system. A training program provided by the trainings expert from Bambi Medical will help with a faster adoption and implementation of the designed system.

An additional part of the strategic plan can also outline potential future applications for the Care Cloud, such as other neonatal conditions, other age groups, different departments, and adding algorithmic risk scores. For example, it could be implemented in adult or pediatric wards where constant data visibility is not desirable for the patient, but access to such data is critical for the care professionals. The wireless design of the Bambi Belt adds further benefits, providing freedom of movement for patients. These possibilities will be further explored and added to the business case during future system integration consultations. Scaling the implementation beyond maternity wards could also contribute to the project's viability, ensuring it remains a valuable tool for monitoring in various hospital departments.

4.5 Added value for the companies

Next to the added values for the three focus areas, this project also created added value for the companies involved in this project. During the project, the possibility of introducing continuous monitoring at the maternity ward was explored. Through research and close collaboration with stakeholders, a solution was developed to integrate continuous monitoring in a practical way using the Care Cloud. The roadmap outlines how this can be further developed and implemented, particularly valuable for the two companies that were involved in this project:

Healthy Start:
Healthy Start's mission is: *"We aim to enable a healthy start for our children and youth by identifying opportunities and co-creating preventive strategies with partners, parents, and youth"* (Healthy Start, 2024). This project supports that mission by designing a new way to improve monitoring at maternity wards. Better monitoring allows infections to be detected earlier, leading to faster treatment and better outcomes for neonates. During the project there was close collaboration with care professionals and parents, as well as co-creation sessions to ensure a suitable solution. This project came forward from a use case from Healthy Start (chapter 1.1), the outcomes directly address and improve the problem they aimed to improve.
By building on this work, Healthy Start can increase its impact on parents, care professionals and neonates. Scientifically, improved infection detection supports antibiotic stewardship, and in the future, predictive algorithms could enhance early diagnosis even more. Furthermore, the strategic roadmap includes steps for Healthy Start's future work (actions), providing a direction for their continued efforts.

Bambi Medical:
This project also brings added value to the company Bambi Medical, whose goal is: "*Making babies' lives happier from day one by developing, testing and producing new technologies for the NICU, such as the Bambi Belt"* (Bambi Medical, 2023). Until now, Bambi Medical has mainly focused on NICUs, but this project explored the potential of using the Bambi Belt at maternity wards. If integrated with the Care Cloud, this could open a new market, increasing product sales and brand recognition. It aligns with the company's goal of improving newborn care, this project adds value to that societal goal with improving the care for neonates at risk of infection, and potentially other neonates in the future. Wireless monitoring and earlier infection detection, especially with future predictive algorithms, can significantly improve neonatal health and well-being, making their lives happier from day one. Part of Bambi Medicals goal is to develop, test and produce new technologies, the Care Cloud can be one of these new technologies. The strategic roadmap outlines how Bambi Medical can further develop and test the Care Cloud and how to implement it for use at the maternity wards. This allows for collaboration with hospitals, enabling their product to be sold and used in other departments than were they focus on now, thereby expanding their market reach.

Concluding

Discussion
Contributions
Limitations
Reccomendations
Conclusion

Discussion

Contributions

The importance of closely monitoring neonates at risk of infection has been researched before. Tesini (2022) stressed the importance of recognizing the infection as soon as possible. This project acknowledges this importance and explores possible ways of using continuously monitoring to help identifying this infection quicker.

Other studies have researched different forms of monitoring and its advantages, limitations and impact on nurses and parents. This project recognizes the tension between the socio and technical aspects of the systems and stresses the importance of a well-functioning interaction between the social and technical elements. It contributes to the social elements by improving the experience of the neonates, nurses, and parents at the maternity ward. Next to that the technical systems are redesigned to improve the use of the system and stimulate faster recognition of the infection.

The development and implementation of the Care Cloud are initially designed for the maternity ward for neonates at risk of infection. However, this result could be implemented in other wards within the hospital as well, especially due to its positive effects on the 'parent-friendly mode', in which the patient or its parents cannot see the constant data. This exposure can have several negative effects, according to Gross, Dahl, & Nielsen (2011): "However, constant exposure to health metrics can increase patient anxiety, especially if they misunderstand or misinterpret the data presented. Some patients may become fixated on minor fluctuations, leading to unnecessary worry." This project contributes to an innovative way of protecting parents from these negative effects and the Care Cloud can possibly be helpful to patients at other wards as well to protect them from continuous data exposure.

Limitations

While the study provided valuable insights, it was limited in scope. Due to its nature as case study, the project primarily focused on research and implementation within the maternity ward at Reinier de Graaf Hospital in Delft. As a result, the findings may not fully reflect the conditions or practices at maternity wards in other hospitals.

Most findings were based on interviews and observations, with some insights derived from just a few participants. Parental opinions were collected from five interviews, and some information came indirectly via care professionals. While many insights were confirmed through observations and interviews, further quantitative research is recommended to validate the results before broad implementation.

Another notable limitation of the study lies in its highly iterative and qualitative nature. This approach, while valuable for generating rich and nuanced insights, makes replication more difficult and increases the potential for biases. Although efforts were made to mitigate these biases through data triangulation, involving multiple researchers in the study could have further minimized subjectivity and enhanced the reliability of the findings.

Another limitation is the early decision to use the Bambi Belt as the wireless continuous monitoring device. While effective for measuring heart rate and respiratory rate, it does not (yet) capture other vital signs, such as temperature, which is a key indicator of infections (Sullivan & Fairchild, 2021). This lack can limit the monitoring's comprehensiveness and highlights the need to explore alternative devices in the future.

In summary, while the study has laid a strong foundation and provided valuable insights, the limitations highlight the need for further research and validation to ensure that the results can be confidently applied in broader contexts.

Recommendations

Exploration of other wireless monitoring devices:
Investigate alternative wireless monitoring devices. While the Bambi Belt served as the use case for this project, it only measures heart rate and respiration, which may limit its ability to monitor a broader range of vital parameters. Research has shown that temperature is a crucial indicator for detecting infections, yet this parameter is not currently monitored by the Bambi Belt. Future research could explore other wireless monitoring devices that could replace the Bambi Belt and better support the overall vision of continuous neonatal monitoring in maternity wards.

Care Cloud in shared rooms:
Nurses highlighted a challenge: infected neonates are often moved to the neonatology ward, separating them from their mothers. While neonatology provides specialized care, it lacks the integrated mother-and-neonate approach of maternity wards. A solution could be shared rooms using the Care Cloud, keeping mothers and neonates together during treatment. As nurse 1 noted: *"Precies ja, dat de baby bij moeder kan blijven, voor de moeder en kind binding, dus dan wel die gecombineerde kamers met een neonatologieverpleegkundige voor de baby en een kraamverpleegkundige voor de moeder."* Further work can dive deeper into this.

Parental concerns post-monitoring:
An issue identified during the research was the uncertainty parents may feel when monitoring is discontinued when the neonate is healthy enough to go home. After a period of continuous monitoring, transitioning to a phase where no monitoring is available can cause anxiety for parents. Further research should be conducted to explore how to address this issue and provide reassurance to parents during this transition phase.

Expanding monitor functions:
To further extend the features of the Care Cloud, additional indicators such as temperature and saturation meters can be considered. Additionally, algorithms that automatically calculate risk scores can be developed and integrated into the Care Cloud. This can be carried out in collaboration with Healthy Start, Bambi Medical, and a patient monitor company.

Project conclusion

This project explored the potential use of continuous neonatal monitoring in maternity wards, focusing on neonates at risk of infection. It highlights the importance of early detection and aims to reduce unnecessary antibiotic use. The collected data included stakeholder opinions, literature research, design principles, and other valuable insights, which were carefully integrated to ensure alignment with stakeholders' values and needs. The design goal addressed three focus areas: medical aspects, nurses, and parents, each with specific requirements based on research and close collaboration. This resulted in the project successfully addressing all the requirements and a strategic roadmap outlining the steps to achieve the future vision and the conceptualization of the Care Cloud. Both of which are grounded in extensive research conducted over this six-month project.

The project aimed to exceed expectations by introducing the Care Cloud for continuous neonatal monitoring at maternity wards. The advantages of the Care Cloud include early infection detection, reassurance between visits, parent-friendly design, seamless data access, enhanced workflow, and its portable design. Importantly, the Care Cloud is designed to support the clinical gaze and maintain personal patient contact, which remain top priorities (Parreira, et al., 2021). Moreover, this design has the potential to reduce the workload of care professionals. As Dye, et al. (2023) state: *"Manual monitoring is labor-intensive and contributes to staff fatigue and increased workloads."* By automating certain monitoring tasks, the Care Cloud could reduce workload while ensuring that the clinical gaze remains central to patient care. It also addresses concerns as gaps in between visits, explaining gut feeling and unnoticed deterioration, about the intermittent approach (Alasad & Abu Tabar, 2003). Furthermore, the design ensures pleasant experiences by minimizing sensory overload through alarms to enhance the overall experience for both care professionals and parents (Cvach, 2012).

The strategic roadmap outlines all the necessary steps to achieve the future vision within three horizons and supports a successful implementation. The steps are divided based on the categories and responsibilities of different parties. The Care Cloud is a highlighted design within this roadmap. However, the roadmap is adaptable: if budget or time constraints prevent the full development of the Care Cloud, a more cost-effective and time-friendly interim solution can be implemented in the meantime. This alternative would still enable continuous monitoring in a nurse-and parent-friendly manner, increasing the feasibility of implementing the project.

This project emphasized the importance of integrating the perspectives of different stakeholders and amplifying the voice of nurses to drive the development of this design, it stresses the importance of including the user in different design stages. This project generated significant value for the three focus areas, as well as for Healthy Start and Bambi Medical, by introducing continuous monitoring in maternity wards through the Care Cloud. It aligns with the goals of both organizations, supports early infection detection, and creates new market opportunities for Bambi Medical. The results and strategic roadmap provide concrete steps for further development and implementation. When fully executed, the roadmap and the Care Cloud will provide significant benefits to all key stakeholders and beyond.

In conclusion, this project has made significant progress towards achieving the initial vision and goals. Moving forward, it is time to follow the strategic roadmap to ensure effective implementation and long-term success!

Values for the three focus areas:

Medical aspects:

- Quicker identification, can be integrated with predictive algorithms, enables timely start of treatment if necessary.
- Avoids unrecognized deterioration of the neonate's condition.

Nurses:

- Reduced worries between the intermittent visits.
- The data can support explaining their gut feeling to pediatricians.
- Quick access to patient data with the ability to review historical records.

Parents:

- Reassuring feeling knowing their child is continuously monitored.
- Prevents parents from fixating on the screens with data.
- A parent-friendly looking design that includes a nightlight.

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Appendices
Appendix A: Design brief

DESIGN FOR our future

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME
Complete all fields and indicate which master(s) you are in

Family name	Sanders	7304	IDE master(s)	IPD		Dfl		SPD	✔
Initials	K.M.		2nd non-IDE master						
Given name	Karlijn		Individual programme *(date of approval)*						
Student number			Medisign						
			HPM						

SUPERVISORY TEAM
Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Sylvia Mooij	dept./section	Dos / RMCB
mentor	Kim Boltjes	dept./section	Dos / Dive
2nd mentor	Justien Dingelstad		
client:	Healthy Start		
city:	Delft/Rotterdam	country:	Netherlands
optional comments	TU Delft, Erasmus University Rotterdam and Erasmus MC join forces in Convergence.		

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Sylvia Mooij - IO — Digitally signed by Sylvia Mooij - IO Date: 2024.08.29 13:35:42 +02'00'

Name Sylvia Mooij Date 29082024 Signature

CHECK ON STUDY PROGRESS
To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total ____ EC

Of which, taking conditional requirements into account, can be part of the exam programme ____ EC

★	YES	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Rik Ledoux 2024.08.30 08:59:33 +02'00'

Name Rik Ledoux Date 30-8-24 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen — Digitally signed by Monique von Morgen Date: 2024.09.03 09:20:21 +02'00'

Name Monique von Morgen Date 3/9/2024 Signature

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Name student Karlijn Sanders **Student number**

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

Project title Improving the experience for nurses and/or parents by continuous monitoring at the maternity ward

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)

The client for this project is Healthy Start. Healthy Start is a collaboration of multiple organizations (figure 1). The goal of Healthy Start is: "to realize scientific and societal impact – focused on prevention and intervention – to improve physical, mental and social health of children and adolescents.". "Within Healthy Start we explore the early-life origins of disparities in health and wellbeing from a transdisciplinary perspective. In this way we can identify early-life opportunities." (Healthy Start - Convergence, 2024)
This project is also about early-life opportunities, with focus on newborns with a risk of life-threatening bacterial infection (sepsis). It is difficult to identify possible bacterial infection. A possible tool to help with monitoring this sepsis risk can be the Bambi Belt. Bambi Belt is a non-invasive product that can wirelessmonitor the vital signs. Prior to this graduation project I performed an explorative research project on barriers and facilitators for using the Bambi Belt for monitoring risk of sepsis within three potential future use cases.
I decided to focus on the use case of newborns at the maternity ward with a high risk of infection (figure 2), where monitoring is now done by a nurse who monitors the newborn manually every three hours. During this project I will explore how nurses and parents experience this and how the concept of continuous monitoring could influence their experience. I will focus on creating solutions to improve the experience for nurses and/or parents. It is important that the (main) stakeholders are satisfied. The main stakeholders of this project are the nurses, Bambi Medical and parents. They all have different wishes and requirements. There are many different parts to consider during this project. For example; interaction, responsibility, workload, organizational changes and shifts in various fields.

Healthy start - convergence. (2024, 27 juni). Convergence. https://convergence.nl/healthystart/

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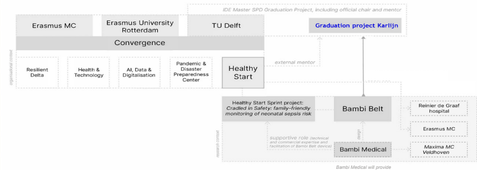

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DESIGN FOR our future

TU Delft

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)

Prior to this graduation project I performed an explorative research project. During this project a lot of themes and barriers around this topic became clear to me. I decided to focus on the use case of newborns at the maternity ward with a high risk of infection (figure 2). The current way of monitoring here is done by measuring values manually every three hours. Within three hours a lot can happen when there is risk for life-threatening bacterial infections. There can be a lot of uncertainty for parents in the meantime. For life-threatening bacterial infections it is important to determine the infection as fast as possible. The problem is that manual measurement is only measured at one moment, every three hours. There is no data within, which can lead to slower determination and uncertainty. I want to explore how the experiences will change for nurses and parents when continuous monitoring with the Bambi Belt would be introduced at the maternity ward. At the moment the maternity ward is not equiped and used to continuous monitoring. I hope to add value for the experiences of nurses and/or parents at the maternity ward.

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 roadmap to generate an overview of the steps that are needed for improving the experience for nurses and/or parents around contineously monitoring with the Bambi Belt at the maternity ward. Elaborating this with designing a concept for one specific challenge of the roadmap. This will show the concept of how continuous

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)

For this project I will use the triple diamond approach (Marin-Garcia et al., 2020).
1. (Discover the underlying problems); I will conduct research to understand the context and the stakeholders. I will do this with in-depth interviews, observations and possible other qualitative research.
2. (Define the main problems); I will create a future vision and define the focus on which main problems I will try to solve. Possible with creative sessions.
3. (Development of roadmap); I will create a roadmap in which the steps are visible that need to be taken to reach the future vision. I will create steps/solutions for this roadmap with help of creative sessions with stakeholders.
4. (Deliver); At the end I will deliver the final version of the roadmap.
5. After the roadmap I will choose one challenge and proceed with ideation for solutions.
6. From those ideas I will design one concept for one specific solution. This concept will be helpful to demonstrate and conceptualize a part of the roadmap.

Marin-Garcia, J. A., Garcia-Sabater, J. J., Garcia-Sabater, J. P., & Maheut, J. (2020). Protocol: Triple Diamond method for problem solving and design thinking. 11(2), 49–68. https://doi.org/10.4995/wpom.v11i2.14776

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	19-08-2024
Mid-term evaluation	17-10-2024
Green light meeting	16-01-2025
Graduation ceremony	14-02-25

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	23
Number of project days per week	4.5

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)

Appendix B: Personal approach

In addition to the academic framework, a personal approach was also incorporated into the project.

Vision
From the moment I applied for this graduation project, I felt a strong connection to its vision. I deeply believe in the importance of improving neonatal care and was motivated to turn this vision into reality. My alignment with the vision gave me focus and determination throughout the project.

Personal Touch
I gain energy and inspiration from working with people, so I integrated this into my project approach. I scheduled numerous interviews, observation days, meetings with experts, and co-creation sessions. These interactions not only inspired me but also helped drive the project towards meaningful results.

Structure
Having a clear structure and planning was valuable for me. Before the project started, I created a detailed timeline with milestones for all six phases. I also set personal interim deadlines to track my progress and ensure I stayed on course. Each Friday, I created a more detailed plan for the following week. This structured approach was instrumental in managing my first large, independent project.

Reflection
Reflection played a key role in refining the project approach. By regularly reflecting on my experiences and progress, I was able to make adjustments where necessary. This helped ensure the project stayed on track while maintaining my own engagement and enthusiasm.
This combination of academic structure and personal touches allowed me to approach the project in a way that was both methodical and inspiring.

Appendix C: More information about future forms of monitoring

Continuous monitoring with algorithms and predictive analytics

The most advanced form of monitoring involves the use of algorithms and predictive analytics. These systems do not merely monitor current vital signs, but they have incorporated algorithms and predictive analytics to detect patterns and predict clinical deteriorations before they become critical (Ruminski, et al., 2018). By using machine learning and artificial intelligence (AI), these systems can recognize patterns and trends that may not be immediately apparent to human observers.

Limitations: The effectiveness of these systems depends on the quality of the data and the accuracy of the algorithms (Ruminski, et al., 2018). There is also a risk of over-reliance on technology, which can lead to complacency among care professionals if not properly managed.

Advantages: Predictive monitoring systems can significantly improve patient outcomes by enabling preemptive interventions. They are particularly valuable in settings like surgical wards, where early detection of complications can be life-saving (Leenen, et al., 2021).

Remote and wearable monitoring

Remote monitoring involves the use of wearable devices that patients can carry with them, sometimes even after being discharged from the hospital. These devices continuously track vital signs and transmit the data to care professionals, allowing for possible continuous monitoring outside the hospital environment (Liao, Thompson, Peterson, Mandrola, & Beg, 2019).

Limitations: The reliability of remote monitoring depends on the technology's accuracy and the patient's adherence to wearing the device. Additionally, there are concerns about data privacy and the potential for technology failures (Choi & Walker, 2019).

Advantages: The wearable is remote, so there is more flexibility for moving around and the possibility of remote monitoring outside the hospital (Liao, Thompson, Peterson, Mandrola, & Beg, 2019).

Continuous monitoring with algorithms and predictive analytics
Impact on patients and/or parents:
Predictive analytics enables more proactive interventions, which means that faster intervention is possible. Worse conditions can be prevented with predictive analytics which can have an impact on the physical condition of the patient (Leenen, et al., 2021). However, many predictive systems function as “black boxes,” meaning that patients and/or parents are often unaware of how or why certain decisions are made. This lack of transparency can lead to distrust, particularly if the system recommends interventions that seem unnecessary from the patient’s perspective (Topol, 2019).

Impact on care professionals:
For care providers, predictive systems offer valuable clinical insight, reducing cognitive load by alerting them to potential problems before they become apparent through traditional monitoring methods (Ruminski, et al., 2018). This allows for earlier and more targeted interventions. However, over-reliance on predictive algorithms can result in a decrease in clinical intuition and observational skills. Care professionals may begin to rely too heavily on data, potentially overlooking critical patient cues that are not captured by the technology.

Remote and wearable monitoring
Impact on patients and/or parents:
Remote monitoring allows patients to maintain their independence, while still benefiting from continuous healthcare oversight (Tan, Sumner, Wang, & Yip, 2024). This can significantly improve quality of life for patients with chronic conditions who want to avoid frequent hospital visits (Liao, Thompson, Peterson, Mandrola, & Beg, 2019). Patients can be more comfortable in their own environment instead of the hospital. Despite the advantages, remote monitoring raises concerns about data privacy. Patients may feel uncomfortable with the continuous collection of personal health data and fear potential breaches of sensitive information (Choi & Walker, 2019).

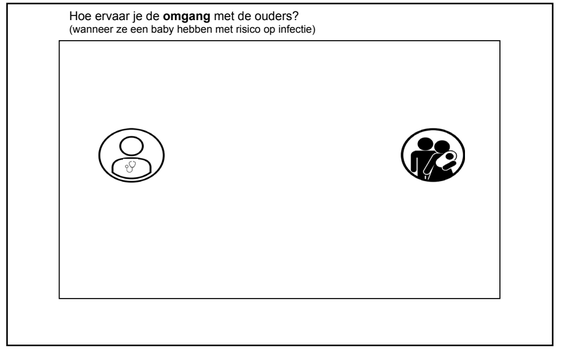
Impact on care professionals:
For clinicians, remote monitoring allows for the management of a larger number of patients over greater distances. Which can lead to less physical pressure in the hospital. There are less patients to physically visit or provide care for within the hospital (Liao, Thompson, Peterson, Mandrola, & Beg, 2019). However, remote systems often generate vast amounts of data, leading to data overload for healthcare providers, who must filter out the noise to identify critical trends and abnormalities (Rashidi & Cook, 2013).

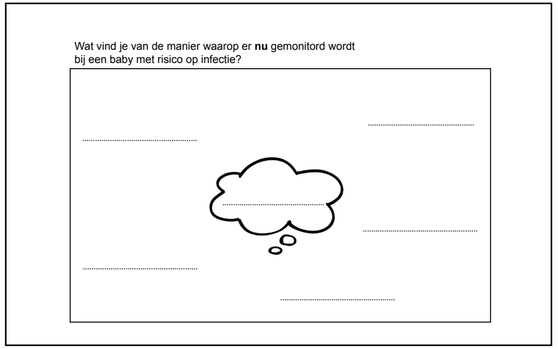
Future forms of monitoring
Next to the above explained forms of monitoring, there are also forms of monitoring that can be (complementarily) used for this goal in the future. Such as continuous monitoring with algorithms and predictive analytics to detect patterns and predict clinical deteriorations before they become critical (Ruminski, et al., 2018). By using machine learning and artificial intelligence (AI), these systems can recognize patterns and trends that may not be immediately apparent to human observers. A limitation of this is that the effectiveness of these systems depends on the quality of the data and the accuracy of the algorithms (Ruminski, et al., 2018). Next to that they need to be precise enough to capture the context of an individual, which requires a lot of data and parameters, resulting in complex systems. Developing these systems takes a lot of time and money. There is also a risk of over-reliance on technology, which can lead to complacency among healthcare providers if not properly managed. But the advantage of predictive monitoring systems is that it can significantly improve patient outcomes by enabling preemptive interventions. They are particularly valuable in settings like surgical wards, where early detection of complications can be lifesaving (Leenen, et al., 2021).

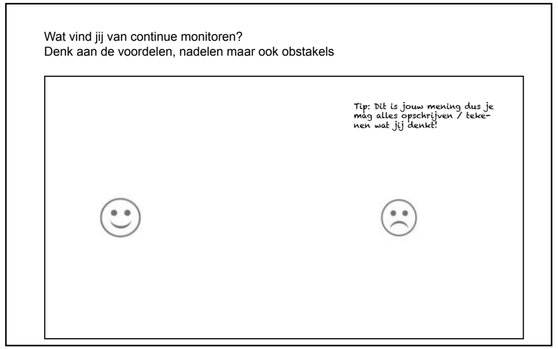
Another form of monitoring that can be explored in the future is monitoring from home. These remote devices continuously track vital signs and transmit the data to care professionals, allowing for possible continuous monitoring outside the hospital environment (Liao, Thompson, Peterson, Mandrola, & Beg, 2019). A big disadvantage is the lack of clinical gaze and fast response from care professionals.

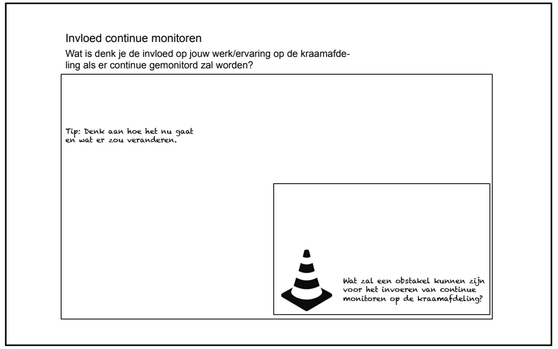
For the scope of this project, these future forms of monitoring are a step too far ahead. This project focusses on introducing new way of a currently developed monitoring device at the maternity ward, when this works properly within the hospital, future possibilities can be explored.

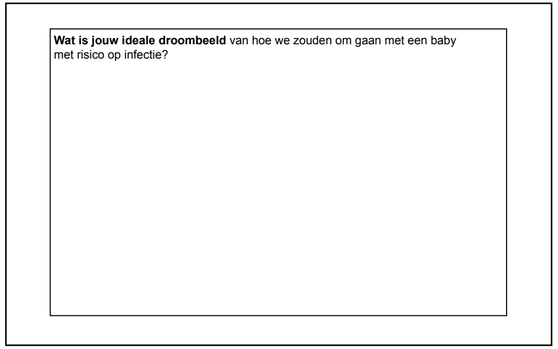
Appendix D: Booklet











Appendix E: Topic guide expert interview

Goal: Describing how thing are currently in the maternity ward, what their experiences are and opinions about continuous monitoring.
Introduction: About graduate student, the project, recording consent
Their role: What is their job, what activities, where
Infection: Can you describe the situation, feelings, what do you want to change? Experience between 3 hours
Continuous monitoring: their opinion in general, and at maternity ward
Bambi Belt: introduction, first impression, opinion about it
Wrap up: extra things they want to add? Who to speak to next?

Appendix F: Stakeholders

Stakeholder overview

With the project vision clarified, the context and Bambi Belt thoroughly explained, it is now essential to outline the stakeholders involved in this process. Understanding the key stakeholders and their roles will help direct the focus for the rest of the project and determine who will be closely collaborated with throughout.

To illustrate this, a stakeholder map has been created. This map categorizes stakeholders into four quadrants based on their level of influence and interest in the project. The quadrant in which each stakeholder is placed indicates the extent of collaboration required during and, if relevant, after the project.

Client
The client for this project is Healthy Start. Healthy Start is a part of Convergence, which is a collaboration of multiple organizations (figure X). TU Delft, Erasmus University Rotterdam and Erasmus MC join forces in Convergence. They combine their strengths, knowledge, and methods to address societal challenges. A direction of Converge is Health, which Healthy Start is working in. The goal of Healthy Start is: "to realize scientific and societal impact - focused on prevention and intervention – to improve physical, mental and social health of children and adolescents.". "Within Healthy Start we explore the early-life origins of disparities in health and wellbeing from a transdisciplinary perspective. In this way we can identify early-life opportunities." (Healthy Start, 2024)

Prior to this graduation project there was a research project conducted by the graduate student, Karlijn Sanders. This project was initiated by researchers from Healthy Start. During this research project three use cases, chosen by Healthy Start, were researched, and explored. After finishing the research project, the context for this graduation project was shaped together with the client and graduate student.

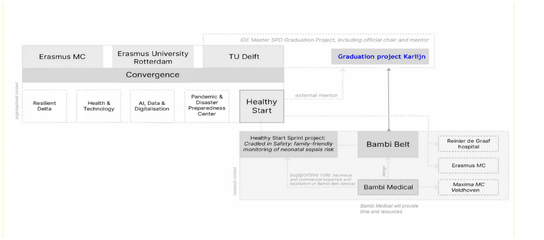


Figure F.1: Overview of involved organizations and within Healthy Start

Stakeholders

This graduation project is carried out in a medical environment. Which means that there will be multiple stakeholders from different organizations. Within health care there can be complex mutual relations sometimes. Such as diverse interests and priority, mainly about the financial consequences (Albayrak, 2024). Next to that there are resource constraints, conflicts of interest and complex regulations and policies. Those factors can be challenging and should be managed by taking care of all the stakeholders. For this project there has been decided to focus on two main stakeholders:

1. Care professionals (maternity care nurses, pediatrician, midwife)
2. Parents

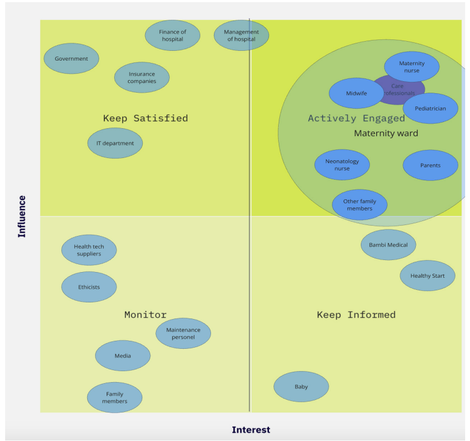


Figure F.2: Stakeholder map based on influence and interest.
These main stakeholders have been placed in the framework (Schuurman, 2019) based on their interest and influence in (and possibly continuation of) this project. The relationship between interest and influence determines the extent of which stakeholders to work with very closely or whom can be informed from a little bit more distance. To manage all the main stakeholders there has been a framework created to know how to strategically manage the stakeholder groups.

The quadrants in this framework with the stakeholder management strategies are as following; Bottom left: strategy; Monitor; Top left: strategy; Keep satisfied; Bottom right: strategy; Keep informed; Top right: strategy; actively engaged.

Approach stakeholder groups:
During the project it became evident that it is important to balance the interests of the stakeholders. To give this a sense of direction there has been decided to focus mainly on the top right part “the actively engage” stakeholder group. This stakeholder group will have influence on the development and possible implementation of the project. Within this part there are key stakeholders. For this project the 2 key stakeholders are:

1. Care professionals (maternity care nurses, pediatrician, midwife).
2. Parents

The second stakeholder group to focus on during the project is “Keep informed”. They are also an important stakeholder group in and after the project. The client Healthy Start and Bambi Medical are in this stakeholder group. They have a lot of interest, and their opinion will be highly valued during the project. They will be actively engaged as well. Their wishes will be considered during the project, this can influence the outcome. But their requirements will probably only be carried out they align with the main stakeholders named above.

Stakeholder strategies per quadrant

Bottom left: strategy; Monitor
This group has low influence and low interest in the success of this project. During the project they are monitored and evaluated every now and then whether any changes have occurred. It could be that people from this group shift to one of the other stakeholder groups.

Top left: strategy; Keep satisfied
This stakeholder group has not a lot of interest by this project, not in a positive but also not in a negative way. But they do have influence. This is why it is important to keep them satisfied. As long as this group of stakeholders is satisfied, they usually don’t interrupt. It is important to tell them what the (positive) influence of the project will be for factors that are important for them.

Bottom right: strategy; Keep informed
The stakeholder management strategy with this group is to proactively inform them. This group has relatively little influence to intervene or really change things. These stakeholders often need formal processes, procedures, or complaints to get things moving. They should be involved in the development of this project. It is important to make sure that this group proactively will be met during the project. This group is important to interact with and collect feedback.

Top right: strategy; actively engaged
This stakeholder group not only has interest in this project, but they can also strongly influence the outcome. They can influence the possible implementation or success of the project. During this project there will be actively engaged with this stakeholder group. This will be done with informing, actively involving, giving them a voice, and let them decide things. Together there will be decided what is important during the project. The strategy to actively engage this stakeholder group will be enhanced with the creative sessions. Nevertheless, other stakeholders who are a bit further outside the scope of this project, such as the government, regulatory bodies, salesforces, media etc. Should be analyzed for a smooth implementation after this graduation project.

Appendix G: take aways for redefined problem definition:

Based on the main insights from the research phase, the initial problem definition and the insights led to the redefined problem definition.

Take aways early onset neonatal infection.

- **Prompt recognition is critical**: Early-onset neonatal infection must be identified as soon as possible to avoid severe complications like sepsis.
- **Challenges in early detection**: Due to the varied symptoms of neonatal infections, identifying them in early stages is often difficult, requiring vigilant observation.
- **Close monitoring is essential**: Neonates at risk of infection should be closely monitored to detect signs of infection quickly, allowing for timely intervention. (**Neonate needs to be monitored closely to rapidly identify the infection.**)
- **Antibiotic treatment has significant risks**: While antibiotics are necessary for confirmed infections, they can negatively impact a neonate's immune system, increase the risk of certain health issues later in life, and contribute to antibiotic resistance.
- **Antibiotics should be used only when necessary**: Decisions to initiate antibiotics are based on specific frameworks with risk- and clinical indicators to minimize unnecessary exposure.

Take aways forms of monitoring.

- **Clinical gaze supports monitoring:** Clinical gaze is a foundational element and usually used alongside other monitoring types. It's essential for personalized care, as it incorporates the healthcare professional's intuition and experience.
- **Manual monitoring gaps:** Intermittent time between manually monitoring intervals can delay the detection of acute deterioration, making it less suitable for critically ill patients (Fieselmann, Hendryx, M.S., & Wakefields, 1993).
- **Real-time response with continuous monitoring:** Continuous monitoring provides real-time data and quick alerts, enabling prompt intervention for critical changes in a patient's condition.
- **Centralized vs. bedside monitoring balance:** Centralized monitoring improves efficiency by displaying multiple patients' data in one location but may reduce direct caregiver-patient interaction. Bedside screens, however, allow for quicker, personalized response but can lead to information overload and patient anxiety.
- **Bambi Belt as continuous monitoring:** The Bambi Belt is a form of continuous monitoring. It has roughly the same features as the current way of wired continuous monitoring, but it brings advantages for freedom of movement and interaction.

Take aways findings field research.

- **Challenges in current monitoring**: There are long intervals between checks, making it hard to know what happens in between. Nurses also struggle to explain their gut feelings to pediatricians when they sense something is wrong.
- **Improved trend detection with continuous monitoring**: Continuous monitoring provides more data over time, making it easier to identify trends and detect deterioration earlier compared to single snapshots during manual checks.
- **Balancing focus between mother and neonate**: Nurses worry about continuous monitoring might shift attention solely to the neonate, neglecting the mother's needs in maternity wards.
- **Staffing challenges with continuous monitoring**: Continuous monitoring requires more resources, and care professionals fear they lack enough staff to manage central screens and extra tasks effectively.
- **Parents' perspective on data transparency**: Parents appreciate knowing their baby is being monitored but often prefer not to see all the data themselves, as it can lead to unnecessary worry.
- **Importance of personal interaction**: Both parents and care professionals value personal contact during monitoring. This interaction reassures families and helps healthcare workers maintain a human connection despite technological advances.

Appendix H: Elaboration of requirements design goal

Medical requirements	Explanation
Clear overview of continuous data, with possibility to see the history of data	It is important that a clear overview of continuous data is presented. This can help with detecting the infection. The Bambi Belt (case study) measures vital signs like heart rate and apnea detection (breathing) (Bambi Medical, 2023). The design requirement is that the design will have an opportunity to clearly see this data and have the opportunity to go back into the history.
Stable flow of continuous data should make spotting trends possible.	There should be a stable flow of continuous data to help spotting trends. Trends will provide information over time, which helps detecting the infection faster (care professional interview 1).
Improve response time to detect the infection.	A take away from the research phase was that "**Prompt recognition is critical**: Early-onset neonatal infection must be identified as soon as possible (chapter 2.2). The design should help with preventing this deterioration, and thus should decrease time to start treatment.
Decrease time to start treatment when there is an infection, which helps preventing deterioration.	A take away from the research phase was that "**Prompt recognition is critical**: Early-onset neonatal infection must be identified as soon as possible (chapter 2.2). The design should help with preventing this deterioration, and thus should decrease time to start treatment.
Maternity ward is for providing care for both mother and neonate, the design should help remain this	The maternity ward is intended to provide care for both mother and neonate. A design requirement as that this must remain, not all the care should go to the neonate. The mother is also important. As described in the research: *"Ik ben dan heel erg bang dat er heel veel tijd naar de baby'tjes toe gaat, wat soms ook ten onrechte is. En dat daardoor de moeder minder aandacht krijgt, terwijl ze verblijven juist op de kraamafdeling omdat moeder ook zorg nodig heeft.: 3:13 ¶ 61 in Interview 2.docx*

Nurse-friendly requirements	Explanation
Continuous monitoring should reinforce the gut feeling as part of the clinical gaze.	One of the problems that came forward from the interviews with nurses is that they find it sometimes difficult to explain their gutfeeling to the pediatrician. In the current situation the visit of the pediatrician is a snapshot which not always presents the whole situation. The design of continuous monitoring can help showing data from the previous hours to help reinforce their gut feeling. This can help them convey their gut feeling and clinical gaze to the pediatrician.
Provide reassurance between visits.	The current way of monitoring is based on visits with an interval of 3 hours. The field research pointed out that nurses are sometimes worried about the health of neonates in between their visits. They are between closed doors and no one is observing them. One of these worries is " Wat als hij na 1 minuut opens slecht gaat". This design requirement will help to provide reassurance between those visits.
Avoid extra shifting from neonatology ward to maternity ward because of monitoring possibilities.	One of the worries that came forward from the interviews with care professionals is that they do not want extra neonates shifting to the maternity ward when they are going to use continuous monitoring. They are worried that other departments might think that they can monitor more neonates, also ones that currently do not belong at the maternity ward.
Avoid unnecessary interruption of the environment on the ward due to alarms.	At the moment the maternity ward is quite relaxed regarding alarms. Most care professionals mentioned that they want to avoid that the maternity ward will be changed into a neonatology ward regarding all the interrupting alarms one hears there.

Parent-friendly requirements	Explanation
Monitoring should not look too medical.	The current atmosphere at the maternity ward should not be affected too much with a way of monitoring that looks too medical.
Not affecting current situation parent child interaction.	The current interaction between parents and their child should remain. They should be able to maintain the independence more or less the same as they have now.
Not restricting parents' freedom of movement.	To help parents with their independence in care and their interaction it is important to not restrict their freedom of movement within the personal room too much.
Avoid giving parents extra stress.	Parents are usually overwhelmed with their emotions of their newborn and right after the birth. The design should avoid giving extra stress to the parents.
Avoid overly clinical appearance in personal room.	It should be avoided that the design has an overly clinical appearance in the personal room. It is also a room where family can visit. *"Met draden oogt zieker. Dan dat je gewoon een gezonde pasgeboren hebt met net even een aandachtspuntje. Het oogt gelijk heftiger voor foto's, broertjes, zusjes, wat dan ook al die plakkers oogt gewoon meer medisch, ja.En dat wil je voorkomen."* 5:16 ¶ 85 in Interview 4.docx Avoid overly clinical appearance at the maternity ward, especially in their personal room.

Appendix I: Tables of evaluated ideas

Table I.1: Ideas for location solution

Idea for location device	Explanation	Staff friendly score	Family friendly score
hallway Above / next to the Door	A small device placed above the door, angled toward the hallway, so nurses can check data before entering the room. It remains out of parents' line of sight, preserving the room's calm ambiance.	✅Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting ❌ Not interrupting environment 1,5/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress 🟰 Avoid clinical look 4/5
On the Crib Frame (Inside Edge)	Positioned on the inside edge of the crib frame, this placement allows nurses to lean over and check data directly, while the device remains invisible to parents standing back.	✅Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ❌ Not interrupting environment 2/4	❌ Monitoring should not look too medical. 🟰 Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 1/5
Corner Wall Mount (Near Ceiling):	A small, discreet screen placed high in a corner near the ceiling. Nurses can see it from the door or within the room, but it's subtle enough not to draw parents' attention.	✅Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2,5/4	❌ Monitoring should not look too medical. 🟰 Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 1,5/5
Room plan, private space and viewing direction	There can be a new room plan, where there is more private space for the parents and the data will be displayed in the viewing direction of the nurse. Screens will be in the viewing direction.	✅Reinforce gut feeling 🟰Worries about health neonate 🟰Avoid extra shifting 🟰/✅Not interrupting environment 2,75/4	🟰 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress 🟰 Avoid clinical look 3,5/5
In the room, but only visible with nurse	The location of the device will be in the personal room. It will only be visible when the nurse is present. headsup display in the window, only visible from a specific perspective, like in the car only for the driver.	✅Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ✅ 🟰Not interrupting environment 2,75/4	✅/❌ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress ✅/❌ Avoid clinical look 4/5
Centralized place nurses	In the central nurse room the data will be visible on a screen. There is always 1 person present at this place. Parents usually do not come in this area.	✅Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting 🟰/✅Not interrupting environment 2,75/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ❌ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Portable screen (goes with nurse)	A small, portable with a screen facing the nurse's direction, kept near the crib. This portable screen can be rotated or positioned by the nurse without drawing the family's attention.	✅Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting ✅ Not interrupting environment 3/4	🟰 Monitoring should not look too medical. 🟰 Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4,5/5

Table I.2: ideas for data translation

Idea for data translation	Uitleg	Staff friendly score	Family friendly score
Smiley	An emoji can explain the health condition of the neonate, a sad face for bad condition, an sick emoji for super bad condition and happy emoji for good conditions.	🟰Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4,5/5
Color changing	The data can be translated into different colors to explain the health condition. Fore example blue light = calm yellow light = alarming try to avoid red (alarming) option: A "firefly" glow that moves between three zones (green for calm, yellow for attention, red for high alert) as a quick visual reference	🟰Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2/4	✅/❌ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress 🟰 Avoid clinical look 3,75/5
Number 01-10	The health data can be translated into a number. Ranging from 1-10 . For example 10= perfect condition and 1 = very bad condition.	✅Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting 🟰 Not interrupting environment 2,5/4	❌ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 2/5
Childish animation of total health condition	Digital pet, sleepy bunny on a screen that breathes along with the baby to show heart and breathing rate (or jumping a live). option: blooming flower animation A flower graphic that opens fully when vitals are steady and relaxes closed if vitals are less stable, giving a peaceful visual cue. option: A virtual plant that grows healthier or wilts slightly, symbolizing the baby's condition, giving parents a soft, nurturing visual.	❌Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress ✅ Avoid clinical look 4,5/5
Breath-Responsive Clouds and forest scene	A set of clouds that float on a screen and gently expand and contract with each breath option A small animated forest scene with swaying trees or a gentle breeze, indicating the baby's breathing and heart rhythm.	❌Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Graphics with numbers	The same as used on the monitors at the moment at neonatology ward. With graphics and numbers visible.	✅Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting ❌ Not interrupting environment 2/4	❌ Monitoring should not look too medical. 🟰 Maintain parent-child interaction ❌ No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 1/5
Option for switching between modes	Depending on the wishes and knowledge of the parents, the modes of translating data can be switched.	✅Reinforce gut feeling ✅Worries about health neonate 🟰Avoid extra shifting ✅ Not interrupting environment 3,5/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress ✅ Avoid clinical look 4,5/5

Table I.3: Ideas for warning nurses

Idea for warning nurses	Explanation	Staff friendly score	Family friendly score
Vibration wearable	A smartwatch or wristband gives a subtle but distinct vibration pulse pattern unique to the type of alert, such as a faster pattern for breathing issues or a steady, slower pulse if the parents press the call button. option: ripple / heartbeat vibration different rhytm, check screen after	- Reinforce gut feeling ✅Worries about health neonate ✅Avoid extra shifting ✅Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Color-Coded Lamp with Gentle Flashing: in room	A small, color-coded light in the room softly pulses in different colors for different issues (e.g., red for a breathing alert, blue for a call button) and doesn't flash continuously to avoid causing stress Option: projection instead of light	- Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting ✅Not interrupting environment 1/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress 🟰 Avoid clinical look 3/5
Lamp notification as wearable (as croc) **Option: on uniform nurse**	A small, color-coded light as wearable softly pulses in different colors for different issues (e.g., red for a breathing alert, blue for a call button) and doesn't flash continuously to avoid causing stress	- Reinforce gut feeling ✅Worries about health neonate ❌Avoid extra shifting 🟰 Not interrupting environment 1,5/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4/5
Glimmering Light Wall Panel in nursing station:	A softly glowing light panel in nursing station that twinkles gently when there's an issue, with intensity indicating the alert's urgency.	- Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Scented Aroma Alert:	For non-urgent cases, a light scent, like lavender, could be released at the nurse's station to prompt them to check in without any audio or visual disruption. More urgent scents like peppermint could be used in critical cases.	- Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting ❌ Not interrupting environment 1/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4,5/5
Visual alarm light directly outside of personal room	A softly glowing light panel in hallway outside personal room that twinkles gently when there's an issue, with intensity indicating the alert's urgency.	- Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2/4	🟰 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4,5/5
Audiotorial alarm in room	Alarming sound in personal room, Alarm is only hearable in the room, and not in the hallway or cenral room.	- Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting ❌ Not interrupting environment 1/4	❌ Monitoring should not look too medical. 🟰 Maintain parent-child interaction ❌ No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 1,5/5
Audio alarm hand helt	The audio alarm will be hearable for the nurse and the people around her (already in use at maternity ward)	- Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting ❌ Not interrupting environment 1/4	🟰 Monitoring should not look too medical. 🟰 Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress 🟰 Avoid clinical look 2,5/5
Audio alarm in central room	The adio alarm will be hearable in central room (computer room) only for nurses or other health professionals, Not hearable for parents. Restriction: always some one at central post	- Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting 🟰 Not interrupting environment 2/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Nature sound, like bird chirping	A soft bird chirp chime plays, unique so each type of alert—more frequent chirps for breathing issues, or a single chirp if a call button is pressed. It's calming and blends into the background, only drawing attention when the nurse is available	- Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting 🟰 Not interrupting environment 1,5/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress 🟰 Avoid clinical look 4,5/5
No warning from monitor (current situation)	There will be no warning from the monitoring directly Only parents can call for the nurse (current situation) The hand helt makes audiotorial noice at this moment, Room number is displayed	- Reinforce gut feeling ❌Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 1,5/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ❌ Reduce parental stress ✅ Avoid clinical look 3/5

Table I.4: Ideas for 'device'

Idea for device	Explanation	Staff friendly score	Family friendly score
Personal screen	A bedside screen that shows key data like heart rate or breathing rate, making it easy for nurses to check at a glance without using their hands. Currently used at neonatology ward. option: Embedded Crib display A screen built subtly into the crib frame, which only activates and shows data when a nurse scans their ID badge, keeping the info hidden from view when the nurse is not present.	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting ❌ Not interrupting environment 2,5/4	❌ Monitoring should not look too medical. 🟰 Maintain parent-child interaction 🟰 No movement restriction for parents ❌ Reduce parental stress ❌ Avoid clinical look 1/5
Hand helt (mobile) or tablet / note book	The screen with the data is visible on the hand helt of the nurse. The nurse takes the handheld or tablet / note book with them to different rooms. Option: Digital tablet / note book A customized nurse's tablet app with customizable alert settings and real-time monitoring, allowing nurses to view detailed vitals, track trends, and see updates quickly. Nurse carries this with them paper look from notebook can look friendlier	✅Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting ✅ Not interrupting environment 3/4	🟰 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 4/5
Central monitoring screen	A screen that displays vital signs for all monitored babies at the maternity ward. There is always 1 person looking at the screens.	✅Reinforce gut feeling 🟰Worries about health neonate ❌Avoid extra shifting ✅ Not interrupting environment 2,75/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
Display in kid friendly toy	A soft toy with a small, hidden screen on its back or under a flap that nurses can open to view data, making it child-friendly and non-intrusive. Visible for parents and nurses.	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 3/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress 🟰 Avoid clinical look 3,5/5
Smart glasses	Glasses with a small heads-up display that can unobtrusively show heart rate or breathing stats, so the nurse has real-time data right in their line of sight.	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 3/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress 🟰 Avoid clinical look 4,5/5
Portable mini projector	A handheld projector that can display vitals on any surface, like a wall or bedside, when needed, giving flexibility in how and when to check the data. This can be used to show it to peditrians	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2,5/4	🟰 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress 🟰 Avoid clinical look 3/5
Wearable with screen	A discreet wearable with a small LED screen that shows heart rate, breathing rate, and alert icons for quick checks while keeping hands free. Like smartwatch	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting ✅ Not interrupting environment 3/4	✅ Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents ✅ Reduce parental stress ✅ Avoid clinical look 5/5
"Magic" Mirror Display:	A small, non-intrusive mirror on a nearby table or wall that displays vital stats when activated by the nurse's presence, keeping data concealed when not in use. Option: hidden wall panel display: A screen embedded in the wall that is angled for nurse viewing only, making it visible when the nurse is in the room but hidden from the parents' perspective. Behind a picture: A hidden display behind a picture frame on the wall, where only nurses know to slide or lift the frame to check data. This maintains a homely feel for families.	✅Reinforce gut feeling 🟰Worries about health neonate ✅Avoid extra shifting 🟰 Not interrupting environment 2,5/4	🟰 Monitoring should not look too medical. ✅ Maintain parent-child interaction ✅ No movement restriction for parents 🟰 Reduce parental stress 🟰 Avoid clinical look 3/5

Appendix J: report previous research project

RESEARCH PROJECT

Cradled in safety: family-friendly monitoring of neonatal sepsis risk

Doel:

Tijdens dit research project is de huidige situatie van het monitoren van neonaten met risico op infectie in kaart gebracht. Hierbij is gekeken naar wat de voordelen, barrières en bijkomende vraagstukken zullen zijn als de Bambi Belt hierbij komt helpen.

Karlijn Sanders

Inleiding

Het doel van dit research project is om onderzoek te doen naar de monitoring van neonaten met risico op infectie. Hierbij zijn er diepte-interviews, observaties en analyses uitgevoerd om de huidige situatie in kaart te brengen. Maar ook om een exploratief onderzoek te doen naar wat de voordelen van het gebruik van de Bambi Belt in deze use cases kan zijn. Bij deze voordelen komen ook barrières kijken, hieruit komen ook vraagstukken naar voren. Deze barrières en vraagstukken vergen nog eventueel verder onderzoek voordat de Bambi Belt daadwerkelijk in deze use cases gebruikt kan worden. De use cases die zijn gebruikt voor dit project zijn:

Use case 1: Pasgeborenen die vanwege een verdenking infectie worden behandeld met antibiotica en opgenomen liggen op een neonatologie afdeling: Snoerloze continue monitoring in plaats van monitoring met draden
Use case 2: Pasgeborenen met een verhoogd risico op infectie, maar geen behandeling:
- Bambibelt op de kraamafdeling in plaats van verpleegkundige controles elke 3 uur op de kraamafdeling

Use case 3: Bambibelt in de thuissituatie in plaats van verpleegkundige controles elke 3 uur op de kraamafdeling

Methode

Voor dit onderzoek is er gebruikt gemaakt van kwalitatief onderzoek. Hierbij zijn diepte-interviews afgenomen met een verloskundige, kinderarts, verpleegkundigen, ouders, dataspecialist, Bambi Medical en kraamzorg. Ook is er voor het in kaart brengen van de huidige situatie geobserveerd in het Reinier de Graaf ziekenhuis in Delft. Vervolgens is alle informatie die voortkwam uit de interviews en observaties gecodeerd met behulp van het programma Atlas.ti. Na het coderen zijn er overkoepelende thema's voortgekomen uit de thematische analyse.

Thematische analyse

Tijdens de thematische analyse is er gewerkt met het programma Atlas.ti. Ook zijn de thema's visueel weergegeven in afbeelding 1 en is er een overzicht gemaakt van de huidige situatie, de barrières, voordelen en vraagstukken rondom de implementatie van de Bambi Belt.

Thema's:

1 Verantwoordelijkheid/ opvolging
2 Verschil product kenmerken
   - Mobiliteit
   - Gebruiksvriendelijkheid
3 Verschuivingen
   - Mankracht
   - Werkdruk
   - Capaciteit
   - Controles
4 Infectie monitoring met Bambi Belt
5 Organisatie
   - Gegevensverzameling
   - Kosten
6 Monitoring
   - Alarmen
   - Interactie
7 Thuis monitoring
8 Toekomst

1. Verantwoordelijkheid/ opvolging:

Het thema verantwoordelijkheid is een overkoepelend thema voor veel codes geweest tijdens het onderzoek. Zodra er een nieuw product, in dit geval de Bambi Belt, in het ziekenhuis wordt geïntroduceerd moet er natuurlijk iemand verantwoordelijk zijn dat dit goed gebeurd. Vervolgens wordt het zorgpersoneel verantwoordelijk dat ze dit product zo goed mogelijk gebruiken. Ze zullen dus moeten leren hoe dit werkt en ook hoe er om wordt gegaan met de nieuwe oorzaken die een alarm of storing tot gevolg kunnen hebben. Denk bijvoorbeeld aan het verplaatsen van de Bambi Belt, of het niet meer werken van een sensor. Het zorgpersoneel zal hierdoor een nieuwe verantwoordelijkheid krijg om dit te leren.

Los van de verantwoordelijkheid in het ziekenhuis zullen er ook nieuwe verantwoordelijkheden ontstaan als een baby met Bambi Belt naar huis zal gaan. De kraamzorg thuis, maar ook de ouders en eventueel andere zorgverleners thuis zullen verantwoordelijk worden voor het gebruik van de Bambi Belt. Er zal een nieuwe dynamiek van opvolging kunnen ontstaan, van zorggevers die afwisselen terwijl het kind continue gemonitord wordt.

Spanning/relatie:
Zodra er iets verandert in het ziekenhuis zal dit voor een reactie zorgen. Hieronder zullen meerdere spanningen beschreven worden.

1. Verantwoordelijkheid verpleegkundige <-> overdracht op thuis zorgverlener
2. Verschuiving van verantwoordelijkheid <-> huidige rolverdeling
3. Ouders eventueel naar huis met Bambi Belt <-> kennis over Bambi Belt

Vraagstukken:

1. Wie zorgt er voor goede instructies voor de (volgende) verantwoordelijke?
   a. Mogelijkheid om een cursus of uitleg mee te geven?
2. Wie is er wanneer verantwoordelijk als het kind naar huis gaat met de Bambi Belt?
   a. Wie reageert er op de alarmen als er thuis een alarm af gaat?
   b. Wie monitort het vanuit het ziekenhuis?
   c. Wie kunnen de ouders als eerste bereiken voor vragen? Ook s nachts

"Daar moet je wel afspraken over maken. Wie gaan die ouders bellen 's nachts hè? Dat is altijd 's nachts hè? Dat er een alarm afgaat." *1:35 ¶ 681 in Interview verloskundige.docx*

"Je gaat wel met dat soort dingen te maken krijgen, maar je moet duidelijke afspraken maken wie er dan verantwoordelijk is en wie ze dan bellen. Wij moeten ook instructies krijgen. Stel, er wordt afgesproken dat je verloskundige belt, wanneer moeten wij dan overleggen met de kinderarts?" *1:37 ¶ 713 in Interview verloskundige.docx*

2. Verschil product kenmerken

Als er een nieuw product in het ziekenhuis wordt geïntroduceerd moeten we er zeker van zijn dat deze even goed of beter werkt dan de huidige oplossing. In dit geval blijkt dat er vooral obstakels zijn rondom het losgaan van de huidige plakkers. Ze gaan vaak los als het kind beweegt, maar ook als ze verzorgd worden. Daarnaast wordt het kangoeroeën bemoeilijkt omdat ouders het spannend of lastig vinden om het kind op te pakken. Ook gaan de plakkers door de warmte van huid op huidcontact sneller los. Dit geeft (onnodige) alarmen wat kan zorgen voor stress en onrust. De vraag is of de Bambi Belt in de praktijk ook veel storingen kan geven als deze van plek verschuift.
Bambi Belt kan wel voor meer mobiliteit met de baby gaan zorgen, uit onderzoek bleek dat dit als een van de grootste voordelen wordt gezien. De interactie met de baby zal minder spannend en wellicht ook makkelijker gaan.

Spanning/relatie:
Zodra er iets verandert in het ziekenhuis zal dit voor een reactie zorgen. Hieronder zullen meerdere spanningen beschreven worden.

1. Kennis huidige product <-> wennen aan nieuw product
2. Versterking van mobiliteit baby en ouders <-> kwaliteit van monitoring
3. Keuze voor een nieuw product <-> kwaliteit/ prestatie van beide producten

Vraagstukken:

1. Hoe kan de Bambi Belt ervoor zorgen dat er minder (onnodige) alarmen afgaan?
2. Hoe zit het met het verschuiven of de juiste plaatsing van de Bambi Belt?
3. Hoeveel tijd is er nodig voor het zorgpersoneel gewend is aan het gebruik van een nieuw product?
4. Welke voordelen wegen op tegen de nadelen van Bambi Belt i.p.v. huidige plakkers?
5. Hoe duurzaam is de Bambi Belt t.o.v. de huidige plakkers?
6. Kan de Bambi Belt hergebruikt gaan worden?
7. Op welke vlakken wordt er ingeleverd als er wordt gekozen voor de Bambi Belt?
8. In hoeverre heeft de mobiliteit voordelen?

3.Verschuivingen

- Mankracht
- Werkdruk
- Capaciteit
- Controles

Als de Bambi Belt ook gebruikt gaat worden voor het thuis monitoren zullen er een aantal verschuivingen gaan plaats vinden. Om te beginnen zal de capaciteit in het ziekenhuis wellicht groter worden. Als baby's ook thuis gemonitord kunnen worden dan zal er eerder een bed vrij kunnen komen in het ziekenhuis. Maar het werk rondom het monitoren van deze baby thuis zal door iemand anders moeten worden overgenomen, hierin verschuift de werkdruk dus. Er is nog meer onderzoek nodig om te zien waar dit heen verschuift.
Een andere verschuiving die in de werkdruk voor verandering kan zorgen is dat de ouders op dit moment vaak de verpleegkundige als eerste aansprreekpunt hebben. Zodra er een alarm af gaat komt de verpleegkundige bij de baby en de ouders. De verpleegkundige zal de eerste vragen maar ook alarmen opvangen en deze filteren en zo nodig doorschakelen naar de arts. Wanneer er thuis wordt gemonitord, is er geen verpleegkundige continue in de buurt. Hierdoor zal het lijntje naar de arts vaker en sneller worden gebruikt. Dit zal een verschuiving geven in het aantal vragen en dus ook de werkdruk/capaciteit voor de artsen.

Spanning/relatie:

1. Capaciteit in ziekenhuis vergroten door eerder naar huis te sturen <-> hogere werkdruk voor de zorgverleners thuis (kraamzorg?)
2. Verpleegkundige als aanspreekpunt/ filter van alarmen <-> wat doen ouders met alarmen/ direct in contact met arts
3. Capaciteit verpleegkundigen op NiCu afdeling <-> hoeveelheid werk voor thuisverpleging

Vraagstukken:

1. Wie voert de controles uit als er een alarm thuis af gaat?
2. Hoe wordt de capaciteit verschuiving opgevangen die optreedt als er thuis gemonitord wordt?
3. Wat voor invloed heeft het thuis monitoren op de efficiëntie binnen de zorg bij baby's?
4. Wat verandert er voor de capaciteit binnen het ziekenhuis
5. Wat zullen de verpleegkundige merken van deze verschuiving?
6. Wat voor invloed heeft deze verschuiving op de werkdruk en beziggheden van personeel binnen het ziekenhuis?

"Het lijntje naar de arts wordt nog korter dan normaal.
Nu kan de verpleegkundige namelijk al heel veel ondervangen, zoals vragen van de ouders." *4:29 ¶ 347 – 353 in Interview Verpleegkundige.docx*

"Dat is dus sowieso ook nog een ding. Wie let er dan op? Want er ligt geen baby in het bedje daar, dus wie kijkt er dan?" *1:38 ¶ 743 in Interview verloskundige.docx*

4. Infectie monitoring met Bambi Belt

Een van de mogelijke richtingen van het onderzoek kan zijn om te kijken naar waar de Bambi Belt kan worden ingezet voor infectie monitoring. Infectiegevaar kan op dit moment soms lastig te meten zijn, omdat er meerdere waardes in het bloed zitten die ook stijgen ten gevolge van de bevalling. *"Geboren worden is stress, dus je hele lichaam is vol stress, hormonen, stresfactoren en die jagen dus ook een heleboel waardes die ook bij een infectie omhooggaan, ook al omhoog. Het kind kan niet zeggen. Hallo, ik voel me belabberd. Het kind mag misselijk zijn na de geboorte. Het kind hoeft zich niet op temperatuur te houden".* *3:27 ¶ 614 – 616 in Interview Kinderarts.docx*

"Maar bottomline is dat we nog steeds niet dé factor in handen hebben die Alleen maar omhooggaat bij infectie en niet beinvloed wordt door de bevalling". *3:30 ¶ 664 in Interview Kinderarts.docx*

Hierdoor kwam het thema naar voren over de combinatie van Bambi Belt op het gebied van infectiegevaar. De vraag is of dit product hierbij kan gaan helpen, zo ja, hoe dat dan in zijn werking gaat.

Spanning/relatie:

1. Nog niet dé factor in handen die alleen omhooggaat bij een infectie en niet door de geboorte <-> Welke factoren er gemeten worden met de Bambi Belt

Appendix J: report previous research project

2. Bambi Belt is hier nu nog niet specifiek voor ontwikkeld <-> Informatie over welke specifieke waardes er gemeten moeten worden voor infectie

Vraagstukken:
1. Op welke vlakken binnen infectiegevaar hebben we iets aan de Bambi Belt?
2. Welke kenmerken moet de Bambi Belt hebben om iets te betekenen bij deze monitoring van infectie?
   a. Welke waardes moeten er gemeten worden
3. Hoe wordt dé factor gevonden die nodig is om infectiegevaar te meten?
   b. Kan de Bambi Belt hierbij helpen?
4. Op welke vlakken moet de Bambi Belt aangepast worden om infectiegevaar te monitoren?

5. Organisatie

Zodra er onderzoek gedaan wordt naar de introductie van een nieuw product op nieuwe plekken komt daar natuurlijk ook organisatorisch wat bij kijken. De organisatie, in dit geval het ziekenhuis, zal beslissingen moeten maken. Er zal fysiek in het ziekenhuis verandering komen door een nieuw product. Maar ook de beslissing of het product überhaupt gekocht gaat worden. De organisatie zal moeten nadenken over de kosten, de nieuwe inrichting van de gegevensverzameling. Wie ze verantwoordelijk stellen om dit te laten implementeren.

Data:
Bij de optie dat een baby met de Bambi Belt naar huis gaat zal de organisatie voor nog meer keuzes komen te staan. Bijvoorbeeld op het gebied van gegevensverwerking, als dit continue gebeurt kan dit in conflict komen met de privacy. Maar ook de veiligheid van het ziekenhuis moet gewaarborgd worden. *"Koppelingen met buiten, hele tijd data heen en weer, zijn risico punten. Elk lijntje naar buiten is risico, hoe minder nodig hoe beter". 5:9 ¶ 37 in Interview data technicus.docx*

Spanningen/relatie:
1. Thuis continue monitoring <-> Privacy
2. Thuis continue monitoring en gegevens deling <-> Security van het ziekenhuis
3. Keuzes van de organisatie (kosten) <-> hogere kosten Bambi Belt dan huidige plakkers
4. Verandering inrichting organisatie <-> nieuwe productintroductie binnen de organisatie
5. Verandering in manier van monitoren (op afstand) <-> Huidige systeem in het ziekenhuis

Vraagstukken:
1. Wat zullen de kosten worden van het implementeren van de Bambi Belt?
   a. Hoeveel verschilt dit met de huidige kosten van het vervangende product?
2. Hoe wordt er omgegaan met de gegevensverzameling?
3. Hoe kan continue monitoring veilig worden gemaakt op gebied van privacy en security?
4. Is bij alle baby's die naar huis gaan met de Bambi Belt continue monitoring nodig?
   a. Hoe kan dit verminderd worden?

5. Hoe wordt ervoor gezorgd dat het systeem in het ziekenhuis klaar is voor het monitoren op afstand?

"Continue meten is een hele hoge drempel. Zowel voor privacy & security. Ziekenhuis op zichzelf niet gehackt wordt." 5:13 ¶52 in Interview data technicus.docx

6. Continue monitoring

Het belangrijkste doeleinde van de Bambi Belt is het monitoren van een (pasgeboren) baby. Gekoppeld aan het monitoren hiervan zitten vaak alarmen. Zowel bij de huidige monitoring als bij de Bambi Belt zullen er alarmen afgaan als een waarde te erg daalt of stijgt. Uit het onderzoek bleek dat er met de huidige plakkers ook vaak alarmen afgaan door het disfunctioneren van de plakkers. Wanneer deze bijvoorbeeld losraken.
Veel geïnterviewden konden zich voorstellen dat de manier van continue monitoren met een Bambi belt een fijnere manier van monitoren voor zowel kind als ouder zal zijn. Dit komt vooral omdat er werd gedacht dat de interactie vergemakkelijkt zal worden. Dat de baby makkelijker opgetild kan worden, minder draden bij het verschonen en dat de plakkers niet los zouden gaan bij het kangoeroeën. Het overkoepelende thema is dus de manier van bevestiging bij het continue monitoren.

Spanning/relatie:
1. Frequentie (valse) alarmen die afgaan <-> aantal controles dat verpleegkundige langs komt
2. Continue monitoring <-> interactie met ouders

Vraagstukken:
1. Wat voor verandering in het aantal (valse) alarmen brengt de Bambi Belt?
2. Wat verandert er in de interactie van kind en ouder?
3. Wat verandert er in de frequentie van het langskomen van de verpleegkundige?
4. Wat is het grootste verschil tussen de Bambi Belt en de huidige plakkers voor de zorgverleners?
   a. En voor de ouders?

"Ook wel sneu, als de baby dan net slaapt en er gaat een plakker los dan gaat het alarm af en moeten wij de plakker weer vast plakken." 7:6 ¶43 in Observatie Reinier de Graaf Gasthuis.docx

7. Thuis monitoring

Een ander thema wat naar voren kwam uit het onderzoek is de mogelijkheid voor thuismonitoring. Dit ligt voor velen nog ver in de toekomst. Dit komt omdat op dit moment het systeem hier nog niet op is ingericht, ook loopt de vergoeding van verplaatsing naar huis nog achter. Er zal iemand verantwoordelijk moeten zijn voor de baby's die naar huis gaan met een Bambi Belt. Ook deze zullen gemonitord worden. De arts is altijd eindverantwoordelijk, maar wanneer deze de baby niet kan zien kan dit invloed hebben op de manier van werken voor de arts.

Iets anders wat naar voren kwam is de mening van de ouders. Er zullen ouders blij zijn om met hun kind in eigen omgeving te zijn, maar andere ouders zullen het misschien ook heel spannend vinden om thuis te zitten zonder continue verpleging. Omdat niet alle ouders hier klaar voor kunnen zijn wordt er in het onderzoek benadrukt dat het nooit een pressiemiddel mag worden. Er zijn rondom dit thema nog erg veel vragen, ook omdat dit voor velen nog echt toekomstmuziek is.

Spanning/relatie:
1. Comfort van thuis zijn met kind <-> afgaan van een alarm thuis
2. Ouders die dit graag willen <-> ouders die hier niet klaar voor zijn
3. Gebruik door verschillende mensen <-> overdracht en instructies
4. Arts is eindverantwoordelijk <-> ziet baby niet fysiek
5. Monitoren op afstand <-> klinische blik van verpleegkundige
6. Zo snel mogelijk starten antibiotica <-> afstand huis tot ziekenhuis

Vraagstukken:
1. Hoe wordt deze transitie bekostigd?
2. Naar wie kunnen ouders toe met vragen?
3. Wie houdt de monitor in de gaten als kinderen thuis zijn?
4. Wat wordt de maximale afstand tot het ziekenhuis in geval van nood?
5. Hoe kan de arts eindverantwoordelijk blijven als deze de baby niet kan zien?
6. Hoe kan er zo snel mogelijk gestart worden met antibiotica als de baby niet in het ziekenhuis is?

Maar het moet niet een pressiemiddel worden. En als mensen het niet zien zitten, moet die mogelijkheid er nog zijn dat za'n kind toch gewoon in dat ziekenhuis kan blijven? Dat ligt altijd op de loer, hè met dat soort dingen. 1:42 ¶ 835 in Interview verloskundige.docx

Je moet realiseren wie is de eindverantwoordelijke ervoor en dat is toch altijd de arts. Als die de ouders thuis moet bellen en je ziet nooit het kind zelf, je kan videobellen dan zie je misschien iets meer, maar ja, weet je als een kind echt een daling heeft waar je op dat moment dan naast staat, dat is toch heel anders? 4:27 ¶ 333 in Interview Verpleegkundige.docx

We moeten daar wel heel goed mee overweg kunnen en weten hoe het werkt en waar we naar moeten kijken. En of het inderdaad een toegevoegde waarde kan zijn voor de thuissituatie, dat is nog wel een groot ding. 6:26 ¶ 53 in Interview Kraamzorg.docx

8. Toekomst

Onder dit thema zitten allerlei verschillende onderwerpen die uit het onderzoek naar voren kwamen en in de toekomst nog wat extra aandacht kunnen verdienen. Zo zijn er verbeter opties voor de Bambi Belt, die ook al in gang zijn gezet door Bambi Medical.
Uitzoeken gebruik Bambi Belt:
Wat gebeurt er als de Bambi Belt verschuift? Geeft dit een alarm?
Hoe wordt het hergebruik van de Bambi Belt bereikt?
Werkt de Bambi Belt ook tegelijk met fototherapie? (lamp)

Pakt de Bambi Belt ook signaal van de buidelstoel (geeft frequentie) of ouders op tijdens het buidelen?

Extra opties voor gebruik Bambi Belt:
1. Opvang direct na geboorte (interview kinderarts), om te helpen bij meten hartactie. *"Soms worden ze geboren met een trage hartactie. En als we dan de longen kunnen openen, openblazen, want er zit vruchtwater in, dan zie je dat hartactie bij komt. Het is voor ons een hele belangrijke parameter, terwijl dan het zuurstofgehalte in het bloed nog ver achterloopt. Dat duurt veel langer voordat verbetering is, maar als je hartactie omhooggaat, dat betekent dus dat je goed bezig bent om die longen te ontplooien. Dus voor de hulpverlener is het dus echt een belangrijke* ***parameter.*** *Wat doen we nu? We moeten luisteren, maar ja, Ik ben bezig, dus dan vraag ik aan degene die mij helpt of die wel luisteren, Maar dat is soms best wel lastig, want Ik ben aan het blazen, dus dat maakt het luisteren lastig. 3:53 ¶ 1108 – 1110 in Interview Kinderarts.docx*
2. Infectiegevaar monitoren: er zal ook getest moeten worden hoe de Bambi Belt zich gedraagt en wat de resultaten zijn bij het monitoren van een baby met verdenking van infectie.

Let op: CE is vaak voor bepaalde intended use. Misschien is dat nu zorgprofessional? Wellicht hiernaar kijken als het ook naar huis wil worden verplaatst en dus ook ouders ermee te maken krijgen.

Overzicht huidige situatie

In afbeelding 2 is een overzicht per use case weergegeven. Zo is er van links naar rechts de huidige situatie (blauw), de voordelen die de Bambi Belt kan brengen in deze use case (groen), de barrières met de Bambi Belt (rood) en de vraagstukken die hierbij naar voren komen (oranje) weergegeven.

Conclusie en vervolgstappen

Zoals te zien is in het visuele overzicht kunnen er met de Bambi Belt veel voordelen behaald worden. Vooral op het gebied van interactie, continue monitoren en mobiliteit. Wel zijn er vooral in use case 3 nog veel barrières en bijkomende vraagstukken. Uit dit onderzoek is gebleken dat eerst use case 2 goed moet worden uitgewerkt en ook in werking moet zijn voordat use case 3 geïmplementeerd kan gaan worden. In het afstudeerproject van Karlijn Sanders zal er verder gekeken worden naar een onderdeel van use case 2. Maar verder onderzoek zal nodig zijn om de Bambi Belt van dienst te laten zijn voor monitoring van neonaten met risico op infectie.

De belangrijkste punten waar onderzoek naar gedaan moet worden voor zowel use case 2 en 3 is:
- Kwaliteit van huidige monitoring en Bambi Belt
- Systeem voor continue monitoring op afdeling die dat niet gewend is
- Implementatie nieuw product
- Omgang met continue data; filteren, ervan leren, algoritmes, voorspellingen
- Prijs en duurzaamheid Bambi Belt

Thuismonitoring:
Onderzoek dat gedaan moet worden voor specifiek voor use case 3 (thuis monitoren) (nadat de Bambi Belt al gebruikt wordt in use case 2):
- Onderzoek naar continue datastroom; op gebied van privacy en security
- Verantwoordelijkheidsverdeling bij thuis monitoren
- Afstand huis tot ziekenhuis; klinische blik, snelheid van starten antibiotica, medische handelingen, reactie op alarmen

Voorstellen vervolgprojecten

Uit het huidige onderzoek zijn veel vraagstukken naar voren gekomen. Naar veel vraagstukken zal meer onderzoek gedaan moeten worden. Een aantal vraagstukken kunnen samengenomen worden in de volgende projectvoorstellen. Dit zijn voorstellen voor vervolgonderzoek. Het eerste projectvoorstel is al nodig voor use case 2. En de andere twee voorstellen zijn voornamelijk als de Bambi Belt ook voor thuismonitoring gebruikt wil gaan worden.

Project 1: Inrichting continue monitoren op nieuwe afdeling
Op dit moment liggen de neonaten van use case 2, die om de drie uur gecontroleerd worden door een verpleegkundige op de kraamafdeling. Deze afdeling is (nog) niet ingericht voor continue monitoring. Ook zijn de verpleegkundige op deze afdeling daar nog niet aan gewend. Er kan gekeken worden wat er nodig is om deze stap met Bambi Belt op deze afdeling(en) te maken. Dit kan samen met het medische personeel maar wellicht ook ouders van deze afdeling gedaan worden.

Project 2: De technische kant van thuis monitoren
Wanneer er met de Bambi Belt thuis gemonitord gaat worden zal er gekeken moeten worden naar hoe dit technisch in zijn werking gaat. Er zal dan namelijk een continue datastroom naar het ziekenhuis komen. Er moet gezorgd worden dat dit veilig gebeurt op het gebied van privacy maar ook security voor het ziekenhuis. Op dit moment wordt er namelijk nog niet continue gemonitord op afstand. Ook zal er nagedacht moeten worden over waar deze informatie dan zichtbaar is. Waar wordt alle data ontvangen en in wat voor systeem kunnen artsen of verpleegkundige naar de monitor van neonaten kijken die thuis zijn. Hier kan meer onderzoek naar gedaan worden. De vraagstukken die uit het huidige onderzoek naar voren zijn gekomen kunnen hier nog extra richting aan geven.

Project 3: Verschuiving van verantwoordelijkheid
Wanneer er thuis gemonitord gaat worden kan dit verschuivingen te weeg gaan brengen. Zo kan er verandering in capaciteit ontstaan, maar ook in werkdruk en verantwoordelijkheid. Wanneer een neonaat met een Bambi Belt naar huis gaat komt er namelijk een bed vrij in het ziekenhuis, maar de neonaat moet nog wel thuis gemonitord worden. Er zal dus een verschuiving in verantwoordelijkheid plaatsvinden. Er kan extra onderzoek gedaan worden naar waar deze verschuivingen precies optreden, wie de verantwoordelijkheid gaat oppakken en hoe deze druk opgevangen kan worden.