

Markus Rosenvinge Pettrém

# Health service innovation of neonatal jaundice detection by using mHealth technology in low-income settings: user-centered implementation project in Nepal

Master's thesis in Industrial Design

Supervisor: Martina Keitsch

May 2023



Norwegian University of  
Science and Technology



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Department of Design



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Health service innovation of neonatal  
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A Master's Thesis by Markus Rosenvinge Pettrém

Department of Design, Norwegian University of Science and Technology,

Spring 2023



# PREFACE

This master thesis is written at the Institute of Design at Norwegian University of Science and Technology (NTNU) in collaboration with Picterus and Kathmandu Medical College. It was undertaken and completed in the spring of 2023 - conducted by me, Markus Rosenvinge Pettrém. The project has given me the opportunity to work with and explore a variety of design methods and approaches, and taught me a lot about my present and potential future role as a designer. I explored how to meet and address peoples needs and challenges in a different culture and setting than what I am used to, and I learned a lot along the way.

Several people have assisted me in this thesis. First of all, I would like to thank Anders Aune for the opportunity to conduct research together with him and Picterus, and for the assistance during the whole thesis. My gratitude also goes out to my supervisor, Martina Keitsch, for her guidance, constant support and follow-up, and to Prof. Dr. Sunil Kumar and Prof. Dr. Sunil Raja Manandhar at Kathmandu Medical College, for facilitating my trip to Nepal and Kathmandu. I also thank my co-supervisors Gabriela Jiménez Díaz and Jennifer Infantini for guiding me through unfamiliar methods and knowledge, as well as Bishowram Shreshta, Ramesh Adhikary and Dalbir Kulal for guiding me through rural areas of Nepal. Last, but not least, I thank all the health workers in KMC who participated in interviews, user tests and work shops, and who patiently took time off their working days to assist me.



# ABSTRACT

## Background

Neonatal jaundice (NNJ) is a common condition in newborns which may cause severe complications if untreated. It is a significant health concern in Nepal, due to factors such as limitations in health care access. Current detection practices, based on visual inspections and invasive methods, can be inefficient and time-consuming for health care workers. Mobile health (mHealth) technology offers more accessible and potentially cost-effective solutions. Picterus, a company located in Trondheim, Norway, has developed an mHealth mobile application which estimates newborn jaundice levels. This thesis explores the feasibility of implementing Picterus in a hospital in Kathmandu, Nepal.

## Process and methodology

The data for this study was collected from health care workers at Kathmandu Medical College (KMC) in March 2023. To gain detailed insight into the health care workers' needs, attitudes and challenges in their daily work, as well as regarding currently used and potential new technologies, service design and user-centered design approaches were used. This included semi-structured interviews, user tests, and focus groups. The goal was to understand and evaluate the existing methods and procedures for detecting NNJ and uncover potential areas for development and improvement.

## Results

Results suggest a clear need for Picterus in KMC, where it can assist doctors in their daily work by eliminating incorrect, subjective assessments. This may decrease unnecessary invasive procedures, which in turn can free up the doctors' time for other tasks. Additionally, Picterus could potentially lower the costs for the parents of newborns, improving the accessibility of assessments. However, several challenges were identified when exploring the potential integration of the service in the hospital, including the app's user experience and the training required for its proper use.

To address these challenges, suggested solutions include upgrading features and wireframes in the application, a two-step training guide including group training and an informational poster, as well as practical recommendations for Picterus' short and long-term development. The implications of these findings could improve the NNJ health care service in KMC and could be used as an indication of whether implementing other mHealth solutions in Nepal is feasible.

# SAMMENDRAG

## Bakgrunn

Neonatal gulsott er en vanlig tilstand hos nyfødte som kan forårsake alvorlige komplikasjoner dersom det ikke behandles. Det er en betydelig helseutfordring i Nepal, på grunn av faktorer som forskjeller i tilgang til helsetjenester. Nåværende deteksjonsmetoder, basert på visuell inspeksjon og invasive metoder, kan være ineffektive og tidkrevende for helsearbeidere. Mobil helse (mHealth)-teknologi tilbyr mer tilgjengelige og potensielt kostnadseffektive løsninger. Picterus, et selskap lokalisert i Trondheim, Norge, har utviklet en mHealth-mobilapplikasjon som estimerer gulsottnivåer hos nyfødte. Denne oppgaven utforsker muligheten for å implementere Picterus på et sykehus i Kathmandu, Nepal.

## Prosess og metode

Data til dette studiet ble samlet inn fra helsearbeidere ved Kathmandu Medical College (KMC) i mars 2023. For å få detaljert innsikt i helsearbeidernes behov, holdninger og utfordringer fra deres daglige arbeid og angående nåværende og potensielle nye teknologier, ble tjenestedesign og brukersentrert designtilnærminger brukt. Dette inkluderte semi-strukturerte intervjuer, brukertester og fokusgrupper. Målet var å forstå og evaluere de eksisterende metodene og prosedyrene for å detektere neonatal gulsott, og avdekke potensielle områder for utvikling og forbedring.



## Resultater

Resultatene antyder et klart behov for Picterus på KMC, hvor det kan assistere leger i deres daglige arbeid ved å eliminere ukorrekte, subjektive vurderinger. Dette kan redusere unødvendige invasive prosedyrer, som vil frigjøre legenes tid til andre oppgaver. I tillegg kan Picterus potensielt senke kostnadene for foreldrene til nyfødte, noe som forbedrer tilgjengeligheten av vurderingene. Flere utfordringer ble imidlertid identifisert ved utforskning av den potensielle integreringen av tjenesten på sykehuset, inkludert appens brukeropplevelse, og opplæringen som kreves for riktig bruk.

For å adressere disse utfordringene, inkluderer løsningene i oppgaven oppgradering av funksjoner og wireframes i applikasjonen, en to-trinns opplæringsguide som inkluderer gruppetrening og en informasjonsplakat, samt praktiske anbefalinger for Picterus' kortsiktige og langsiktige utvikling. Implikasjonene av disse funnene kan forbedre helsetjenesten for neonatal gulsott på KMC, og kan brukes som en indikasjon på om implementering av andre mHealth-løsninger i Nepal er gjennomførbart.

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# INTRODUCTION

This thesis is exploring the feasibility of implementing Picterus, an mHealth (mobile health) application designed for neonatal jaundice detection, within a hospital in Katmandu, Nepal. Applying service design and user-centered design methodologies, the study examines data collected from health care workers at Kathmandu Medical College, during my stay in March 2023. The collected data provided deep insight into their needs, attitudes and challenges in their daily work, and also concerning the adoption and usage of new and current technologies. This understanding was critical in answering the feasibility question, and in developing solutions and recommendations for improving the implementation of Picterus.

## Early phase

The project was introduced to me by my supervisor Martina Keitsch at the start of 2023. It came without a predefined framework. I therefore had to invest considerable time reaching out to potential persons to collaborate with and establishing what the content of the thesis would be. The initial plan was to do research into neonatal jaundice and the health care system in Nepal, as well as to examine existing mHealth technologies for a better understanding of the fields. A few weeks into the project, I got in contact with Picterus which led to a minor shift in the thesis goals, which I will detail later in the thesis. After finding the right collaborations, I aimed at developing the framework and research questions. Attached is the initial description of the project, made in early January. Minor adjustments to the scope were made later, which are discussed later on in the thesis.

## **Master Thesis for student Markus Rosenvinge Pettrem, s221765**

**Title:** Health service innovation of neonatal jaundice detection by using mHealth technology in low-income settings: user-centered implementation project in Nepal

Title in Norwegian: Helsetjenesteinnovasjon av neonatal gulsottdeteksjon ved bruk av mHealth-teknologi i lavinntektsområder: brukersentrert implementeringsprosjekt i Nepal

An interdisciplinary group of researchers from the Norwegian University of Science and Technology and St. Olavs Hospital are researching an mHealth (mobile health) mobile application to detect neonatal jaundice. A similar app was developed by Picterus, <https://www.picterus.com/>. The app offers an affordable, immediate, and accessible solution to estimate bilirubin levels using new and patented technology for skin-color based screening. A pilot study has been conducted in Mexico regarding the use of the app in terms of its functionality, design, and user-friendliness in both rural and urban environments.

The goal of this project is to explore the possibilities of using mHealth in Nepal. The objectives of the project will be to map and evaluate current methods and procedures for detecting neonatal jaundice and their effectiveness. Additionally, the project will look at the advantages and challenges of mHealth approaches in different geographical areas and how an application like Picterus can contribute to improving health outcomes for neonatal jaundice incidence. Important criteria include the availability of information, visualisation, and user-friendliness, for example in local health clinics. Furthermore, with the permission of Picterus, the project will look at the possibility of testing the app in a Nepalese context.

To achieve detailed insight into the stakeholders' needs, perceptions, and attitudes, methods such as direct observations, semi-structured interviews, and focus groups will be used. In addition, the development of an MVP (minimum viable product) will be important to end up with a product with high user-friendliness and availability.

In conclusion, the project aims to improve an app prototype for mHealth in the detection of jaundice.

The project follows the "Retningslinjer for masteroppgaver i Industriell design".

Supervisor: Martina Keitsch

Co-supervisor (if relevant): TBA

Company collaboration (if relevant): TBA

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NTNU, Trondheim, date 08.01.23



Martina Keitsch  
Supervisor



Sara Brinch Head  
of department

## Structure of the thesis

The structure of this thesis comprises eight sections. The initial part, “Planning” and “Background”, go into detail about how the project was initiated and explains its relevance in today’s health care and technology environment. Following this, the “Trip to Nepal” section shares my experiences in Nepal, and how these shaped the direction of the project.

In the “Methodology” section, I provide an overview of the methods used which have helped shape this study. Then, in the “Analysis” part, I present the data collected, providing a detailed overview of the findings. These findings are discussed in depth in the “Discussion” section, where I share my interpretations and the insights I’ve drawn from the data. Based

on the insights, the “Solutions” presents potential solutions and recommendations that address the previous findings in the project.

In the final section of the thesis, “Evaluation”, I will give a retrospective look at the project as a whole, including a discussion on its limitations, an assessment of its overall impact and effectiveness, and some concluding thoughts.



**PLANNING**

**BACKGROUND**

**TRIP TO NEPAL**

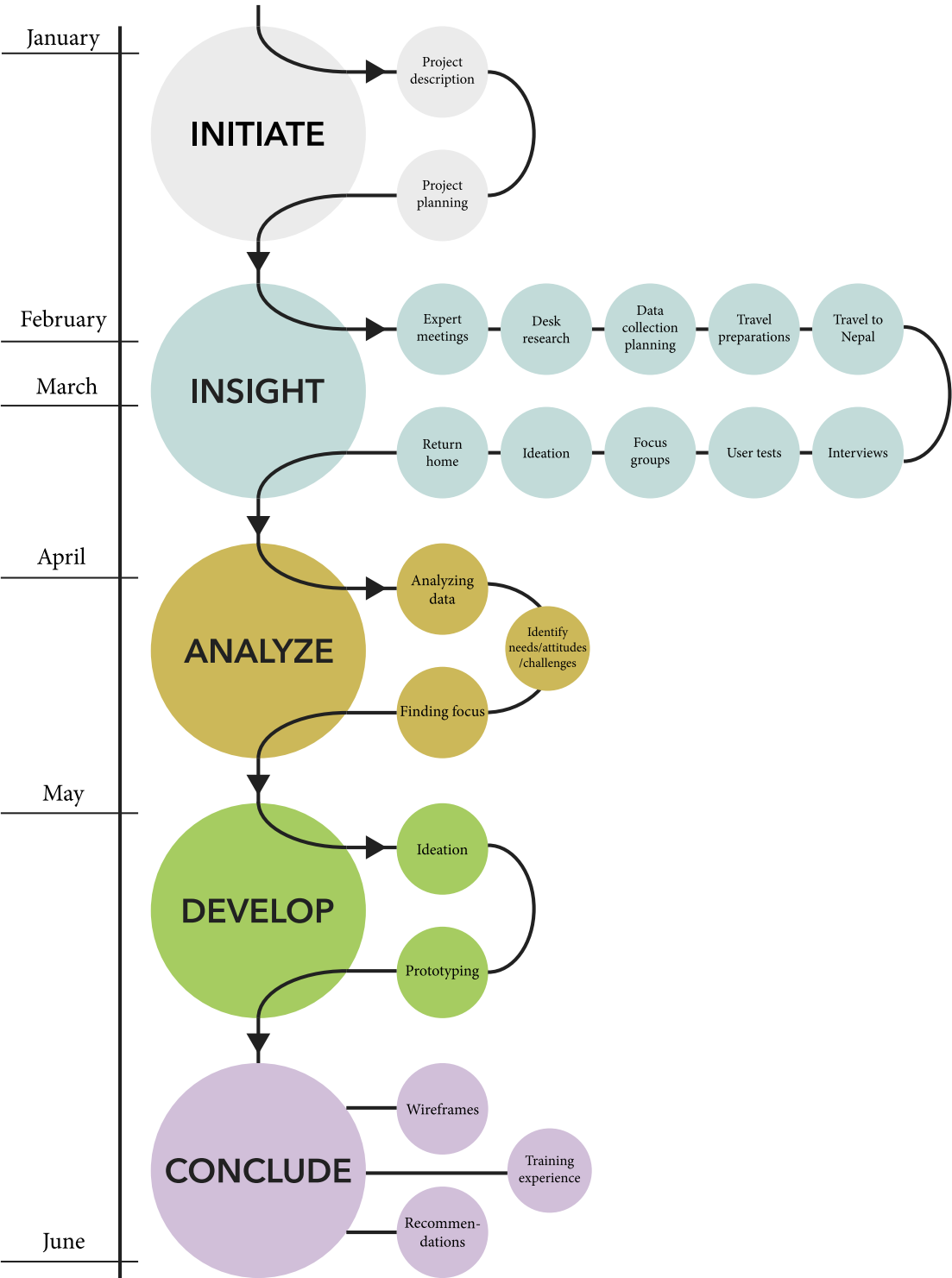
**METHODOLOGY**

**ANALYSIS**

**DISCUSSION**

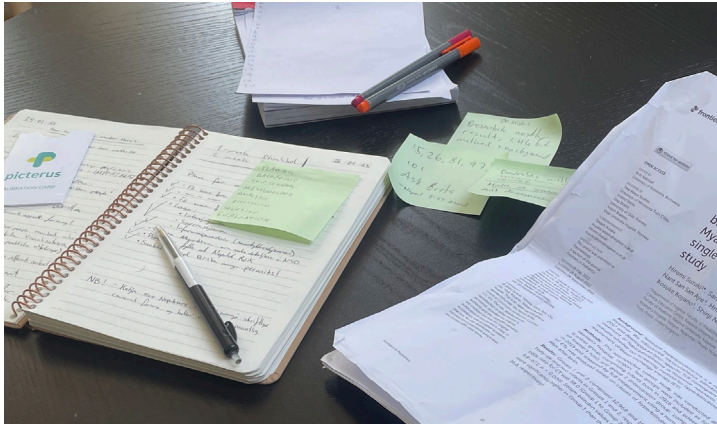
**SOLUTIONS**

**EVALUATION**



## Design process

In the initial stages of this project, I identified that using service design and user-centered design approaches could provide a framework for developing solutions which were based on user perspectives. Therefore, this thesis was built upon the “Double Diamond” design process. This design model, described in more detail in the "Methodology" section, served as a guide for me in shaping the direction of the thesis, and I used its four stages — explore, define, develop, and deliver — as inspiration.



## Service design

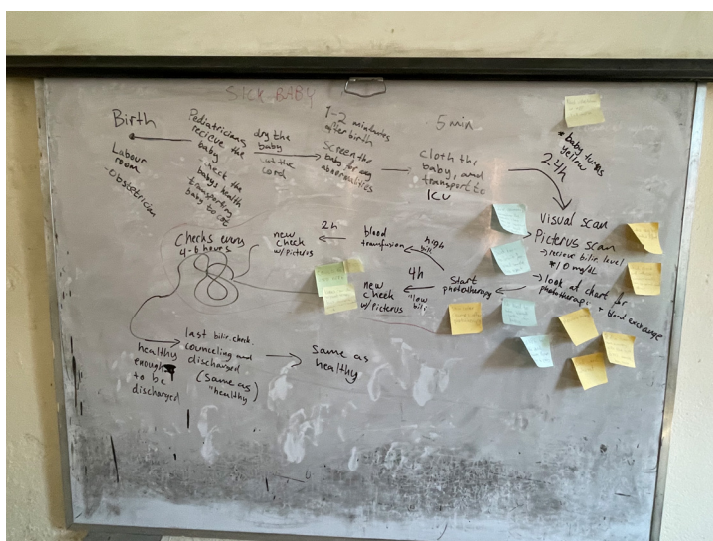
Service design is a holistic approach which is used to design and develop services (Polaine et al., 2013). It involves trying to understand the whole user journey and the different touch points between the service provider and the users. By mapping the users' experiences, pain points and possible areas of improvement, as well as involving the users throughout the process, service design aims to facilitate meaningful services. This method uses a combination of research, ideation, prototyping, and testing to create solutions that meet the needs and expectations of both the users and the service provider.

A service design project seeks to understand the users' needs in the meeting with a service and the connected stakeholder from the initial introduction to the end of use. In the course of my thesis, I wanted to explore and use a variety of techniques and gain insights from them. This strategy enabled me to effectively fulfil the goals and objectives outlined for my thesis, as it facilitated a direct response to the participant's needs and challenges.

## User-centered design

In this thesis, user-centered design approach was used as a guide for the research. User centered design puts users at the forefront of the design process. The goal of this approach is to create solutions that directly meet their needs, preferences and challenges (Kahraman, 2010). The approach is based on the belief that the end users are the ultimate expert on what they need. Therefore, it is essential to actively involve them in the research and design processes.

I tried to engage the users at different stages of my thesis. While geographical limitations posed a challenge in involving the users in every stage, I believe that the user-centered approach ensured that the outcomes of my thesis were relevant, useful and efficient for the end users, as well as for Picterus. It helped me connect the theories I was working with, to real-world applications, enriching the value of my research.



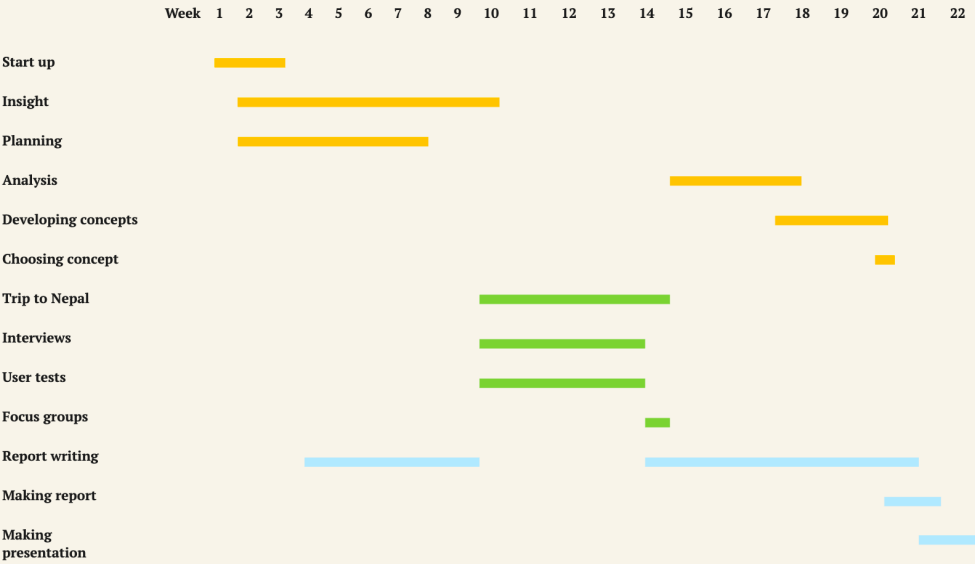
# PLANNING

In this section, I will present the insights gathered and practicalities done during the predatory phase before my trip to Nepal.

## Project management

The success of any project is dependent on efficient planning and effective time management. In this project, a project plan was developed using a Gantt chart, a visual tool used to schedule and track the project activities over the project period. A Gantt chart allowed for a comprehensive overview of the timeline, including milestones and deliverables. If there were any conflicts or delays, the plan was adjusted accordingly. I was aware that the uncertainty of the start of the project, such as not knowing where in Nepal I would be doing research and for how long, could lead to changes later. However, by using this plan as a tool, I was able to ensure that the progression of the project ran smoothly forward, and that tasks were completed without major delays. Seeing the visual progress also created motivation for me along the way.

# GANTT CHART



## Finding a hospital

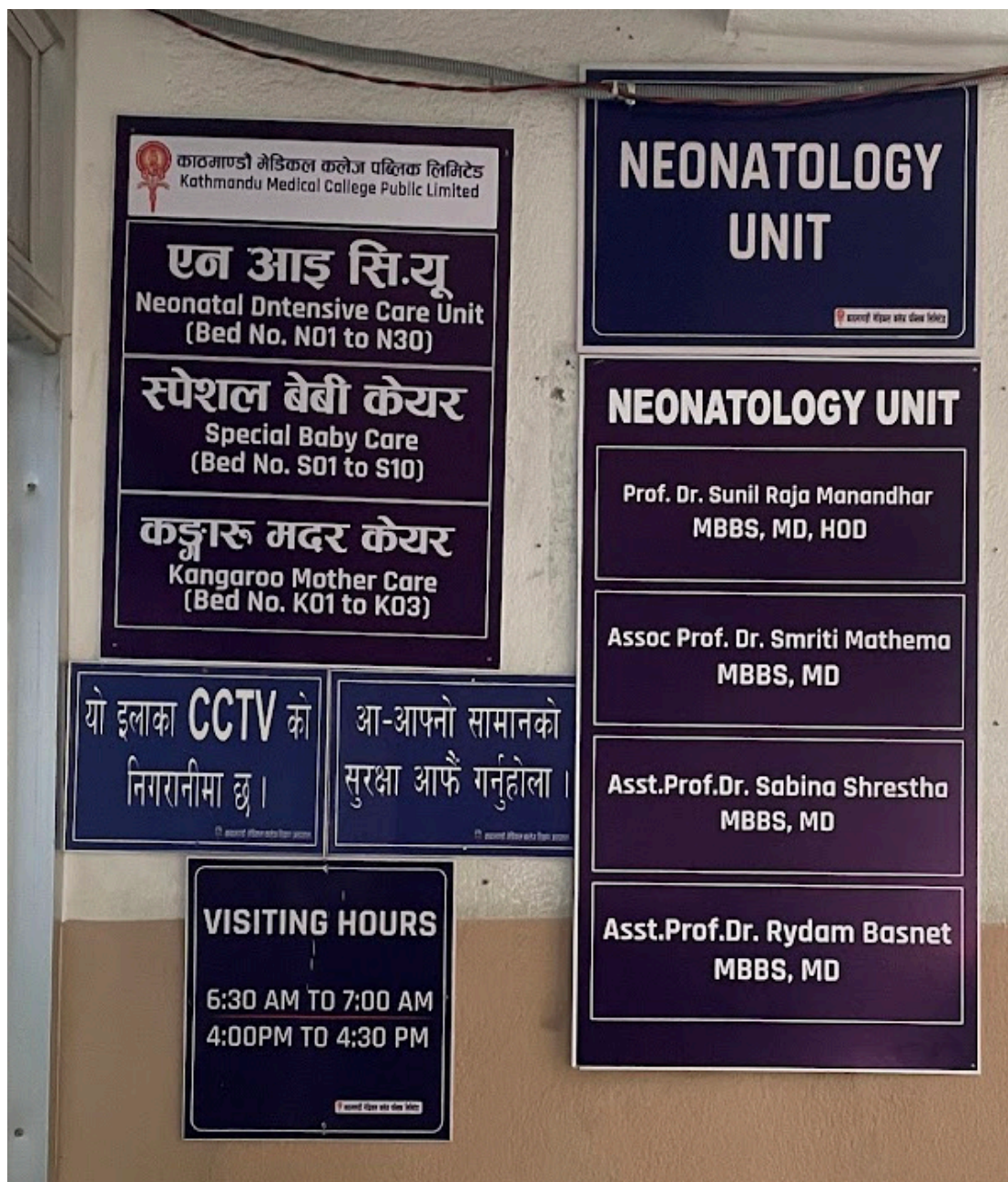
In order to conduct this study, I had to find a hospital in Nepal for collaboration. I also needed a contact person who could assist me in this, and also getting the right Nepalese research permits. Initially, my goal was to collect data from several hospitals, especially focusing on the aspect of urban versus rural, to get more comparative data. After some weeks, I got in touch with Prof. Dr. Sunil Kumar and Prof. Dr. Sunil Raja Manandhar at Kathmandu Medical College (KMC). Prof. Dr. Sunil Kumar is Chair of the Institutional Review Committee of KMC, and Prof. Dr. Sunil Raja Manandhar is Head of Pediatric Department in KMC. They were interested in the study and willing to collaborate. They could offer me help to conduct the study in the hospital, located in Kathmandu. Together with my supervisor, Martina Keitsch, we had a meeting in the middle of February to discuss the research objectives and methodology. Prof. Dr. Sunil Kumar and Prof. Dr. Sunil Raja Manandhar also helped me navigate the process of obtaining research permits at the hospital, which I was told could have been a complex and time-consuming process. Overall, the collaboration

with KMC was a critical component of the study, as it provided access to the necessary resources and expertise to conduct the research effectively.

## Preparing stay in Nepal

With the knowledge of my intended stay in Nepal, I proceeded to make the necessary preparations for the upcoming trip. The first step involved obtaining a permit from the Norwegian Centre for Research Data (NSD) to ensure compliance with data collection regulations (Appendix 5). This required careful planning of the types of data to be collected during the research, which included the creation of an interview guide (Appendix 1). Furthermore, in consultation with Prof. Dr. Sunil Kumar and Prof. Dr. Sunil Raja Manandhar at KMC, I submitted an application for a research permit through the Institutional Review Committee (IRC) at KMC, which was promptly approved (Appendix 6).





## Practical preparations

Prior to the trip, several practical preparations were made. These included applying for a Nepali visa, purchasing flight tickets, arranging accommodation, acquiring the necessary equipment and printing out essential research documents and travel document.

## Meeting with Anders Aune

As part of the preparation process, I travelled to Trondheim to visit Picterus' office and meet with Anders Aune, the chief medical officer and founder of Picterus. During our meeting, we had a brief discussion about the project, and I got the opportunity to meet some of the developers and see their ongoing work. Since Picterus is not yet available on any app store, I was provided with a phone containing a pilot version of the app and calibration cards. These resources would be important for conducting the upcoming user tests in Nepal, allowing me to perform scans using the app.

## MEETING WITH EXPERTS

### Why?

At two different stages in the insight phase, I consulted with experts to gather insights and knowledge. I reached out to two pediatricians from Norway, with experience from working in Norway and Nepal respectively. Insights from these meetings helped shape the methodology and further work of my study, as well as preparing me for the travel to Nepal.

## Meeting with Kristin Brække

Before starting any desk research, I reached out to Kristin Brække, a pediatrician at Oslo University Hospital, Ullevål, whom I already knew, to obtain a better understanding of the subject of neonatal jaundice. We had a talk at her office and a look around at the neonatal unit at Oslo University Hospital, Ullevål.



## Takeaways from the conversation

- Accurately assessing the degree of yellowing in a newborn's skin can be notoriously difficult even for experienced clinicians.
- Insights into what neonatal jaundice is, and the standard procedures used in Norwegian hospitals to diagnose and treat neonatal jaundice.
- Knowledge regarding the potential of technology used in the Apple Watch which can measure oxygen saturation in the blood. This could be a useful inspiration for Picterus to consider in its development.

## Meeting with Erik Bøhler

Kristin Brække recommended I speak to Erik Bøhler, a retired pediatrician she knew with extensive experience of working in Nepalese hospitals through missionary work. As I was not in Norway at the time, I arranged a phone call with him to seek his general insights about the health care system, culture, and people of Nepal, which would help me prepare for my further research activities. Given his expertise, I did not expect him to provide design methodology support for my project.



### Takeaways from the conversation

- The capital of Nepal, Kathmandu, has well-established infrastructure and is vastly different from the rural areas of Nepal. He mentioned that the universities of Kathmandu might be biased in the research they conduct, overly focusing on the upper-middle-class in Kathmandu, missing out on significant information from the rural areas.
- Bøhler believed Nepalis in general have a positive attitude towards Westerners.
- Mainly doctors and students (and people with higher education) tend to speak English. Most people outside of Kathmandu speak little English, making it challenging to learn about Nepali culture in such a short period that I was going to stay.
- Bøhler believed that Nepalis are generally more accepting to being photographed than people in Norway.
- Some may be hesitant to sign consent forms for research, and oral consent may be more practical in such cases.
- Bøhler also noted that Nepal has a «wonderful range of skin colours», which can pose challenges for scanning technologies like Picterus.
- Health services in Nepal often operate on a pay-per-service basis.
- Innovative health technologies need to be precise and accurate, particularly in the critical early days of a newborn's life.
- Picterus could be particularly relevant in areas where access to necessary help is limited.





# BACKGROUND

In this chapter I, will present the findings from the desk reserach on jaundice, the healthcare system in Nepal and mHealth.

## Jaundice

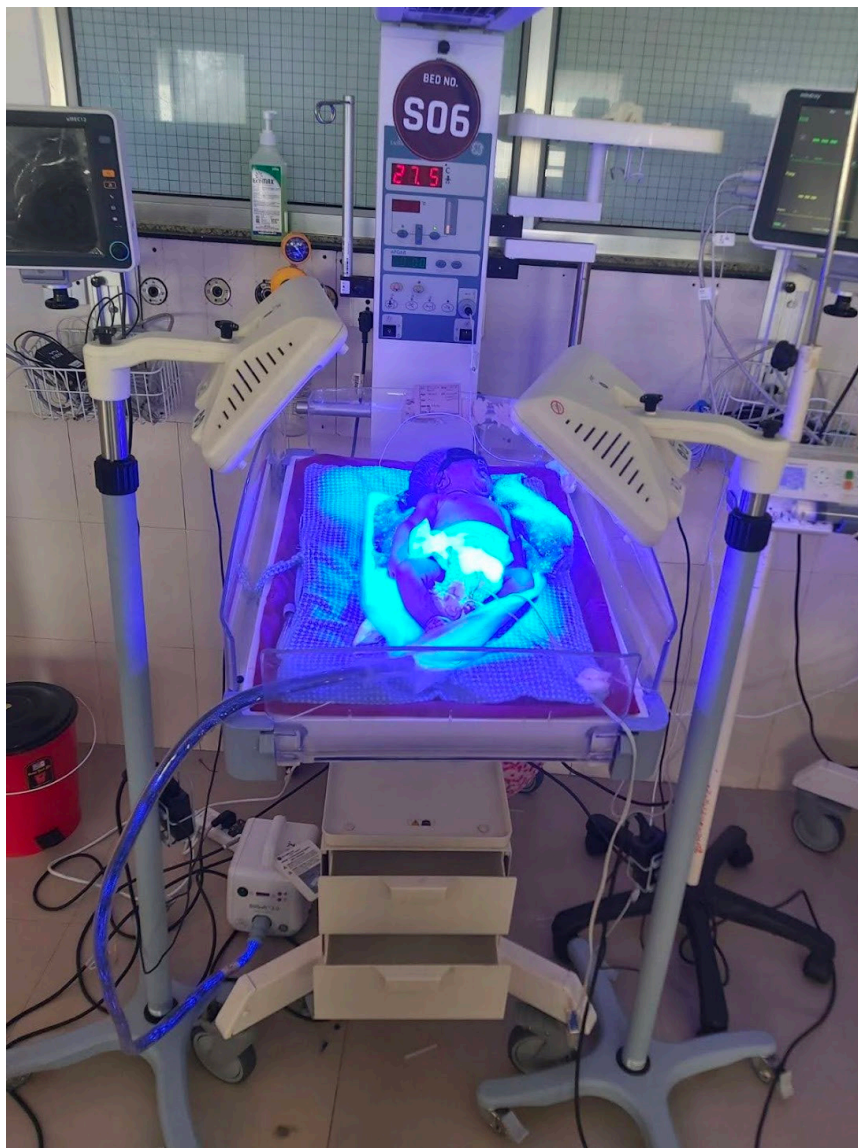
Jaundice is a common condition characterized by the yellowing of the skin and eyes due to the buildup of bilirubin in the body (Joseph, 2023). Bilirubin is a yellow waste product produced in the body when old red blood cells are broken down. It travels to the liver, where it is processed and made water-soluble, before it is excreted in the urine and stool. However, when there is too much bilirubin in the body (hyperbilirubinemia), it can build up and cause jaundice. The buildup of too much bilirubin in the body can be caused by various factors such as liver disease, hemolytic anemia (red blood cells are destroyed or removed from the bloodstream faster than they can be replaced) or obstruction of bile flow.

any illness, it can cause complications if left untreated, resulting in a condition known as kernicterus, which can later present as complications such as hearing loss and cerebral palsy. In the most severe instances, it can also result in mortality. Only around 10% of cases progress to levels of bilirubin that need treatment (Ullah et al., 1996). Early identification and management of jaundice is essential to prevent further complications.

## Neonatal jaundice

When elevated levels of bilirubin are found in babies younger than 4 weeks, it is called neonatal jaundice (NNJ). This is one of the most common conditions in neonatology and occurs in 50% to 70% in term babies and in 80% of preterm babies (BMJ Best Practice US, n.d.). Most commonly, it occurs between the second and fourth day after birth. Although NNJ is usually not a dangerous condition and typically resolves without





A newborn undergoing treatment for NNJ. Kathmandu Medical College, Nepal.

## Detection practices for NNJ

There are different practices for detection of NNJ. These are the most common ones.

### Visual inspection

Visual inspection involves observing the colour of the baby's skin and sclera (eye), and look for yellowness. This is often not recommended, as it has an increased risk of missing cases. It is also difficult to detect yellowness in darker skinned babies.

One way to do a clinical visual scanning, is by using Kramers scale. This is a quick non-invasive method of assessing the degree of jaundice by doing a visual inspection (Kramer, 1969). The scale was developed by Lloyd I. Kramer in 1969. The body is divided into 5 zones, where each zone, in which the jaundice is visible, corresponds to a level of bilirubin levels.

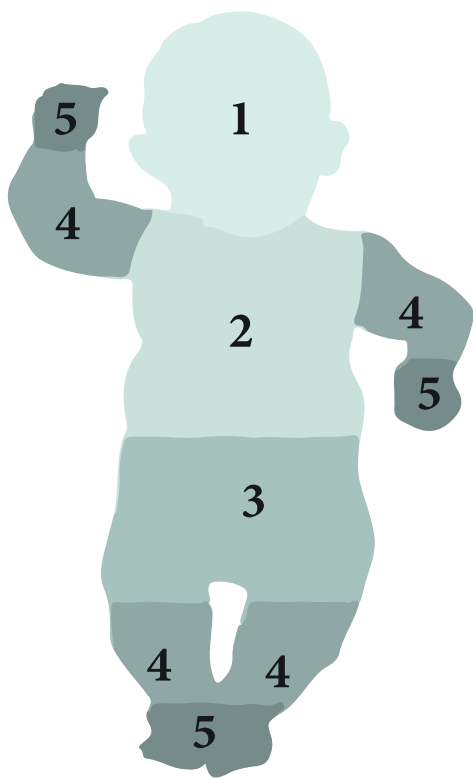
### Transcutaneous bilirubinometry

This is a clinical instrument which measures bilirubin levels non-invasively by shining a special light through the skin, reading of the bilirubin level. This is a quite expensive instrument, costing around 50 – 60 000 NOK (approximately 5000 USD).

### Serum bilirubin measurement

This method involves taking a blood sample of the newborn to measure bilirubin levels.

# Kramer’s scale



1	4-6 mg/dL	70-100 μmol/L
2	8-10 mg/dL	130-170 μmol/L
3	12-14 mg/dL	200-240 μmol/L
4	15-18 mg/dL	250-310 μmol/L
5	15-20 mg/dL	> 250 μmol/L

## Neonatal health care in Nepal

Nepal faces many health-related challenges. A study conducted by Acharya & Poudel (2020b), found that neonatal health care practices in a rural area in Nepal often are poor, unsafe and not satisfying. As a large part of the Nepalese population are living in rural areas, they face difficulties having adequate access to health care services. Further, the study showed that factors such as level of education, the mother's age and place of delivery are associated with the quality of the health care practice. According to the Nepal Demographic and Health Survey 2016, the average age at first birth for women in Nepal was found to be 20.4 years (Ministry of Health, Nepal, 2016). The study also revealed that a significant number of women in Nepal have lower levels of education and live in rural areas. These findings, therefore, suggest that there may be challenges in accessing quality health care for many women in Nepal.

However, government incentives have throughout the years tried to improve the health care system. Nepal's health care system has undergone significant improvements since signing the Alma Ata declaration in the 1970s, a conference where representatives from 134 countries committed to achieving "Health for All",

which emphasized the importance of primary health care (PHC) in improving population health outcomes (Karkee & Jha, 2010). The Nepalese government has since made PHC a cornerstone of its national health policy, with a focus on expanding affordable, reliable, and high-quality PHC services, especially to rural and marginalized populations.

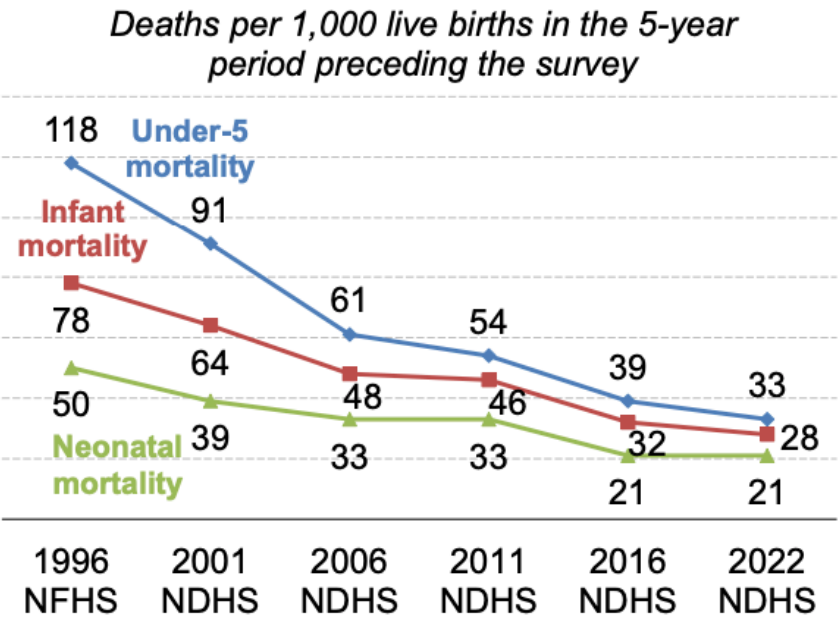


Furthermore, in 2015, the Ministry of Health and Population in Nepal launched their Nepal Health Sector Strategy (Government of Nepal, Ministry of Health and Population, 2015). The report came as a response to the government's vision to develop Nepal from «Least Developed Country» to «Middle Income Developing

Country» by 2022. Further, the report presents that over a 25-year period from 1990, Nepal managed to reduce their infant mortality rate by 67%, and maternal mortality rate by 76%. However, they also state that less progress has been done in terms of neonatal mortality. Given that 85% of all deaths among children under the age of 5 occur within the first year of life, with 64% happening within a month, and considering the neonatal mortality rate in Nepal was 21 per 1000 live births in 2022, this issue is important to address (Ministry of Health and Population, Nepal, 2022). As the government continues to focus on neonatal health care, they have set a goal to reduce the mortality rate to 12 per 1000 within 2030.

NNJ in Nepal

NNJ remains a significant health concern in Nepal. In the last 20 years, NNJ was the 7th leading cause of neonatal mortality in South Asia (Olusanya et al., 2018). Prevention measures, including maternal education and access to health care facilities, are important in addressing this issue. In Nepal, the current common practices in hospitals for detection of NNJ involves taking blood samples and visual assessment using Kramers scale (Roma



et al., 2017). A study conducted at Kanti Bal Hospital in Kathmandu, reported that 94.5% of babies with NNJ were cured, while the mortality rate was 5.5% (Nepal et al., 2009). In comparison, the mortality rate for «Hemolytic disease and other neonatal jaundice» in Norway was 0.3 per 100 000 in 2016 (Folkehelseinstituttet, 2018).

A study conducted in 2019 assessed the knowledge level of women regarding neonatal jaundice, in an area near Kathmandu (Shrestha et al., 2019). The findings revealed that while the majority of the respondents correctly identified yellowness in the eyes as a sign of jaundice, their overall knowledge about the causes, danger signs and treatment of neonatal jaundice was reported to be poor. As discussed earlier, this lack of knowledge increases the risk of neonatal jaundice mortality.

Overall, neonatal jaundice remains a significant health threat in Nepal, particularly in areas with limited health care infrastructure and low awareness.

## mHealth

mHealth (mobile health) is a relatively new term and refers to the use of mobile technology such as smartphones, tablets, and wearable devices to support health care services. These approaches have the potential to improve health outcomes,

especially in less developed countries, by making health care services more accessible and reducing the cost of health care (Van Veen et al., 2019). However, the adoption and success of mHealth approaches are affected by factors such as access to mobile phones and internet connectivity, literacy rates, the economic situation and existing health infrastructure.

A systematic review by Free et al. (2013) showed that mHealth interventions were successful to help people improve their health behaviors, take medications as prescribed, and manage chronic diseases better. mHealth approaches are increasingly being recognized as a promising strategy to address health care challenges. Due to the low cost of mHealth approaches, we see an increased use of mHealth in low- and middle-income countries, which have resulted in increased access to health care and improved health outcomes (Lee et al., 2014).

In Nepal, where there is a shortage of health care providers and challenges in accessing health care services, mHealth has the potential to improve health outcomes and make health care more accessible. Nepal would also be a country benefiting from the low cost of mHealth approaches, given the economic situation the country is in, being classified as a lower-middle-income country by the



World Bank (World Bank Country and Lending Groups – World Bank Data Help Desk, n.d.).

However, there are several challenges connected to mHealth approaches in Nepal. A study by Parajuli et al. (2022) identified inadequate technical facilities, such as lack of internet and electricity, especially frequent power cuts, to be one of the main challenges in implementing mHealth initiatives in Nepal. As less than 85% of Nepali households have access to electricity, this continues to cause challenges. Further, they also discuss the lack of technological competence in Nepal being a challenge.

### mHealth approaches for NNJ

mHealth approaches targeting neonatal jaundice have been the subject of growing interest in recent years due to the potential for these technologies to improve the diagnosis, monitoring, and potential treatment of this common condition, especially in low- and middle-income countries. A study from Ghana by Enweronu-Laryea et al. (2022) found that using a smartphone app as a screening tool for neonatal jaundice, could be considered a feasible tool also in similar settings to Ghana. Another study from India by Lingalidina et al. (2021) found that a mobile app for detecting neonatal jaundice can complement existing methods, and potentially reduce the number of invasive blood samples taken from neonates.



## Picterus

Picterus is a smartphone app that estimates newborn jaundice levels. It can be used for screening and monitoring jaundice, and works by analyzing digital images of the newborn's skin, taken by a smartphone camera. It uses highly accurate colour calibration algorithms which makes it possible to take pictures in different light settings, as well as for different melanin levels in the skin. Currently, there are several research projects ongoing in different countries such as Mexico, USA, Germany and Indonesia (Díaz, 2019). These types of research are important enhance the adaptation of the service in different countries, cultures and settings.

The potential benefits of using this app for early detection and monitoring of neonatal jaundice are significant. It has the potential to reduce health care costs, improve health outcomes, and ultimately save the lives of affected infants. By enabling timely and accurate diagnosis of neonatal jaundice, the app can help health care professionals provide appropriate treatment and interventions, thus preventing serious complications and reducing mortality rates associated with the condition.



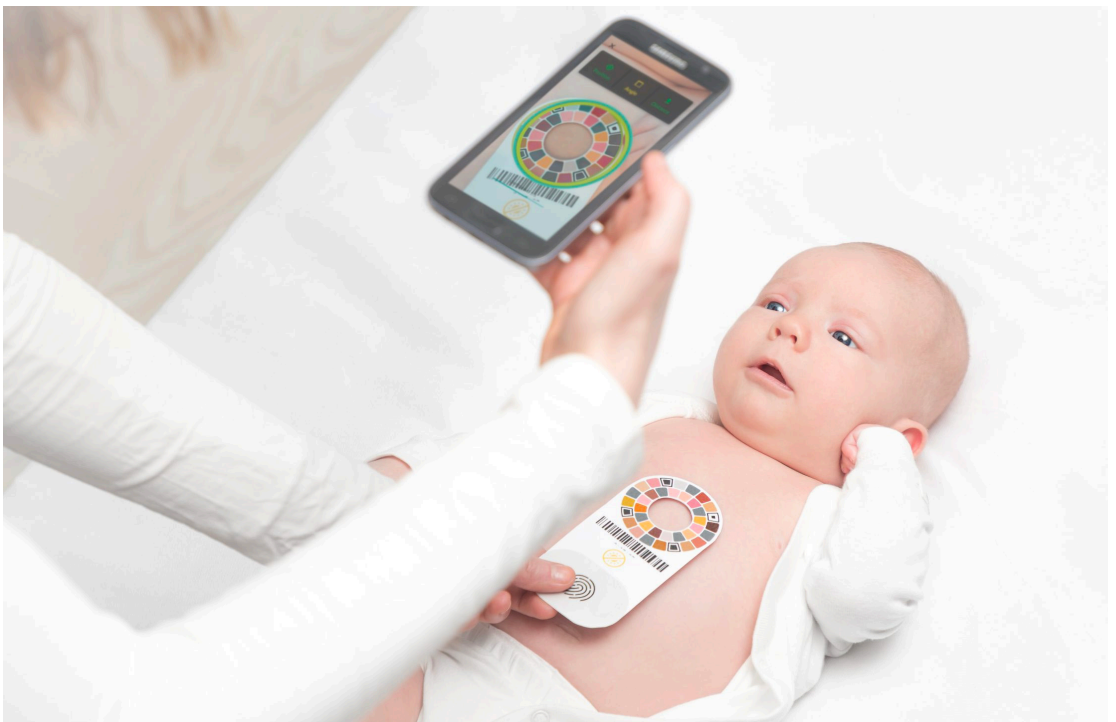


Photo: Picterus. [www.picterus.com](http://www.picterus.com)







# TRIP TO NEPAL

In this section, I will outline the events and practicalities from my trip to Nepal in March 2023.

## Kathmandu Medical College

Kathmandu Medical College (KMC) is a private medical college in Nepal. It was established in 1997, and offers a range of medical services such as neonatal intensive care unit, pathology services and 24 hours emergency. KMC consists of two complexes: one in Sinamangal, Kathmandu, and one in Duwakot, 30 minutes outside of Kathmandu. Most of the services are provided in Sinamangal. The complex in Duwakot was hard struck by the earthquake in Nepal in 2015, but now operates emergency services and has a general OPD (Outpatient Department) Service. Additionally KMC sends resident doctors in shift in some rural areas, included Sipaghat; a small rural village 3 hours drive from Kathmandu.

KMC offers undergraduate and graduate medical programs, including MMBS, nursing and postgraduate residency programs. The hospital serves as a clinical training site for its students.







## Visiting KMC

In March, I traveled to Nepal with a goal of collecting the data I needed for the thesis. After my arrival in Kathmandu, I quickly scheduled a meeting with Prof. Dr. Sunil Raja Manandhar to discuss the project and plan for data collection. Prior to this meeting, we had not yet made any specific plans on where the interviews and user tests would take place or who the participants would be. The meeting took place in his office in KMC Sinamangal in Kathmandu. After discussing my needs to collect data in different geographical settings, we made a plan looking like this:

### First week

Interviews and user tests in KMC Sinamangal

### Start of second week

Interviews and user tests in KMC Duwakot

### End of second week

Interviews and user tests in a health post in Sipaghat

### Third week

Focus groups in KMC Sinamangal

The primary objective of this plan was to try to ensure data collection from diverse participants belonging to an urban, semi-urban, and rural setting. However, I faced unexpected challenges in collecting enough data from Duwakot and the rural health post in Sipaghat, resulting in a limited data collection from a rural setting. Instead, the majority of the data was collected from the urban setting in Sinamangal. As a result, I had to adapt the scope of the project and readjust parts of the research question to reflect this change in data collection, focusing more on the urban setting.



In KMC with Prof. Dr. Sunil Raja Manandhar

## Current NNJ detection practices at KMC

For the current NNJ detection practices at the hospital, two methods are being used: visual scans and blood sample tests. Doctors and nurses visually assess the newborns on a daily basis, noting any changes in skin colour from the previous day. If any abnormality is observed, the Kramers scale is used for further evaluation. In cases where the calculated levels indicate high bilirubin

levels, doctors proceed with a total serum bilirubin test (blood sample). This test is conducted within the hospital and typically takes 1 – 2 hours for the results to be returned. Based on these results, the doctors determine whether treatment options such as phototherapy, Biliblanket, or, in severe cases, blood transfusion, are required.



# METHODOLOGY

In this chapter, I will explain the methodology which guided my research, as well as specific the methods used. I also explain how I have interpreted and adapted these methods to the thesis.

## Double Diamond



The Double Diamond has played an important role in organizing and structuring my design process. By breaking the process into four distinct parts – insight, analyze, develop, conclude – the Double Diamond provides a clear roadmap for navigating through the project (Ball, 2022). It has allowed me to effectively communicate the progression of my work and ensure a systematic approach to design. However, it is important to note that the Double Diamond should not be seen as a rigid, linear process. I have used its flexibility to move back and forth between the different stages when needed, enabling a more iterative and adaptable design approach.

## INSIGHT

### Desk research



Desk research is a method that involves reading and assessing existing literature on specific topics, providing a basis for the understanding of a thesis (Snyder, 2019). Conducting a broad and critical literature search is important in any research. During the thesis, I conducted a literature study to learn about jaundice, medical terminology, mHealth and relevant research findings. This assisted me to establish a framework and develop informed research questions and decisions for my study.





## Semi structured interview

Semi structured interview is a method used to collect qualitative data from participants and is commonly used in design research. It offers a balance between structured and open-ended questions, which allows the interviewer to go deeper into areas of interest during the interview (Denscombe, 1998). I created an interview guide which was adapted to each interview and setting. It was based on questions around three key topics: «The participant and the hospital», «Jaundice» and «Picterus and technology». This method provided me with a lot of significant insights into the perspectives of the participants.



## User testing

User testing is a valuable method for improving the user experience for any application. It involves observing users as they use and interacts with the application, and gathering their feedback on its usability, functionality and design (Barnum, 2010). This feedback can then be used to make improvements and ensure that the app meets the needs of its end users. After conducting each interview, I conducted a user test of Picterus with the doctors and nurses. As the health workers were not so familiar with this method, I designed a simple user test that prioritized the quality of the feedback rather than quantity. I asked them to complete some basic tasks while using the app and explained the «think aloud»-method (Eccles & Aarsal, 2017), to enable me to track their thought process along the way. Think-aloud is a simple and effective method that can be used even with users who have little to no experience with user testing. Their feedback was written down and documented by me while I was watching, without any filming or audio recordings. The questions and tasks is included in the appendix (Appendix 2).

## Focus group

To complement and further follow up the insights gathered from the interviews and user tests, two focus group were carried out in this study. A focus group is a qualitative research method and often involves a small group of people, brought together to discuss a specific topic or develop a product or service (Plummer-D'Amato, 2008). It can be useful to collect detailed feedback and suggestions from relevant stakeholders, and allows for a collaborative and interactive discussion, enabling exploration of different perspectives and generation of ideas. As a moderator, it is important to create a safe and open environment that encourages discussion, and ask follow-up questions to deepen the understanding of the participants perspectives.



In this study, two focus groups were conducted, and aimed to delve into the healthworkers thoughts on the application, specifically exploring areas for potential improvement and challenges connected to implementation. The first focus group, conducted together with three doctors, aimed to map out two scenarios related to the first period of a newborn's life: a healthy newborn and a newborn with jaundice. Through these scenarios the potential situations where Picterus could be used was identified, and the potential improvements of the user experience and challenges regarding the app were discussed. The second focus group session involved nurses and aimed to explore the same areas as the doctor's session, without mapping the newborns life. However, the format was designed as an ideation workshop, where participants used sticky notes to generate rapid ideas within a limited timeframe (Dove et al., 2018).

These discussions allowed for further exploration of the app's usability, design, and features, as well as any additional challenges and suggestions from the participants.

## ANALYZE

### Inductive coding



Inductive coding is a method which can be used in qualitative research, like interview analysis, to identify and discover patterns and categories in the answers (Sarker et al., 2000). It involves looking closely at the data and create different labels for interesting insights, which are further grouped into broader categories. In this thesis, I used inductive coding to help me make sense of all the answers from the interviews. This helped me to identify the key insights for the needs, attitudes and challenges of the health workers.

### Empathy mapping



Empathy mapping is a method that enables designers to gain a deeper understanding of the users they are designing for (Siricharoen, 2020). By trying to put themselves in the shoes of the users and empathizing with their needs, thoughts, and concerns, designers can develop a more human-centered approach to problem-solving. This method assisted in visualizing and organizing the findings obtained during the insight phase, by identifying and highlighting common patterns for the needs, attitudes and challenges of the health care workers.

### User journey map



A user journey map is a valuable service design tool that visually illustrates the complete user experience, capturing the various touch points, interactions, emotions and pain points throughout their journey (Chasanidou et al., 2015). It provides a comprehensive view of a users interaction with a service. This method enabled me to gain a holistic understanding of the user's perspective, identifying pain points and opportunities for improvement.



### Stakeholder map

A stakeholder map is a method used to identify various individuals or groups involved in a particular service (Stickdorn & Schneider, 2012). Stakeholder mapping gathers information about the different stakeholder's roles, responsibilities, and concerns to assess their influence and support decision-making for designers. In this study, stakeholder mapping was used to understand the different stakeholders involved in improving the implementation and usage of Picterus in KMC. This process allowed the identification of areas that could be improved to enhance the overall user experience of Picterus as a service. This insight guided me in understanding how and where I could contribute meaningfully.

## DEVELOP

### Prototyping

Prototyping is a method that involves creating versions or models of a service to test and refine its functionality, usability, and user experience (Hasso Plattner Institute of Design in Stanford, 2013). It allows designers to gather feedback, identify issues, and make informed design decisions.



Figma is an effective digital prototyping tool, that offers numerous advantages for creating different prototypes, such as mobile applications. It enables designers to develop realistic wireframes to showcase the functionality and user experiences of an application. With Figma, it is also simple to share prototypes with others for feedback and evaluation. Figma's prototyping capabilities were a valuable tool for me in visualizing and developing new app designs for Picterus, based on the feedback from user tests.

### Study participants

A total of 23 participants were included in the interviews and user tests, with one additional participant attending one of the focus groups. The participants consisted of doctors and nurses, including MD residents, intern doctors, and one general practitioner, aged 20-40, with the majority being between 25 and 32 years old. The majority of the participants worked in the Neonatal unit at KMC or had prior experience with neonatal care, and were chosen individually together with Prof. Dr. Sunil Raja Manandhar.







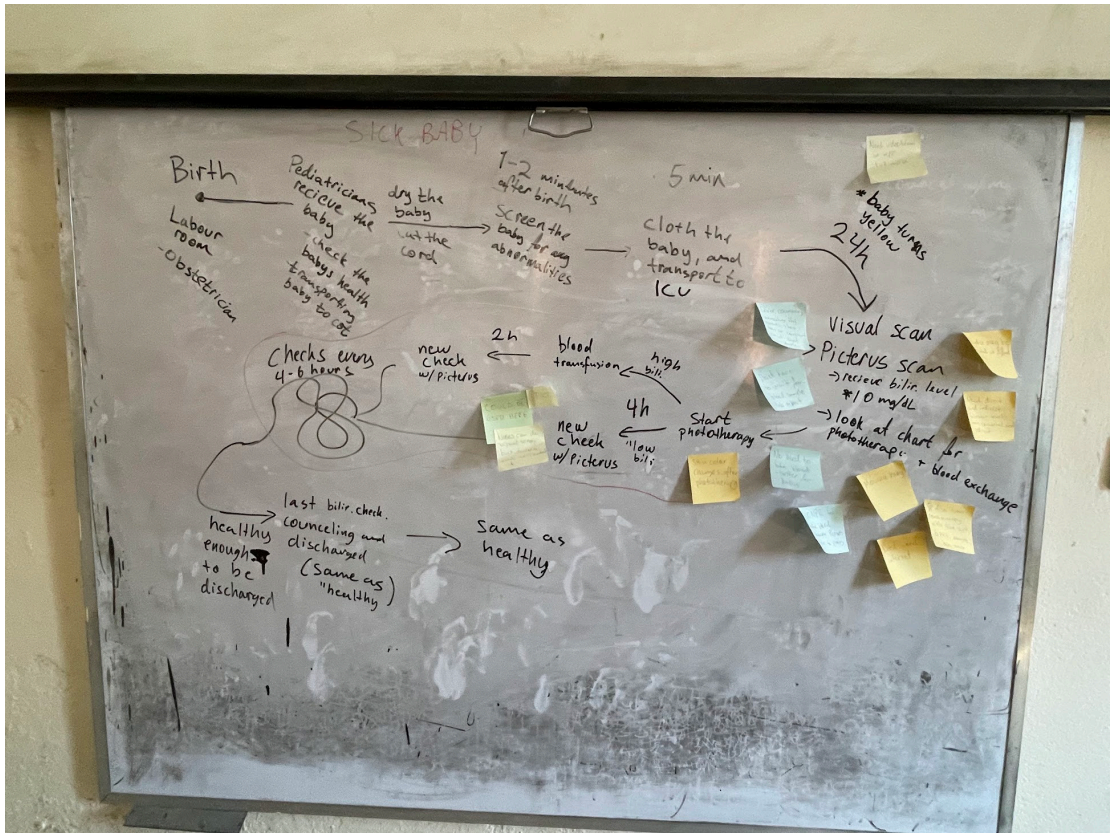












check list. Janice (visual) included.

12h  
up on  
baby  
(mother)

**DOCTOR**  
- to do rounds

USE APP  
AFTER 12  
HOURS

Preferably shared  
phones, but  
realistically parent  
Do not have a  
shared  
because of  
HISTORY

Surveillance  
system, to be  
sure that the  
baby is checked  
every 12h

2h

new  
check  
Picturus

**DOCTOR**

COULD BE  
USED HERE

Nurses can do  
visual scan,  
but doctors  
need to confirm  
it

new  
che  
w/ Pict





# ANALYSIS

In this section, I will present the analysis of the answers from the interviews, the feedback from the user tests, and insights from the focus groups I had with the health workers.

## ANALYSIS OF THE INTERVIEWS

To analyze the answers from the 23 interviewees, I made a document for each of the questions asked and filled in all the corresponding answers in the file. I used an inductive coding approach, colouring different answers with the same content, and then grouping them into common topics (Appendix 7). According to my research question, I coded answers under three categories:

### NEEDS - ATTITUDES - CHALLENGES

Some of the topics address the existing conditions in the hospital, while others focused on the introduction of new technologies and the potential implementation of Picterus. The needs primarily relate to the existing conditions, while the attitudes and challenges mainly address the prospect of new technologies and the potential implementation of Picterus. I will now present the most important findings within these three categories.

## NEEDS

### Save time

The needs of the doctors and nurses I interviewed, can be categorized into several key areas. One of the primary needs identified, was to save time. Analyses of the answers indicate that saving time would be an efficient contribution to reducing the workload of doctors. Additionally, there are indications that reducing the time for the newborn to get the right treatment after suspecting jaundice also would be beneficiary. Further, one participant stated that they often don't have too much time to do a proper examination. Below are two examples from two doctors stating the need to save time.

*"The tests (for jaundice) we are doing now, take a long time. 20 minutes for preparing, then sending babies around. In total it takes around one hour to get the blood just to the lab, then another hour to get the results",*  
male 33

*"New technology should come, because it makes our work more easy of course, and decreases our workload.",* female 20

## Objective visual screening

An objective visual screening tool is another need identified by the doctors and nurses. Current detection practices highly rely on a subjective opinion of how yellow the skin of the baby looks like to the eye. Additionally, they said that they are doing the best screenings in the morning rounds, and that daylight plays an important role for detection. One doctor said that they sometimes find high levels of bilirubin in the blood, after not seeing much yellowness in the skin, while another stated:

***"Our assessing is individual, and subjectively varies. Some might see it, some not. If you are a good pediatric, you might see it very easy, while some might not see it.", male 28***

## Non-invasive treatment method

Another need identified was the need for a non-invasive detection method. This was something many of the doctors and nurses mentioned, discussing the consequences of blood samples like the risk of infections, the pain the newborn suffers and that some parents feel stressed about their baby having to go through invasive methods. This would be

eliminated with non-invasive methods. Additionally, some expressed that it would be easier for the health worker to avoid doing invasive methods.

***"Taking blood out of the vein is so much more complicated. No blood loss, no pain, no crying.", male 28***

## Easy usability

Ease of usability, as well as fast learning of new tools and technology, is another key need identified. As one nurse stated, new technology should be standardized, and people should know how to use it after only a few attempts.

## Better detection practices for babies with darker skin

The doctors and nurses highlighted the need for better detection practices for babies with darker skin types, as the yellowness in the skin is harder to detect.

Additionally, they also expressed the need of being up to date with technology, provide precise information in follow-up conversations with parents and providing parents with economical solutions in neonatal treatment.

In conclusion, the needs of the doctors and nurses are diverse, but specific, ranging from saving time to reducing the burden of newborns. By addressing these needs, I am hoping to use these to increase the chance of a successful adaptation of the application, leading to improved patient outcomes and a better overall health care experience.

## ATTITUDES

### Technology

The attitudes of the doctors and nurses towards technology and its role in the medical field are overall positive. Most of them express excitement, interest, and eagerness to test new technologies and also to learn more about them. Many find new technologies helpful in their work, as they can save lives and decrease the invasiveness of treatment methods. They also express a desire for more technology to be available and an openness to adapt to these new technologies. However, at least one felt a sense of envy towards other countries that have more advanced technologies, which suggests a desire for the health care system to catch up with the rest of the world. Some doctors expressed scepticism towards new technologies and preferred to have solid proof of their effectiveness before fully adopting

them. They emphasized the importance of comprehensive documentation of the efficacy of new, innovative solutions, such as Picterus.

***“There is so much coming, and lives are saved by the new technology. Less invasive methods are very helpful. These new technologies are a huge blessing in the medical field. This is very positive. If there comes some new technologies, I would like to learn them.”, female 25***

***“Is it (Picterus) effective? I would like to do both blood sample and mobile to be sure.”, male 28***



## Picterus

The health worker's attitudes towards a possible implementation of Picterus was generally positive. They were welcoming to this new technology and also perceived it as potentially helpful for their work. The non-invasive method was seen as beneficial and was considered safe.

*“Since this is not an invasive procedure, I think it will be very welcomed.”, female 27*

*“[...], when you have this app, there is no subjectivity, and I would obviously enjoy it.”, male 28*

## Communication with parents

Some doctors expressed a positive attitude towards communicating with parents of newborns who have been in the hospital via eHealth (the use of information and communication technologies for health services and information) appliances.

*«We can easily communicate on phone with them. They are often calling us with questions regarding everything. This is fine for me.»*, female 28

## Use of mobile phone

Some doctors were concerned about using their phone in combination with dealing with neonates, due to the risk of spreading bacterias and radiation from the phone.

*“The phone is full of bacteria. The phone is for personal use. When many people are working in a health post, and all touch the phone to scan, it can be difficult.”, female 25*





## CHALLENGES

### Lack of motivation of health workers

I identified several challenges potentially faced with an implementation of new technologies and mHealth approaches as Picturus. One of the main concerns was a lack of motivation to adapt to new technologies, particularly among older health workers who may be resistant to changing their long-time established practices.

***"Maybe there is a lack of motivation also. We come here, do our duty and then go home. The initiative must come from the management.", female 40***

### Economy

Another challenge was the expense associated with introducing new technologies, which could place a financial strain on the hospital.

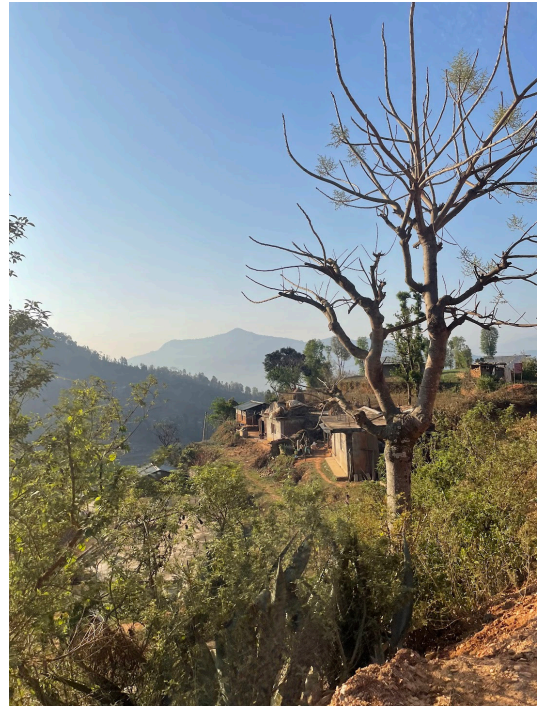
***"There is always a problem of economy. The main factor for technology not coming is economy.", female 40***

## Paper-based documentation

Additionally, the documenting process of the patient results presents a challenge when using new technologies, given that many health care facilities continue to use paper-based systems for patient data management.

## Access to treatment

Limited accesses to treatment facilities in many rural areas also poses a challenge, potentially restricting the impact of technologies such as Picterus. Several doctors and nurses highlighted that identifying high bilirubin levels in a baby is just one part of the equation - the availability of necessary facilities to treat the condition is equally crucial.



## Use of mobile phone

As highlighted in the "Attitudes" section, some health workers expressed concerns about using mobile phones in the presence of babies. This presents a potential challenge for implementing Picterus as well.

## Foreign technology

Lastly, one nurse expressed concerns and scepticism regarding Picterus being a product from a foreign company. This could also be interpreted as a sceptical attitude towards the adoption of Picterus, and could make a possible implementation more challenging.

## FINDINGS FROM THE USER TESTS

Following each interview, a simple user test was conducted to familiarize the doctors and nurses with Picterus and gather their feedback on its functionality, usability, and design. Although the feedback was limited, some noteworthy findings emerged from the user tests.

### Difficulty in locating instructions

Many of the health workers struggled to locate where to read the instructions for how to use the application. Some of them used much time, and others had to be guided by me in the end. Once finding the instructions, they seemed easy to read and understand, other than that some pressed a link on the first page of the instructions, leading them to an external web site, creating confusion.

***"Finding the instructions was a little confusing", female 27***

### Taking a picture

Almost all participants encountered challenges in maintaining the correct distance, angle, and camera position during a screening. "It's not working," one nurse remarked, believing she was using it correctly by keeping the calibration card within the camera's view. However, she did not realize that the angle and distance were incorrect,

even though there was feedback on the screen indicating this.

***"Oh, it has to be all green", male 33, 15 seconds after unsuccessfully trying to capture an image.***

Many were also confused about whether the pictures were being taken automatically. Some even pressed the loading bar, mistakenly believing it was the button for capturing the images.

***"Is it supposed to take pictures automatically?", female 34***

Furthermore, some expressed their impatience with the process of taking the necessary six pictures for a scan, which resulted in difficulties in keeping the phone steady, extending the process even further.

One doctor expressed uncertainty if the app was working properly when the flash, which is supposed to be activated for three of the photos, didn't work due to the phone's low battery.

### Reading results

All health care workers understood how to interpret the bilirubin results provided by the app and nearly all knew the calculations needed to convert between  $\mu\text{mol/L}$  and  $\text{mg/dL}$ , the two units used in the application.

### Changing settings and viewing history of results

Some health care workers struggled to locate the settings for switching between  $\mu\text{mol/L}$  and  $\text{mg/dL}$  within the app, however, none had trouble identifying the history of results.



## FINDINGS FROM THE FOCUS GROUPS

### Focus group with doctors

In order to build upon the insights gained from the interviews, two focus groups were conducted, involving three doctors and three nurses in each session. In the first focus group, with the doctors, we explored two scenarios representing the initial stage of a newborn's life: one scenario involved a healthy newborn and another scenario involved a newborn developing jaundice. During this session, we specifically searched to identify potential areas where the application potentially could be utilized and to understand the needs and concerns of the doctors in regards to this.

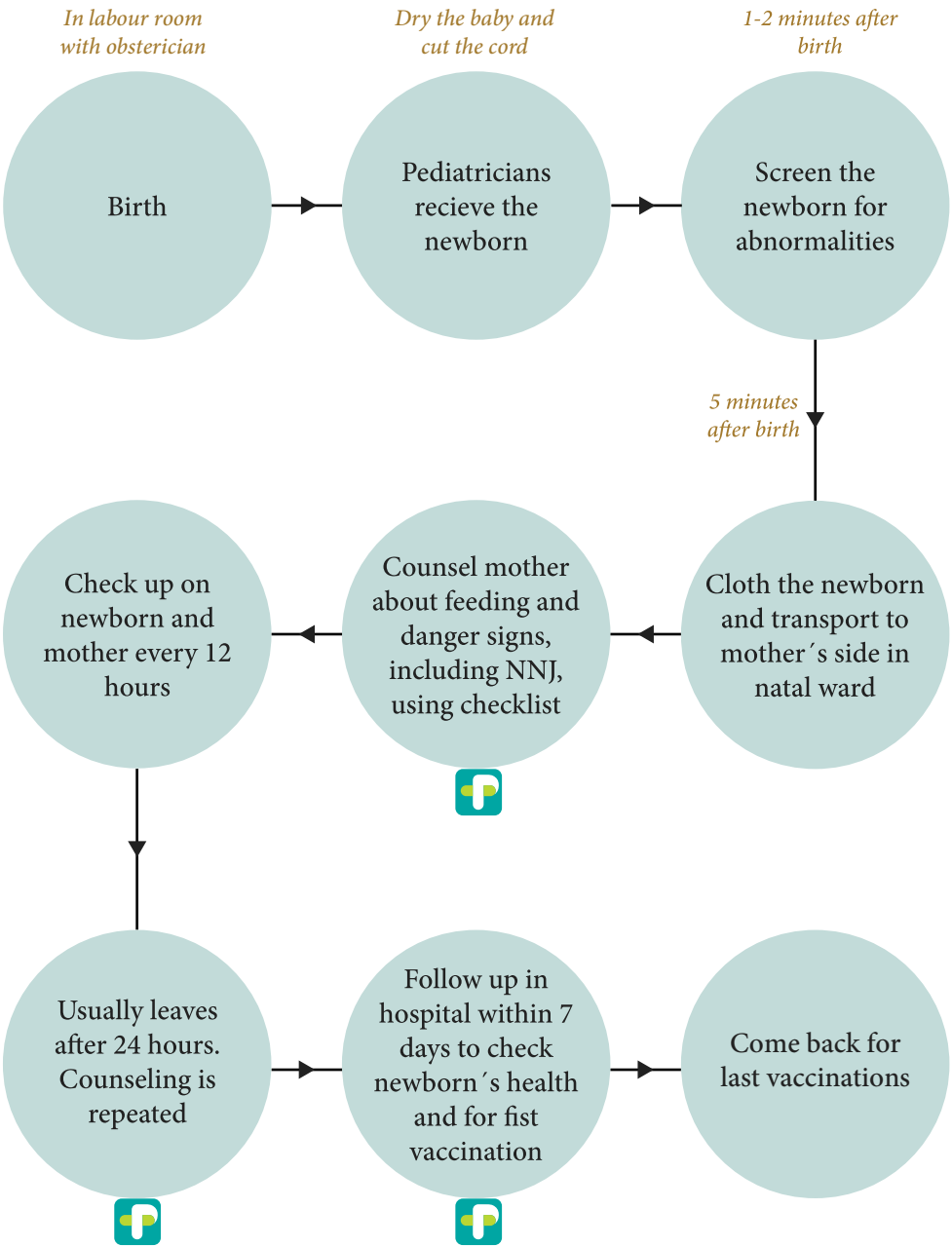
First scenario: healthy newborn



Note



Use Picterus



The exploration and mapping of a healthy newborn's first weeks of life highlighted three distinct situations where the app potentially could be utilized:

1. During check-ups of both the mother and the baby in the post natal ward.
2. Prior to the discharge of the baby from the hospital.
3. During subsequent follow-up visits in the weeks following birth.

It was determined that the doctors would be responsible for performing the scans using the app in all these scenarios.



## Second scenario: sick newborn

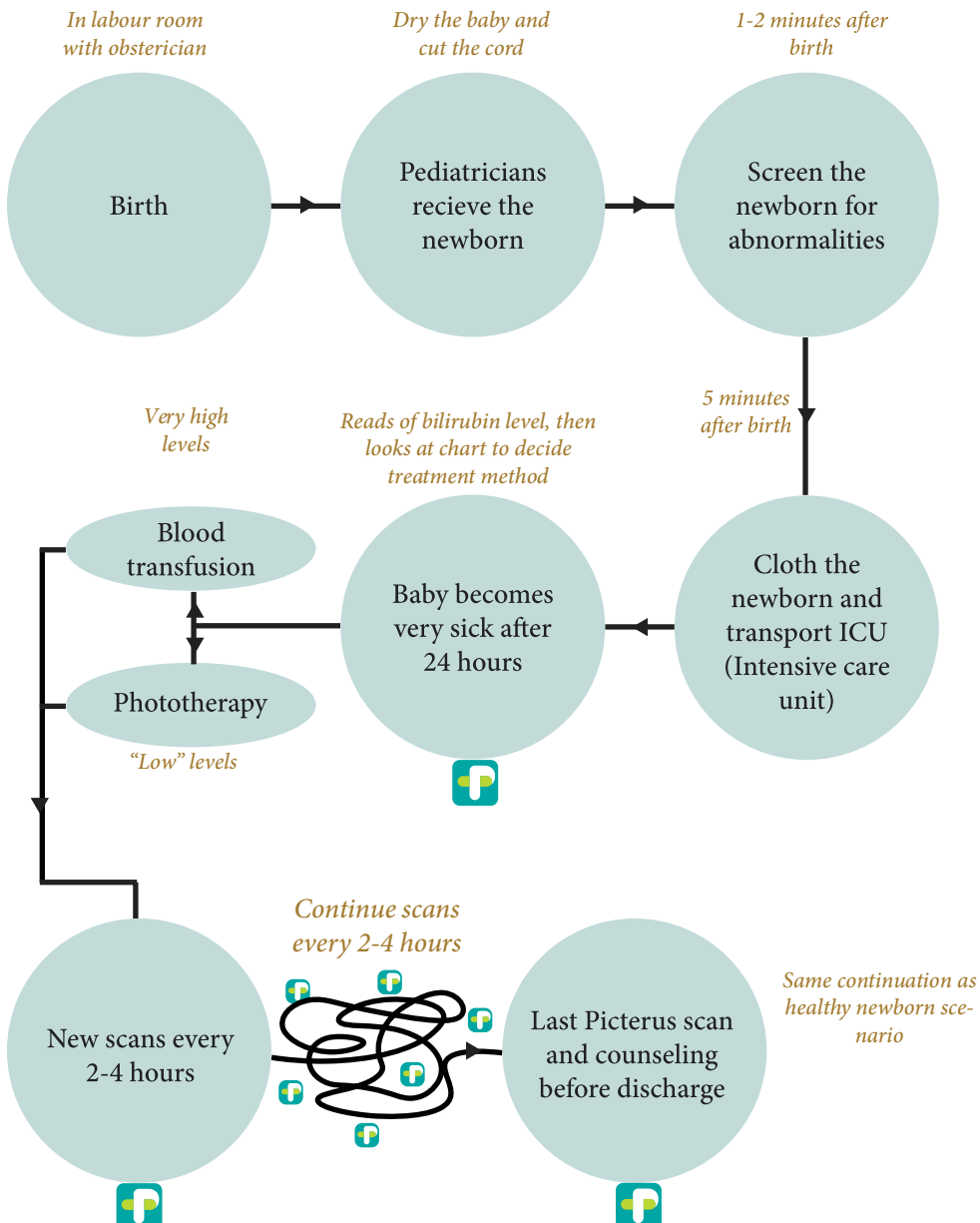
In the second scenario, the newborn developed jaundice symptoms within 24 hours after birth.

Event

Note



Use Picterus



This scenario unveiled more frequent use of the app, as the baby required scans every 4-6 hours following the diagnosis of jaundice. In this context, the nurses could assist in performing visual scans to support the monitoring process.

In the two scenarios, we brainstormed and discussed ideas to improve the user experience and highlighted potential challenges for implementation. Since I was about to leave Nepal, this was the only opportunity I had to do some ideation and developing of possible solutions together with the users. Under other circumstances, this stage of the process would have come later in the project.

### Ideas for making the user experience better

During the discussions, the doctors proposed several ideas to enhance the user experience of the service. They suggested the implementation of a shared phone system, allowing for the tracking and documentation of the baby's results over time. This shared system was seen as a valuable feature, promoting both hygiene and convenience. Additionally, the doctors emphasized the importance of a surveillance system to ensure regular and periodic scanning with the app, minimizing the risk of missing any assessments. Furthermore, based on their experience using the app during the user tests earlier, they expressed a preference for a short tutorial video (1-2

minutes) as an introduction to the app, offering a more intuitive way to learn its functionality compared to reading lengthy instructions.

### Potential challenges regarding the application

Further, the doctors highlighted several challenges that could potentially affect the possible implementation of the application. One notable challenge was the movement of the screening object, making it difficult to capture precise pictures with the app, something they experienced during the user tests. Concerns were raised regarding the assessment only being on the chest, as jaundice can occur in different areas of the body, and relying solely on pictures of the breast might not provide a sufficient evaluation. Additionally, the doctors expressed concerns about having to take multiple pictures, as taking six pictures could be experienced as time-consuming which could lead to impatience and frustration. Further, they acknowledged the potential limitations of internet connectivity, especially in rural areas, and raised concerns about the cost for parents compared to traditional blood tests, which currently cost 600NPR (approximately 5 USD) for the parents. Lastly, they noted that the skin colour of the baby could change during phototherapy, potentially affecting the accuracy of the screening and posing a challenge for accurate assessments.

## Focus group with nurses

In the second focus group session, which involved three nurses, we explored the same categories as in the doctor's session, by generating a wide range of quick ideas on sticky notes. However, we also focused on identifying potential benefits which showed to confirm some of the findings from the interviews. Several of the findings had already been addressed. However, new insights emerged including the risk of calibration cards spreading infections when shared among newborns, the possibility of creating an offline version of the app, and the potential benefits of conducting group discussions and exercises to share experiences and enhance skills.











# DISCUSSION

In this section, I discuss the findings from the last chapter. I will present my interpretations and the understanding I've gained from the data, with the goal of identifying potential challenges that could guide me at a later stage.



## EXPLORING THE NEED FOR PICTERUS

Based on the insights gathered from the interviews and focus groups, the next step was to evaluate the extent of need for Picterus, and thus answer one of my main research questions. Since the data was predominantly collected from KMC Sinamangal, this hospital served as the initial focus. Additionally, the feedback from the focus groups indicated that doctors were likely users of the app, providing a foundation for further exploration.



## Empathy mapping

### Why

To better visualize the needs and challenges of a doctor in the hospital and to align them with the solutions Picterus can offer, I created an empathy map. This tool allowed for a deeper understanding of the doctor's perspectives, thoughts and emotions. I used the current neonatal jaundice detection practices as a basis. This analysis enabled me to identify unmet needs and potential factors that validate a part of my research question, to identify if there is a need for Picterus. By applying this empathetic, user centered approach, I tried to answer if Picterus not only could meet their needs and challenges, but also improve their experience in screening and managing neonatal jaundice.

### Findings

When comparing the results from the empathy map to what Picterus can offer, several key points can be highlighted. The empathy map showed that doctors sometimes are frustrated with the current methods for assessing jaundice. They are stressed by time needed to assess jaundice, and they are worried about potentially harming the baby by using invasive methods. They also show a desire to provide the best possible care. Picterus can help to address these concerns, as it offers a quick, safe and non-invasive way to assess jaundice. This will save the

doctors time and save the baby from possible harm.

Furthermore, the empathy map shows the challenges faced by doctors in identifying jaundice in different skin tones, and their concerns about using subjective visual screening methods. Picterus addresses these concerns by offering highly accurate colour calibration algorithms that enable scanning in various lighting conditions and for different melanin levels in the skin. This feature can help improve the accuracy of jaundice detection, especially as newborns in Nepal have a wide range of skin tones. Additionally, Picterus offers the potential to reduce financial burdens on parents, who currently have to pay of up to 600NPR (approximately 5USD) for a blood sample test. The estimated cost of using Picterus is currently around 2.5USD per use, and efforts are underway to further reduce this price.

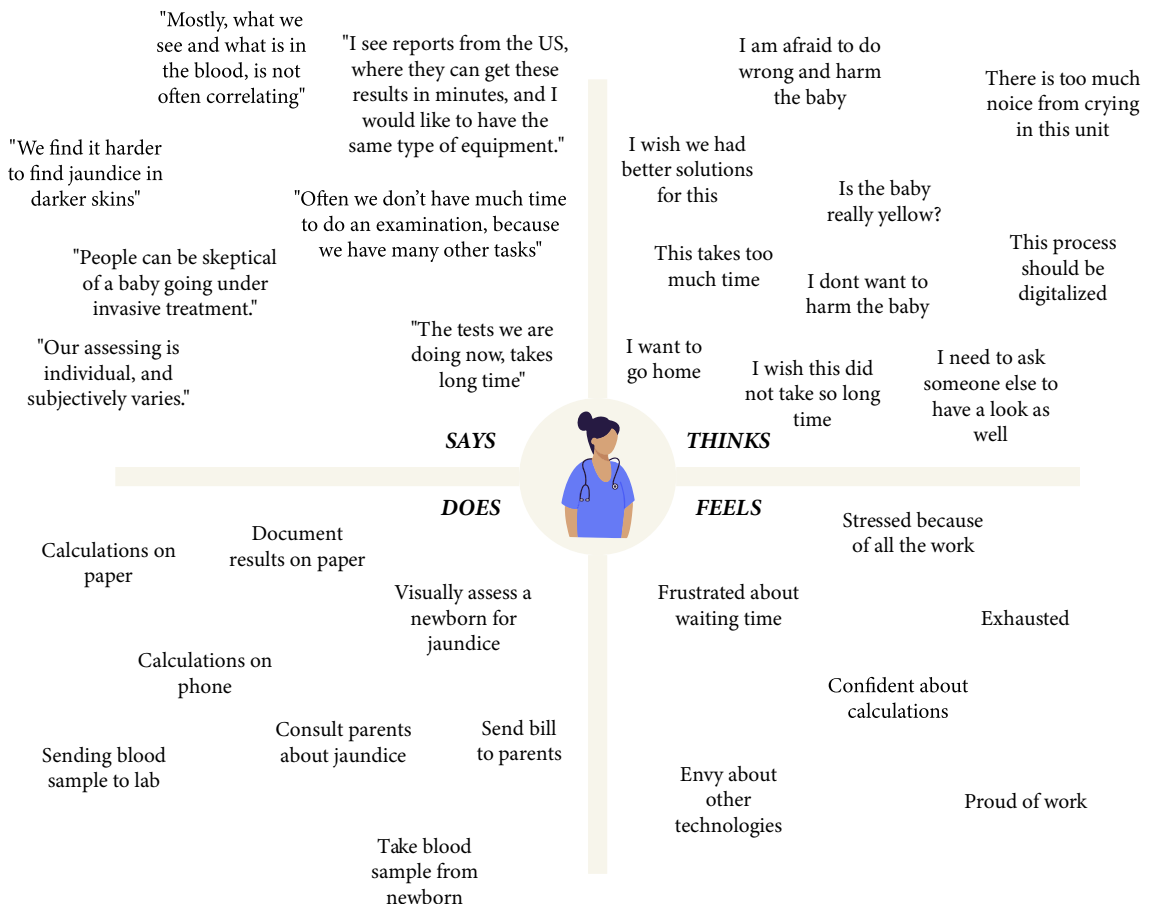
### Conclusion

Generally, the findings from the empathy map align well with the capabilities and potential advantages that Picterus provides. However, it's important to note that Picterus currently only offers screening capabilities and can not be used

for diagnosing, and therefore only relevant for the early phase of detection, instead of visual assessments. By addressing the challenges and needs expressed by doctors and providing a user-friendly, efficient, and non-invasive solution, Picterus has the potential to significantly enhance the detection practices of neonatal jaundice,

ultimately improving health care outcomes for affected newborns. Despite this, there are still some challenges before the service can function optimally. In the next section I will explore these possible challenges, with an overall goal to identify opportunities for the user experience of the service to be improved.

### Empathy mapping - assesing newborns for jaundice



## IDENTIFYING IMPROVEMENT OPPORTUNITIES

When exploring the possible implementation of Picterus, it is important to note that it is currently limited to screening purposes and cannot be used for diagnosis. With this in mind, it becomes clear that its current primary purpose would be to serve as a substitute for the visual scan currently performed. Therefore, my focus will be on exploring potential improvements opportunities within the first scenario, with a healthy newborn, from the focus group session with the doctors, where there would be no need to set a diagnosis.



## User Journey Map

### Why

To identify opportunities for improving the overall user experience of Picterus as a service in KMC Sinamangal, a user journey map was created. By mapping out each step and touchpoint along the doctors journey of using Picterus, and potential interaction with stakeholders, it becomes possible to identify pain points and areas for improvement. These identified pain points serve as important cues for directing the development of solutions, ensuring that they truly meet the needs of the doctors.

### How

To ensure a holistic approach to improving the user experience, the user journey map does not only consider interactions with the app, but also considers the larger context in which the service is used. This includes factors such as the physical

environment, time constraints, and the feelings of the users. By considering these contextual elements, the user journey map can provide a comprehensive understanding of the user's experience and on potential areas for improvement beyond the app itself.

I acknowledge that there are more stakeholders involved in the process of a potential implementation, including more of the hospital management, IT department, and authorities. These types of stakeholders would be outside the scope of my thesis, but their perspectives and needs should be taken into consideration to ensure a successful integration of Picterus at a later stage.

Touchpoints

Pain points

## User journey map

# 1

### Initial phase - implementation of the app

#### 1.1 Being introduced to the app by the management

- Concerns and skepticism about the app's reliability, accuracy, or security
- Inadequate resources or support provided by the management for training and onboarding
- Low resources at the hospital

#### 1.2 Downloading app

- Need Android phone

#### 1.3 Learning how to use the app

- Low technological competence
- Reading through the instructions once may not be sufficient
- Complex user interface

#### 1.4 Implementing app into daily routines

- Lack of motivation to adapt to new routines
- Limited awareness or understanding of the app's functionalities and benefits
- Inadequate training
- Time constraints and competing priorities
- Complex user interface

# 2

### Preparations before use

#### 2.1 Inform mother that a scan is needed

- Mother is scared about new, unknown technology
- Mother not willing to let the newborn being taken pictures of

#### 2.2 Finding a calibration card

- Card dirty after previous use

#### 2.3 Opening app on phone

- Bacterias on phone
- Not having a phone close by
- Unwilling to use personal phone due to possibility of getting notifications or calls
- Needing to borrow phone from someone else

# 3

## Performing a screen

### 3.1 Exposing the newborns' chest

- Uncertainty or anxiety about exposing the newborns' chest area, particularly for parents or caregivers who may be unfamiliar with the procedure
- Hygiene
- Baby can become cold

### 3.2 Placing card on newborns' chest

- Medical equipment in the way
- Restlessness or resistance when an object is placed on the chest
- Placing it wrong
- Irritation in skin

### 3.3 Performing scan

- Baby is moving
- Lack of adequate training
- Difficult to take pictures due to required angle, distance and position
- Navigating wrong in app
- Calibration card detaching
- Stressing and uncomfortable for newborn with flash
- Insufficient feedback in app

### 3.4 Viewing and interpreting the results

- Wrong unit showing ( $\mu\text{mol/L}$  or  $\text{mg/dL}$ )
- Inconsistency in the app

# 4

## Finishing work after use

### 4.1 Documenting results

- Patient privacy and data security
- Time consuming
- Lack of standardized documentation templates or systems

### 4.2 Doing further actions for treatment if necessary

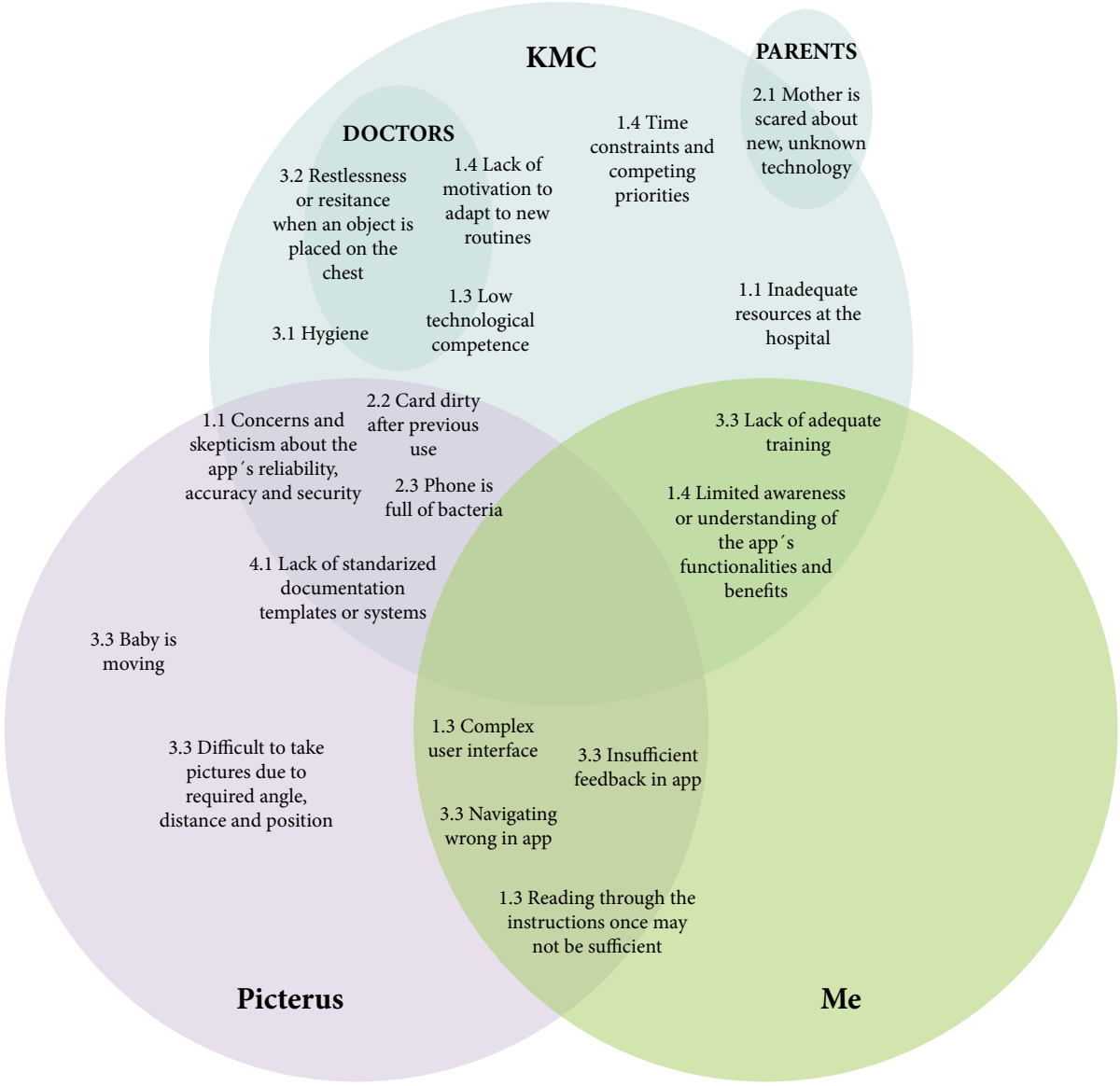
## Stakeholder map

### Why

Next, a stakeholder map was created containing the most important pain points from the user journey map. By making this, I tried to identify the key stakeholders involved in the implementation of Picterus and their possible areas of contribution. The stakeholder map helped in visualizing the interdependencies and potential collaboration opportunities among the stakeholders. By analyzing the pain points and identifying the relevant stakeholders, I gained valuable insights into where and how improvements can be made to enhance the overall user experience of Picterus as a service. This insight also guided me in understanding how and where I best could help.

### Findings

The findings led to two primary areas for further development where I, within the premises of this thesis, directly could contribute: improving the user experience and navigation within the app, and revising the training process for the app. These improvements are aimed at ensuring a more intuitive and seamless experience for the doctors while effectively equipping them with the necessary skills to utilize the app. Just as important, this also has the potential to improve the quality of further studies, by providing a better service for using the app.





# SOLUTIONS

In this section, I will propose different solutions based on the findings and analysis previously presented. These solutions aim to address some of the pain points identified discussed in the user journey and stakeholder mapping, with the goal of improving the implementation and user experience of Picterus as a service. I have developed both practical and possible solutions and recommendations for the present and future. They have the potential to improve the overall neonatal jaundice health care in KMC, and possibly Nepal and other less developed countries. Hopefully this can be a contribution to a future successful adoption of Picterus as a valuable tool in different health care systems.



Lack of adequate training



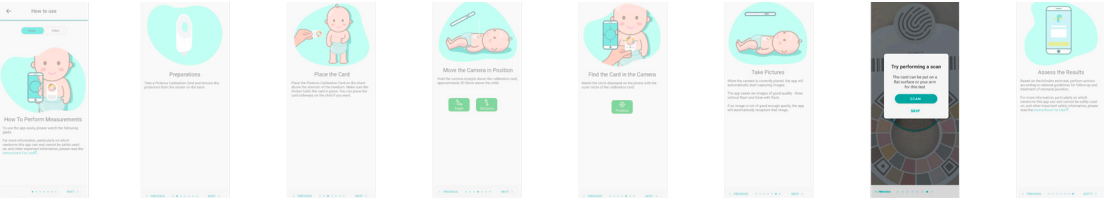
Limited awareness or  
understanding of the  
app's functionalities and  
benefits

## IMPROVING TRAINING EXPERIENCE

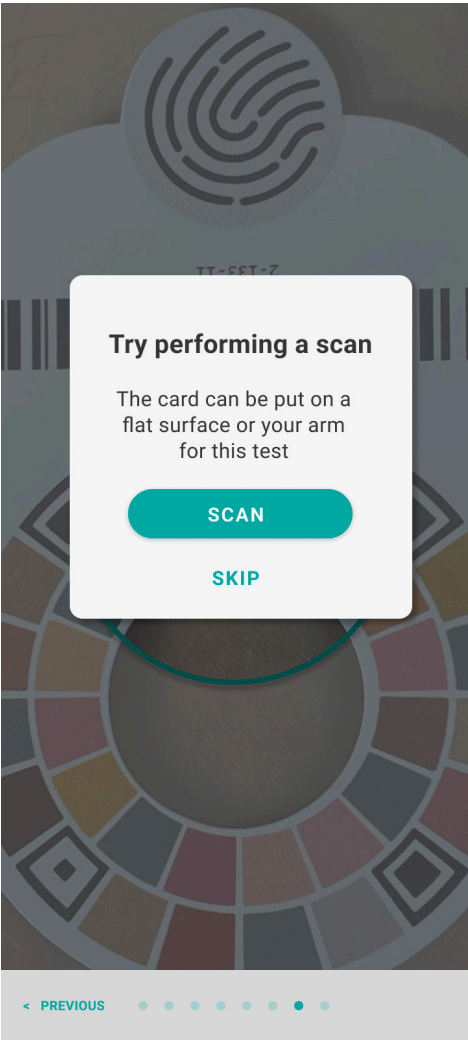
To meet the identified pain point “Limited awareness or understanding of the app's functionalities and benefits” and “Lack of adequate training”, I suggest that implementing a comprehensive training system, could be an effective solution. This would improve users’ understanding of the app and the benefits it offers. Three suggested solutions have been developed, each targeting a different aspect of the training process.

## Enhanced in-app instructions

The instructions in the application have been revised to incorporate a “Learn by Doing” design principle, offering a more interactive and engaging learning experience. To provide hands-on practice, a “Try to Perform a Scan” feature has been added to the “How to use” section. This feature allows health care professionals to familiarize themselves with the scanning process in a simulated environment before implementing it in real clinical situations with newborns. This proactive approach does not only strengthen the understanding of the application's usage, but it also builds confidence, leading to more precise results in the actual context (Kolb, 1983). Additionally, in response to several requests from the health workers, I have incorporated an instructional video feature in the app. This addition could improve user understanding and reinforce the knowledge they have already gained from reading the app's instructions. An instructional video like this has already been developed by Picterus.



Instructions in app



# GROUP TRAINING GUIDE FOR PICTERUS



## INTRODUCTION

Welcome to this group training session guide for the neonatal jaundice screening application, Picterus. This document serves as a guide for effective group training sessions aimed at familiarizing healthcare professionals with the use and functionalities of Picterus. With a systematic approach that combines theoretical knowledge, practical demonstrations, hands-on practice, and open discussions, the training sessions are designed to equip participants with the confidence and proficiency to use this innovative tool in their daily practice. The session takes around 15-20 minutes.

## PREPARATIONS

1. Bring one or more dummies for the participants to use during practicing.
2. Ensure all participants have downloaded Picterus on their phones in preparation for the training.

## GUIDE

### 1 Introduction to neonatal jaundice (2 min)

Provide the health workers with an overview of neonatal jaundice, its clinical significance, the importance of early detection, and the limitations of existing diagnostic methods such as visual screening.

### 2 Understanding the app (3-4 min)

In this part, introduce the Picterus app, including its purpose, functionalities, main features, and the advanced technology behind it, such as machine learning and image processing.

### 3 Live demonstration (2 min)

Conduct a real-time demonstration of using the app, talking through all steps from handling the calibration card to interpreting the bilirubin level results.

### 4 Hands-on-session (5 min)

Allow the participants to practice using the app themselves. Be available to assist, guide them through potential difficulties, and respond to any questions they may have.

### 5 Discussion and feedback (5-10 min)

Finally, hold an open discussion for participants to share their experiences, talk about any challenges encountered during the session, and provide feedback on both the app and the training process.

### Group training guide

A suggestion for a guide for group training sessions has been developed. It outlines the content and structure of the training sessions, breaking down the procedures into smaller steps and encouraging active participation. This guide, which has been designed to be easily implemented by management, provides a structured and consistent training experience. Group training has been shown to be an effective method of learning, facilitating for team building and enhancing problem-solving abilities (Rutherford, 2014).



### Instructional poster

To build on the knowledge gained during the group training sessions and provide a quick reference guide in the workplace, an instructional poster was developed. The poster provides a visual step-by-step guide on using Picterus, like the instructions in the app, and can be conveniently placed in areas of the hospital where the application is frequently used. The effectiveness of visual aids in enhancing knowledge retention has been well-documented (Sagaran et al., 2015; Duchin & Sherwood, 1990).

## A GUIDE ON HOW TO USE

# picterus

- a smartphone app that estimates newborn jaundice levels



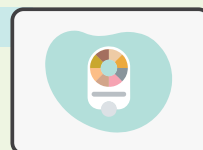
Picterus is a mobile application made for early neonatal jaundice screening. Using patented biomedical optics technology, it allows for accurate estimations of neonatal jaundice levels, while adjusting for skin pigmentation variations. Its primary aim is to support early detection and timely intervention, providing a quick, accurate, and efficient alternative to traditional visual scans.

## INSTRUCTIONS

1

### PREPARATIONS

Take a Picterus Calibration Card and remove the protection from the sticker on the back.



2

### PLACE THE CARD

Place the Picterus Calibration Card on the chest above the sternum of the newborn. Make sure the sticker holds the card in place. You can place the card sideways on the child if you want.



3

### MOVE THE CAMERA IN POSITION

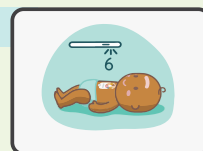
Hold the camera straight above the calibration card, approximately 20-30cm above the child. Match the circle displayed on the phone with the outer circle on the calibration card.



4

### TAKE PICTURES

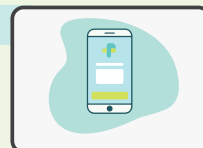
When the camera is correctly placed, the app will automatically start capturing images. The app needs six images of good quality - three without flash and three with. If an image is not of good enough quality, the app will automatically recapture that image.



5

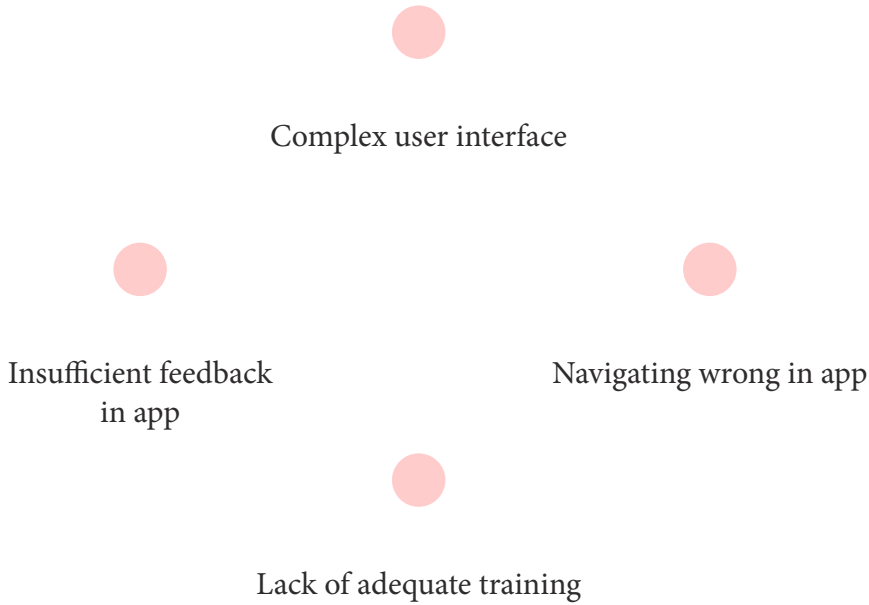
### ASSESS THE RESULTS

Based on the bilirubin estimate, perform actions according to national guidelines for follow-up and treatment of neonatal jaundice. For more important safety information, please read the "Instructions for use" in the app.

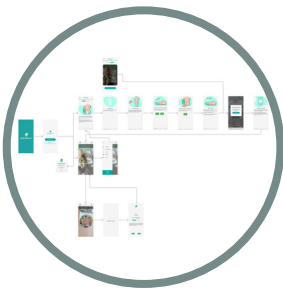


Download the app:





## UPDATED WIREFRAMES



In an effort to improve the overall user experience of Picterus, I developed updated wireframes in Figma. These updates were made to meet the pain points “Complex user interface”, “Navigating wrong in app”, “Lack of adequate training” and “Insufficient feedback in app”. While I cannot delve into every detail in this section, I would like to highlight some of the main changes and suggested improvements made to the app interface. All the suggestions are described and can be found in Appendix 4.

## “Learning by doing”-approach

As discussed earlier, I followed the concept of “learning by doing”, by introducing a “Try to Perform a Scan” feature during the instructions.



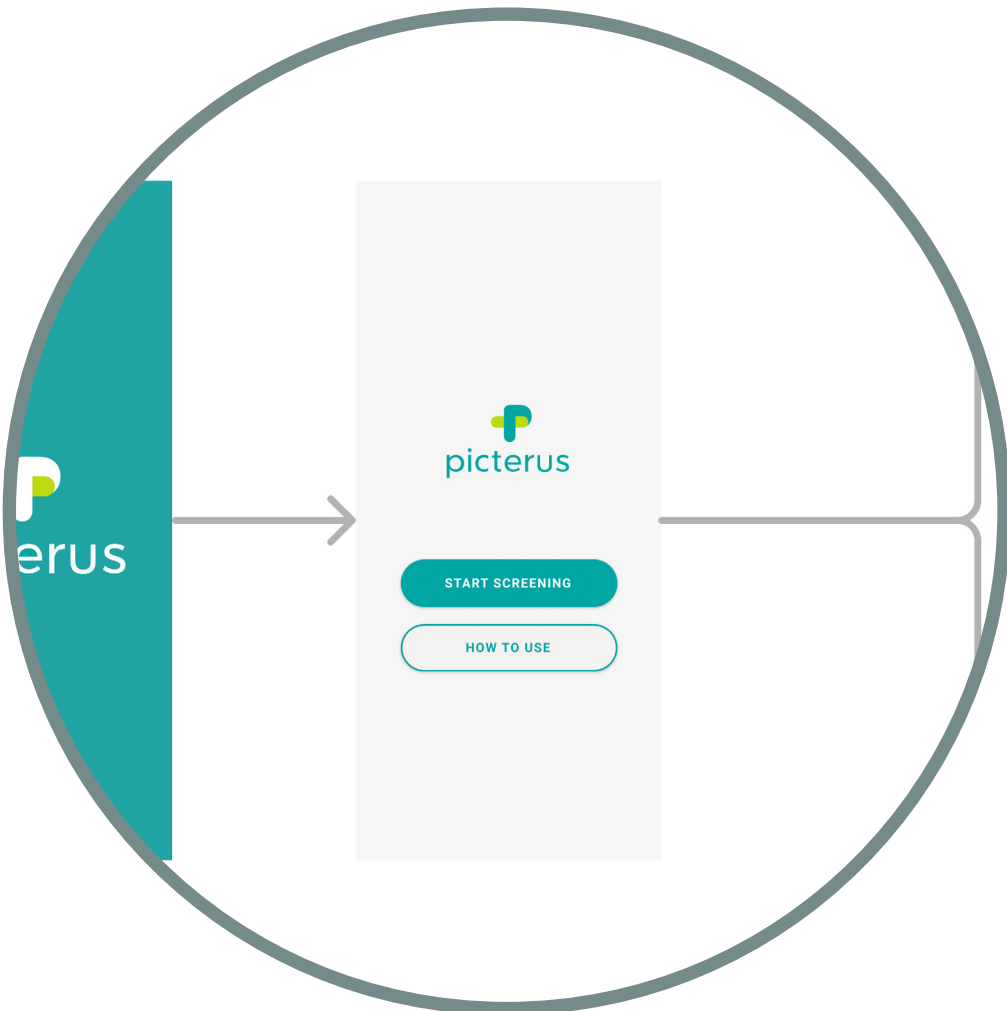
## More accessible menu

Based on design principles and user feedback, I made the menu more accessible and user-friendly. Fitts’ law (MacKenzie, 1992) suggests that the time required to rapidly move to a target area, such as a button on a screen, is a function of the distance to and the size of the target. In practice, this suggests that larger buttons can be reached more quickly and are therefore more user-friendly. I therefore added an accessible navigation bar at the top of the main screen, simplifying navigation and improving overall usability. I also removed the sound on/off button, as it was suggested to be unnecessary based on feedback from the doctors.



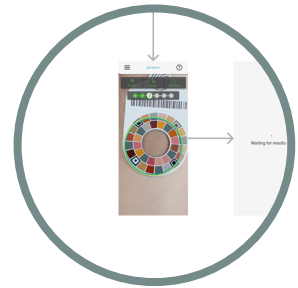
### Adding a start screen

To improve the accessibility of the instructions, particularly for first-time users, I suggest to implement a start screen. This screen can provide a clear option to either access the instructions directly or to proceed with performing a scan, simplifying the onboarding process and improving user experience.



## Updated loading bar

I made several suggestions for improvement to the loading bar when capturing images, to provide better feedback and improve user understanding during the process. These updates include:



### 1. More direct feedback

The loading bar now provides more explicit feedback when a picture is taken, by displaying a check mark after each image capture, ensuring that users know that their action has been registered.

### 2. Relocation

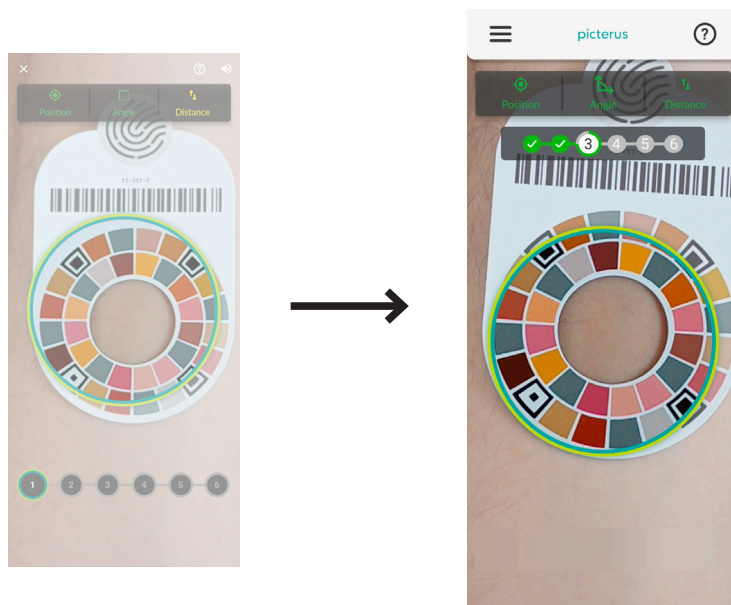
In order to reduce accidental interactions, which caused confusion several times during the user tests, I moved the loading bar higher on the screen, making it less tempting to press while capturing images.

### 3. Improved visualization

I did minor changes to the visual representation of the loading bar to enhance its clarity and make it more visible.

### 4. Larger and more visible numbers

To improve readability, I increased the size of the numbers displayed, making them easier to see and understand. I also suggest highlighting the number for the current image being captured, to avoid potential confusion.







## RECOMMENDATIONS FOR PICTERUS

To ensure a successful implementation of Picterus, I propose several recommendations to address the doctors identified pain points. These recommendations aim to improve the functionality, usability, and also impact of the app. While I acknowledge that Picterus already are working on addressing several of these aspects, it is important to confirm the need for these improvements, as it adds value to the overall development process.

## POTENTIAL SHORT-TERM FOCUS

### Picture-capturing technology

Firstly, updating the picture-capturing technology would be an important aspect. Exploring possibilities to capture fewer than six pictures and implementing camera locking on the calibration card can simplify the image capture process. It may cause less frustration and time used per scan, thus enhance the user experience.

### Phone hygiene

Additionally, developing guidelines for assessing phone hygiene is essential when dealing with neonates (Daoudi et al., 2017). Mobile phones are often full of bacteria, and health care providers might need recommendations on maintaining phone cleanliness which will reduce the contamination risks. This will ensure safe usage of mobile devices in conjunction with Picterus. I would suggest conducting research to determine the optimal approach for phone usage (personal or shared) with Picterus. This could also serve as a potential business opportunity for Picterus.

### Provide documentation of effect

Communication about the app's reliability, accuracy, and security, is found to be necessary. This was a concern that some of the doctors had. Delivering comprehensive and transparent information to health care providers will build trust and confidence in the app. This can facilitate Picterus' acceptance and adoption.

### Unique newborn profile

Further, I would recommend to further explore the inclusion of a unique newborn profile feature within the app. This can bring significant benefits in hospitals dealing with a many newborns. By having individual profiles or IDs for each baby, health care providers can easily track and manage the test results of each newborn.

## POTENTIAL LONG-TERM FOCUS

### Documentation template

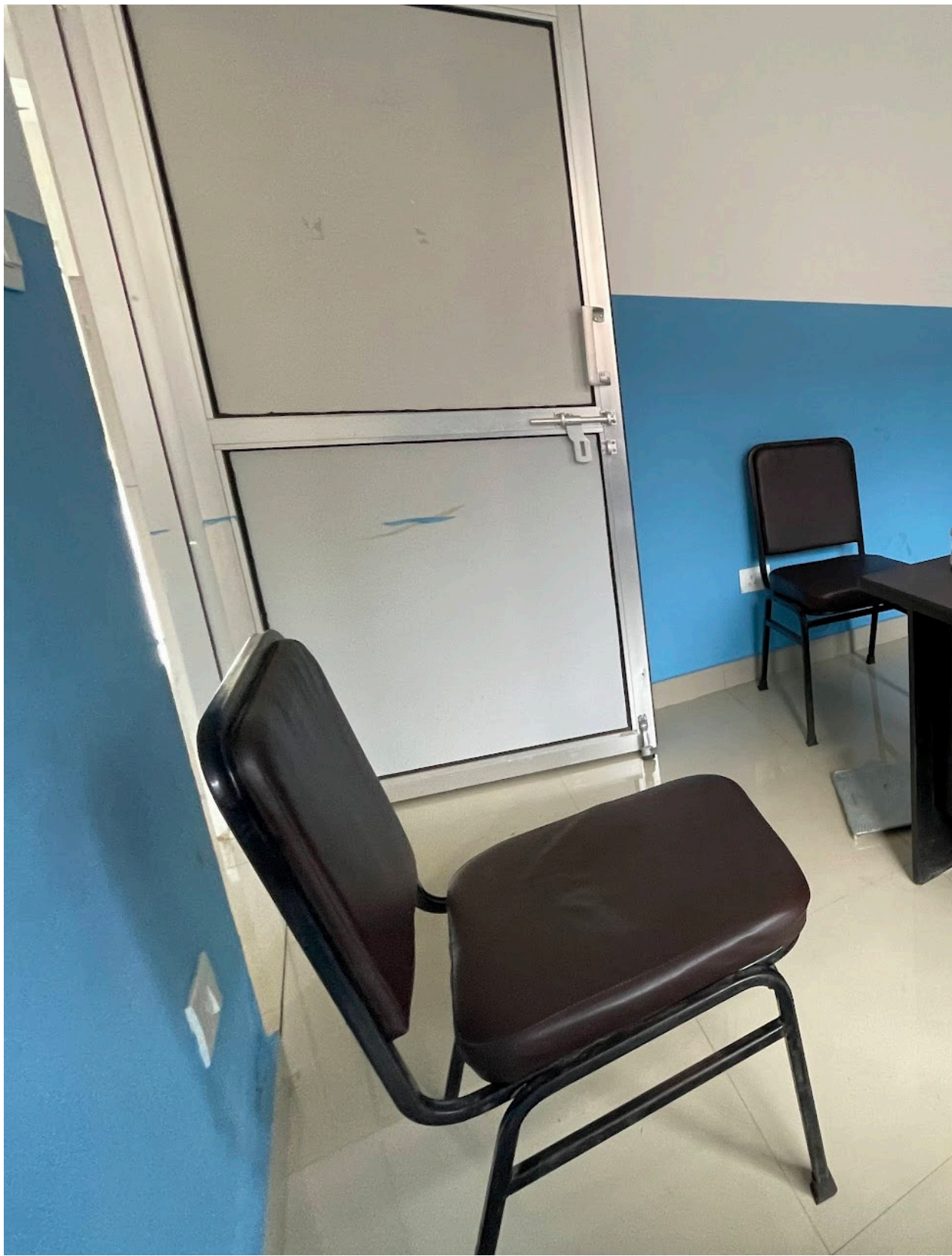
In the long term, creating a documentation template which can be used in hospitals, or in this case KMC, is an interesting opportunity, especially if the technology is developed to a diagnosis tool. This template can provide a standardized format for recording and managing NNJ assessments conducted using Picterus, facilitating efficient monitoring and follow-up.

### Data systems for monitoring in rural areas

Additionally, I would suggest looking at possibilities for making a flexible monitoring data system that can be adapted by local health authorities. This has potential to help health outcomes, especially in rural areas. With this type of data system in place, health care personnel in areas with limited health care facilities could collaborate with parents by monitoring their app usage. They could also provide timely guidance and support to ensure that the app is being used correctly and effectively.

### Conclusion

These suggestions provide potential areas of improvement for Picterus to explore further. While they have the potential to enhance functionality and user experience, leading to improved neonatal jaundice health care, it is important to note that additional research and evaluation would be necessary to assess their effectiveness.









# EVALUATION

## METHODOLOGY

In this section, I examine the methodology used in this thesis. It was a chance for me to evaluate the research process, including the methods and techniques I used. I looked at the advantages and challenges of each method and found areas for improvement. It was interesting to understand and reflect on the methodologies used, as it gave me a better overall picture of how they influenced the research outcomes. I learned more about how their approaches could be improved and adapted in future projects.

	Advantages	Challenges	Improvement potential
Desk research	Access to a wide range of existing information for a better understanding of subjects I knew little about	Difficult to find relevant literature and studies	Desirable with courses in how to do literature research
Meeting with experts	Gave me a better understanding of some subjects, which prepared me better before the trip to Nepal		Could have reached out to more experts
Semi-structured interviews	The most important source to user insights	Prepare questions for better for improved outcome	Use more time to familiarize participants with the project
User testing	Participants were happy to test new technology	Participants were not familiar to this format	Make a small info-poster/guide for users
Focus groups	Included very useful discussions	Did not know before arrival in KMC who I would participate	Set aside more time for this
Inductive coding	Systemized all my findings	Took time to learn, understand and use	Refining coding techniques
Empathy mapping	Gave me a clear over-view of the persona I was working with		Incorporating more user input
User journey mapping	Puts the user in a real scenario	Missing out on pain points	
Stakeholder mapping	Gave a clear indication as to what solutions I could develop	Could not include all stakeholders	Could look into other methods for dividing responsibility for pain points
Figma prototyping	Quick generation of wireframes		Start earlier

## LIMITATIONS OF THE THESIS

### Lack of real-world implementation

The feasibility assessment and recommendations outlined in this thesis are based on theoretical examination and insights gathered from health care professionals. However, it is important to underscore that the actual implementation and effectiveness of the suggested improvements in real-world conditions were not explored in this study. During the analysis and focusing phase, there is a possibility that some elements of the process were influenced by personal subjectivity, due to the inability to validate my findings with the users. Further studies are necessary to evaluate the practical implications and outcomes of implementation.

### User testing

As I during this study only had the chance to go to Nepal once, and for a short time, user testing with the doctors was not conducted for the updated wireframes in the app, which was developed after

returning home. While the wireframes were, based on feedback, designed to enhance user experience, the lack of user testing left me not having the opportunity to explore the effectiveness of these changes. User testing would be beneficial to validate the suggested improvements.

### Short preparation time for the participants

During my time at KMC, my days began with uncertainty about who I would be interviewing. The head of the neonatal unit in KMC, Prof. Dr. Sunil Raja Manandhar had to assess whether the situation in the unit allowed a health worker to take time off to conduct interviews and user tests with me. With most of the health workers in the unit having little knowledge of my study's details, this setup often took them off guard as they had little or no time for preparation. Had they been informed in advance, they could have had the opportunity to make up some

thoughts and opinions, which might have enhanced the feedback and overall quality of the interviews.

### Other challenges from stakeholder map

There were several other interesting findings from the stakeholder map which, due to the focus of this thesis, were not discussed. These findings, however, may present interesting paths for future exploration and research.

Among these findings was the challenge, and identified pain point, that the service is operating in a landscape filled with competing priorities. Being an early developer of mHealth technology for NNJ may serve as an opportunity for Picterus to establish themselves as frontrunners. Though, it requires a precisely developed service to not get outcompeted by others. Additionally, low resources at the hospital could pose a challenge. This may lead to poor training and support of the service, or the inability to provide necessary tools

for using Picterus effectively. Another noteworthy point was a concern of low technological competence among health care workers. Each of these findings, while not the primary focus of this thesis, points to broader considerations and challenges in the meeting between health care and mHealth. They are also interesting opportunities for further research and development. They serve as a reminder that while focusing on specific aspects of a problem or solution, there is always a wider context that can offer additional insights. It further confirms the need for holistic approaches, such as service design.

## WRAP-UP MEETING WITH ANDERS AUNE

In a wrap-up meeting with Anders Aune from Picterus where we discussed the project, some important topics were highlighted. Picterus has a long-term goal of establishing the service in Nepal and they want to use the contacts I have gathered to initiate new projects that build on the findings and results of my work. Aune recognized the importance of being hands-on, seeing this as a key value driver.

Furthermore, there is a plan to arrange a meeting where I can share my findings in detail with the team and have a thorough discussion. Many of the insights from my thesis confirmed their previous findings, which they see as adding value. Anders Aune expressed overall satisfaction with the project's outline, but still agreed with its limitation. Overall, it sat a positive and successful tone for the conclusion to this project.

## FINAL THOUGHTS

### Needs, attitudes and challenges

In order to create a successful and effective design solution, it was crucial to understand the needs, attitudes, and challenges of the end users. This human-centered design approach puts the focus on the people who will use the service which is being designed, along with their needs and desires.

In this study, understanding the needs of the health care workers helped me to compare how these met the capabilities and potential benefits of Picterus. Besides, it helped me understand what types of solutions they need. Additionally, their attitudes provided valuable insight into their willingness to adapt to new types of technologies and an application like Picterus. Lastly, identifying the challenges they faced using existing methods, and possible challenges with using Picterus and mHealth approaches, determined how the application could address those challenges and what changes that may be done to improve the overall process.

Overall, the insights gained from this process were very important and created the basis for answering the research questions and also to explore how a possible solution to the challenges raised may look like. It enabled me to design a useful and effective service, which fitted into the daily routines of the health workers at the hospital. However, I recognize that using alternative methods, like making a value proposition canvas (Osterwalder, 2014), might just as well have offered significant insights. Identifying and considering this method earlier in the process could potentially have been beneficial.



## mHealth

mHealth indeed appears to have significant potential to improve health outcomes in countries like Nepal. The increasing availability of mobile technology provides a unique opportunity to expand access to health care services, also in rural areas. This has the potential to greatly reduce differences in health care availability, as well as improve the overall public health. Picturus could be a door opener to increase the acceptance of mHealth in Nepal.

However, implementing mHealth solutions is not without challenges. Infrastructure issues, such as poor internet access or lack of electricity in certain areas, as well as cultural factors and illiteracy rates, could limit the effectiveness and acceptance of these solutions. In addition, it is important to train health care workers to efficiently be able to use these tools. As my research has indicated, improving technological competence within health care settings is critical to make sure that they are ready to utilize many of the technological advancements coming in the future years.

## Findings

The findings suggest that there is a need for Picterus in KMC Sinamangal and that it is feasible to implement the service in the hospital. Several of the health workers participating in this study also emphasized the need for such a tool. This support comes from their first-hand experience of the challenges with neonatal jaundice, and their awareness of the positive impact that a user-friendly, efficient and accurate tool such as Picterus can have. The service has the potential to improve neonatal health outcomes, by removing the risk of incorrectly subjective assessments, which leads to fewer unnecessary invasive procedures such as taking blood samples, saving the time of the doctors, allowing them to focus on other important tasks, and further lowering the costs, making assessments more accessible. However,

the study only limits answering for health workers in one hospital in Nepal

. The findings also suggest that, given the accessibility to health care in urban settings, the app will likely be used only by health workers, and not parents of the newborns. In rural areas, where parents may have more responsibility for the health care of their newborn, the situation could be different, but this is yet to be determined.

## Outcomes

The training guide, instruction poster and the updated app wireframes I developed, could offer potential in improving Picterus as a service, as they are directly addressing the identified pain points faced by doctors in a scenario where the doctors are using Picterus as a part of their daily work. They are readily implementable, and could potentially provide immediate benefits, but lacks testing which would confirm the level of effect. Furthermore, some of the recommendations I presented for Picterus could give value for the future, by giving strategic direction to improve their service. Some of the them align with the developing Picterus currently are doing, which strengthens the value of their ongoing work and provides confidence.

However, it's important to acknowledge there are several challenges remaining, particularly regarding the implementation of such a service in rural areas of Nepal. During my stay in Nepal, a few doctors raised concerns about the practical need for a service like Picterus in these regions. They noted that irrespective of the severity of a newborn's condition, the treatment of jaundice often falls back to traditional methods like exposure to sunlight, which has a limited effect. This viewpoint brings some interesting ethical implications. Introducing a service like Picterus, which could lead to hope and optimism, might not necessarily lead to improved health outcomes in a context

where the resources and knowledge to follow up may be lacking.

Picterus has potential to raise awareness about mHealth technologies in Nepal, which could lead to improved health services and outcomes. Acharya et al.'s 2020a study on the potential of mHealth to improve community-based health services in rural Nepal also supports this potential. They found that mHealth interventions can improve communication between health care providers and patients, increase patient engagement and adherence to treatment plans, and ultimately lead to better health outcomes.

Designers also can help to raise awareness and make valuable contributions, by creating and developing opportunities for mHealth, resulting in improved information sharing and public health in Nepal.

Further research into the feasibility and the results of implementing mHealth solutions is important. It can be a step stone into integrating mHealth services in low-resource settings, such as in Nepal, ensuring that technological benefits reach everyone, not just those in the cities or well-equipped hospitals. Hopefully, Picterus, and designers, could play a prominent role in this exciting progression.









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## Appendix 1 - Interview guide

### General

1. How long have you been working in the health sector / What is your background?
2. How many employees are in this health center?
  - 2.1. How many in the pediatric department?
3. How many newborns do you deal with, either at the hospital or at home?
  - 3.1. How many home deliveries are there vs deliveries at hospital?
    - 3.1.1 Do the parents who give home delivery come to the hospital for medical checks?
4. Who is examining the newborn baby?
5. How much time do they have for the baby?

### Jaundice

6. How would you describe your knowledge of NNJ?
  - 6.1 How is this health center/unit/health post knowledge about NNJ?
7. What are your neonatal jaundice detection practices? (Describe)
8. How often does a baby have moderate jaundice?
9. What happens if you detect severe jaundice?
10. What is the competence of parents regarding neonatal jaundice, and how do you speak to the parents about practicalities around jaundice when the baby is discharged from the hospital?

### Picterus/app for detection

11. What's your attitude towards new technology in your work?
12. Are you currently using your phone for anything work related? Any mobile applications?
  - 12.1. How is the technological competence in this hospital?
13. How could an app like Picterus effect you work?
  - 13.1. Do you see any challenges, if it were to be implemented?
14. In which degree do you feel it is achievable for parents of new born babies to use this app on their own?
15. What type of communication and collaboration between doctors and parents would be necessary for it to work?

## Appendix 2 - User test guide

1. Please locate and read through the instructions on how to use the app
2. Please perform a bilirubin scan of the baby
  - 2.1 How to you interpret the results?
  - 2.2 Do you think it is possible to change from  $\mu\text{mol/L}$  to  $\text{mg/dl}$ ?
3. Can you locate and change from  $\mu\text{mol/L}$  to  $\text{mg/dl}$ ?
4. Can you locate the history of results?



## Appendix 3 - Consent form

### Consent form for participation in my master's thesis

This is a question of whether you wish to participate as an informant through an interview for my master's thesis. The purpose of the thesis is to examine to what extent mHealth solutions are relevant in your position, and how current solutions function. Furthermore, I will look at how an app like Picterus can contribute to making the diagnosis of neonatal jaundice accessible.

#### Purpose

NNJ is still considered a global health burden, as around 80% of preterm and 60% of full-term newborns will develop jaundice. These cases are alarming as 10% of the affected newborn will most likely progress to high bilirubin levels, which can cause brain damage and other neurological disabilities

#### Problem

To examine the prevalence of jaundice in Nepal, and look if there is a need for a non-invasive and affordable screening tool for neonatal jaundice.

#### What does it mean for you to participate?

If you wish to participate in the project, it involves participation in the form of an interview where the information from the interview will be used in the work to answer my research question. The interview will include questions about your experiences with mHealth technology, what you find challenging, and what competence you feel is needed. The supervisor will have access to information from the interview. However, personal information or other information that can lead to your identification will not be given.

#### Participation is voluntary

Participation in the project is completely voluntary. If you choose to participate, you can withdraw your consent at any time without giving a reason. All of your personal information and information from the interview will then be deleted.

#### Your privacy – How I store your information

The thesis will be anonymized and it will therefore not be possible for anyone to recognize you. I will treat the personal information confidentially and in accordance with the privacy regulations in Nepal and Norway. Notes from the interview will be stored inaccessibly to others. If personal information is revealed during the interview, these will be coded so that only I can understand what they mean.

#### What happens to the information after the thesis is submitted?

The notes from the interview will be shredded and deleted when the thesis is submitted and approved. The audio recordings will be deleted permanently. The thesis is due on May 29th, followed by a three-week examination period.

#### Where can I find out more?

If you have any questions about the thesis or would like more information, please feel free to contact:  
Markus Rosenvinge Pettem  
Mobile: +47 992 65 898  
E-mail: [markus.pettrem@gmail.com](mailto:markus.pettrem@gmail.com)

I have received and understood the information about the project, and had the opportunity to ask questions. I consent to:

- ☐ To participate in an interview
- ☐ To participate in an user testing of the application

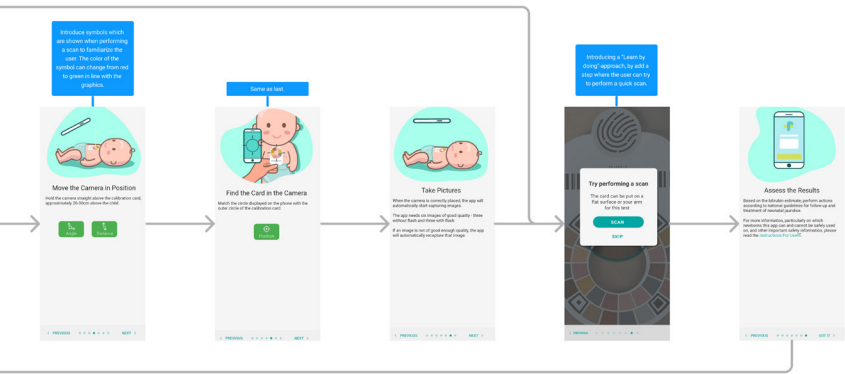
I consent to my answers being stored and processed until the project is completed.

---

(Signature of project participant, place and date)







Appendix 5 - IRC approval for conducting re-  
search at KMC



**Institutional Review Committee (IRC)**  
**Kathmandu Medical College Public Ltd.**  
**Sinamangal**  
(Affiliated to Ethical Review Board, Nepal Health Research Council)

Ref.:25022023/ET

Date: February 25, 2023



**Chairperson**

Prof. Dr. Sunil Kumar Joshi

**Member Secretary**

Dr. Deepak Regmi

**Members**

Dr. Pratibha Manandhar

Dr. Gita Khakurel

Dr. Deepti Shrestha

Dr. Dhiresh Kr. Maharjan

Dr. Naresh Manandhar

Mr. Subhash Chandra Sharma

Ms. Sabitra Poudel

Ms. Aasmin Pyakurel

Mr. Teertha Prasad Poudel

**Administrative Assistant**

Mr. Karun Ghimire

**Address for correspondence:**

Kathmandu Medical College Institutional  
Review Committee  
PO Box 21266, Sinamangal, Kathmandu,  
Nepal  
Tel: 977 1 4469064, 4476152 Ext. 3513  
Email: [kmc.irc@gmail.com](mailto:kmc.irc@gmail.com)

**To whom it may concern**

This is to inform that Markus Rosenvinge Pettrem and his research team from the Faculty of Architecture and Design, Norwegian University of Science and Technology (NTNU) have been granted ethical approval by the IRC of Kathmandu Medical College (KMC) for the study of **“Health service innovation of neonatal jaundice detection by using mHealth technology in low-income settings: user-centered implementation project in Nepal”** on February 10, 2023. They will conduct the study at neonatal ward of KMC under the supervision of Prof. Dr. Sunil Raja Manandhar.

Data collection period: 12 March – 30 April 2023

Study site: Kathmandu Medical College

Prof. Dr. Sunil Kumar Joshi  
Chairperson  
Institutional Review Committee  
Kathmandu Medical College



**Institutional Review Committee (IRC)  
Kathmandu Medical College Public Ltd.  
Sinamangal**

(Affiliated to Ethical Review Board, Nepal Health Research Council)

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Mr. Subhash Chandra Sharma

Ms. Sabitra Poudel

Ms. Aasmin Pyakurel

Mr. Teertha Prasad Poudel

**Administrative Assistant**

Mr. Karun Ghimire

**Address for correspondence:**

Kathmandu Medical College Institutional  
Review Committee  
PO Box 21266, Sinamangal, Kathmandu,  
Nepal  
Tel: 977 1 4469064, 4476152 Ext. 3513  
Email: [kmc.irc@gmail.com](mailto:kmc.irc@gmail.com)

Ref.: 25022023/EI

Date: February 25, 2023



**Receipt**

A sum of Nepalese Rs. 12,400/- (equivalent to USD 100 only) has been received from Markus Rosenvinge Pettrem from the Faculty of Architecture and Design, Norwegian University of Science and Technology (NTNU) as a review fee from Institutional Review Committee Kathmandu Medical College for the study on “**Health service innovation of neonatal jaundice detection by using mHealth technology in low-income settings: user-centered implementation project in Nepal**”.

Institutional Review Committee  
Kathmandu Medical College

## Appendix 6 - NSD approval

29.05.2023, 20:57

Meldeskjema for behandling av personopplysninger

[Meldeskjema](#) / [Helsetjenesteinnovasjon av neonatal gulsottdeteksjon ved bruk av m...](#) / Vurdering

### Vurdering av behandling av personopplysninger

**Referansenummer**  
345325**Vurderingstype**  
Standard**Dato**  
20.03.2023**Prosjekttittel**

Helsetjenesteinnovasjon av neonatal gulsottdeteksjon ved bruk av mHealth-teknologi i lavinntektsområder: brukersentrert implementeringsprosjekt i Nepal

**Behandlingsansvarlig institusjon**

Norges teknisk-naturvitenskapelige universitet / Fakultet for arkitektur og design (AD) / Institutt for design

**Prosjektansvarlig**

Martina Keitsch

**Student**

Markus Rosenvinge Pettrem

**Prosjektperiode**

15.02.2023 - 30.05.2023

**Kategorier personopplysninger**

Alminnelige

**Lovlig grunnlag**

Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 30.05.2023.

[Meldeskjema](#)

**Kommentar**

OM VURDERINGEN

Sikt har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

**FØLG DIN INSTITUSJONS RETNINGSLINJER**

Vi har vurdert at du har lovlig grunnlag til å behandle personopplysningene, men husk at det er institusjonen du er ansatt/student ved som avgjør hvilke databehandlere du kan bruke og hvordan du må lagre og sikre data i ditt prosjekt. Husk å bruke leverandører som din institusjon har avtale med (f.eks. ved skylagring, nettspørreskjema, videosamtale el.

Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1 f) og sikkerhet (art. 32).

**MELD VESENTLIGE ENDRINGER**

Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Se våre nettsider om hvilke endringer du må melde: <https://sikt.no/melde-endringer-i-meldeskjema>

**OPPFØLGING AV PROSJEKTET**

Vi vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet. Lykke til med prosjektet!



# Appendix 7 - Inductive coding

## NEEDS OF THE HEALTH WORKERS

### SAVE TIME

- Some new apps are saving me half an hour on calculations.
- I have this app where I, 30 minutes before a patient comes, I can see some reports in the app.
- Often we don't have too much time to do an examination, because we have so many other tasks (...)
- The lab report of blood test takes 1-2 hours.
- The blood sample test takes 1 1/2 hours.
- We need 45 min to 1 hour for the blood test.
- The blood sample takes 2-3 hours. We collect the blood here, then we send it to the lab downstairs, they examine, and give us report.
- Take a blood test, which takes 1-2 hours. Take blood here, send sample to lab, then doctors decide if phototherapy or not. We have to go down to the lab to receive report.
- (...) apps are helping them doing their work faster.
- The tests (jaundice) we are doing now, takes long time, 20 minutes for preparing, sending babies around, total it takes 1 hour to get the blood just to the lab, then another hour to get the results
- Our procedure now, with sending in blood tests takes much time.
- For the invasive techniques, we have to wait for 1 1/2 hours.
- One problem with the blood sample, it that it is very time consuming.
- It (Picterus) may make our work easier. We don't have to wait for the 2-3 hours.
- (...) blood sample it is painful and time consuming

### FAST TREATMENT OF BABY

- If the baby need immediate phototherapy, we would then not have to wait for so long for treatment, and we can have treatment within minutes.
- The treatment can start much faster (when using Picterus)
- It (Picterus) could be helpful for the baby too, because they don't have to suffer 2-3 hours more.

### DECREASE IN WORK LOAD

- New technology should come. Because it makes our work more easy of course. Decreases our work load.
- We don't have too much time to use the phone when working.

### BETTER DETECTION PRACTICES FOR BABIES WITH DARKER SKIN

- We find it harder to find jaundice in darker skins.
- During early phase of life, the skin color (yellowness) is harder to see.

### DETECTION PRACTICES NOT ONLY DURING DAYLIGHT

- Jaundice is usually detected in sunlight, which is during morning rounds.
- We are always doing the first jaundice checks in daylight, then we can almost correlate it clinically.

### PARENTS NEED ECONOMIC SOLUTIONS

- Our hospital is delivering babies for free, as we are part of this new program. A few hospitals are in this program. In return we are providing a small amount of cash. It does not make a lot of difference, but still it is encouraging.

### PRECISE INFORMATION TO PARENTS

- Some (parents) are very concerned, some not at all, but they don't have very much knowledge. We have to provide the knowledge. It is pretty important to provide with exact information as well. When we say «keep the baby under sunlight» they usually keep the baby in sunlight with all the clothes on, because they don't want the baby to get cold. Many people have no idea.
- We are asking the parents not to use mustard oil on the babies, since it causes yellowness too.
- Also if she (the mother) has had jaundice when she was little, they think the baby will get it.
- They have some knowledge. Some of the parents don't bring the baby to us immediately, but the well educated ones do so. Some parents try sunbathing, before coming to the hospital, and therefore come late to the hospital. Some think that herbal medicine helps. In each an every counseling we teach the parents about this.

- They are not very aware of it. But at the time of discharge, we tell the parents you should keep your baby in morning sunlight, as this will help. We counsel them about the yellowness in eyes and body, and if it is extending to the whole body, we say they should consult a doctor. How it happens, they don't know that. Some think it is turmeric powder. Some also takes herbal medicine. But we advise them not to do this. Many think it is because of meat.
- There are many misconceptions. Someone think mustard oil will help with the jaundice to go away. They think the direct sunlight will help for jaundice. This can be very dangerous. Keeping the baby in sunlight can damage the baby. We are having teaching conversations with the parents. We inform about every step.
- If they are educated, they can know that is can occur. Especially if they have had a baby from before. They might know the difference between physiological and pathological. If they haven't had a baby before, they might not know. Factors: number of babies, education. Some have superstitious believes. They think that the babies can be cured with mantras, and that they get sick because of something the parents/ relatives/friends have done. It happens in some rural areas.
- Surrounding hospitals tell parents to keep the baby in the sunlight, early in the morning. That is the only way of treating. They will look in the babies eyes and tell in they have jaundice. Many people in this area have smart phones. (SIPAGHAT)

### AVAILABLE TECHNOLOGY

- The things that are handy(technological) are very important, because we can't always carry our books around.

### BE UP TO DATE

- There are so many things changing in this word, also in medicine everything is changing so fast, so its important for the medicine to adapt to technology. «We have to work smart».

### NON-INVASIVE TREATMENT METHODS

- To use non-invasive methods makes the procedures less painful, maybe more accurately also.
- Less invasive methods are very helpful. These new technologies are a huge blessing in the medical field.
- If some technologies like this scanning comes, it will be very helpful. We don't have to do anything invasive with may harm the baby, infection, crying of baby.
- Parents can be skeptical of a baby going under invasive treatment. It can be scary.
- Taking blood out of the vein is so much more complicated. No blood loss, no pain, no crying.
- It (Picterus) will be good for both he parents and us.
- We don't need to take out blood sample (with Picterus), so better for the baby. Easier for us, and the baby don't have to suffer for the pain
- (...) blood sample it is painful
- Taking blood from neonates can be painful and sometimes not good.

### OBJECTIVE VISUAL SCREENING

- Our assessing is individual, and subjectively varies. Some might see it, some not. If you are a good pediatric, you might see it very easy, while some might not it.
- We do subjective tests now.
- Mostly, what we see and what is in the blood, is not often correlating. We can see a yellowness in the skin, and then not see much bilirubin when we take the test, and vice a versa. So a clinical assessment is not sufficient. Sometimes we miss out on cases. Some times we see no yellowness in skin, but we find much in blood.
- With this app you are making this more digital, less subjective, more easy.

### CHEAP SOLUTIONS

- There is always a problem of economy. Main factor for technology not coming is economy.
- I know of this other method with a transcutan bilirubimetre. But it is too expensive for us to use, the lab is much cheaper.

### EASY USABILITY

- After 5-6 attempts people will get used to it. It has to be standardized.

### FOLLOW UP WITH PARENTS

- Even after the jaundice is over, we advice the parents to come back within 48-72 hours to measure the level of bilirubin.
- Already now, we are asking parents of newborns to analyse themselves. We teach them how to assess jaundice. We ask them to press on palms and soles, and if they can see the jaundice there, they come to us.
- Some parents feel anxious in this follow up period, worrying about if the bilirubin level will rise.
- It will be useful for them (using the app), but they have to be trained, and even after they use it, they still have to contact the doctor.
- Regarding to the new borns, we have a really close relationship with the families, because of the emotional contact with the baby.

## ATTITUDES OF THE HEALTH WORKERS

### OPEN FOR NEW TECHNOLOGY WHICH SAVES TIMES

- With time, new technology should be "entertained" (good). We save so much time with the new technologies coming now.
- The things that are handy (technological) are very important, because we can't always carry our books around.
- There are so many things changing in this world, also in medicine everything is changing so fast, so its important for the medicine to adapt to technology. "We have to work smart".
- I'm very excited for this. I see reports from the US, where they can get these results in minutes, and I would like to have the same type of equipment.

### NEW TECHNOLOGY IN GENERAL

- I feel very excited about it.
- I am very interested to get to know new technology. If I get a chance to test something new, I am eager to do so.
- I like to be introduced to new technology.
- It is making our work much easier.
- I am pretty excited about that, about any new techniques.
- Interested. Would like there to be more apps. It would make it so much easier.
- There are so much coming, and lives are saved by the new technology. Less invasive methods are very helpful. These new technologies are a huge blessing in the medical field. This is very positive. If there comes some new technologies, I would like to learn them.
- It is definitely good both for us and the patients.
- We get updates on our phone every day, and the status of the babies. I find this message very helpful.
- New technology should come. Because it makes our work more easy of course.
- Lots of new equipment like incubators and machines (are introduced in the hospital). Its welcomed by the hospital.
- Many (of the people working here) think that all these new technologies can help us.

### ON PICTERUS

- I think it will be very welcomed.
- (...), when you have this app, there is no subjectivity, and I would obviously enjoy it.
- Since this is not an invasive procedure, I think it will be very welcomed.
- It will be good to implement.
- If its useful, its obviously welcomed
- It is really good, since we do subjective tests now. With the app, we can know for sure, and sure the right procedure right away. It is a unique approach.
- I would very much welcome an app like this.
- It will be helpful.
- It will be a new approach. I would be happy to use it. This would be very very useful for the pediatric.
- This technology will make our life so easy, so comfortable and so fast. We can have the data in just a few seconds.
- It will definitely be help full. Especially in rural areas. In city areas, if this app is accurate, then definitely everyone will use it.

### CONTACT WITH PARENTS

- We can easily communicate on phone with them. They are often calling us with questions regarding everything. This is fine for me.

- No not at all (using mobile phone work anything work related).
- We are more reliant on manuals.
- Not using any apps now.
- At first it can be difficult (using picterus), because we have to adapt to the new routines, but after that it will be better.

### TRUST IN HEALTH WORKERS

- Not everyone believes in what people say.

### LACK OF MOTIVATION TO ADAPT NEW TECHNOLOGY (ESPECIALLY OLDER HEALTH WORKERS)

- Maybe there is a lack of motivation also. We come here, do our duty and then go home. The initiative must come from the management.
- Older people are not so active in these new technologies. They think that what we have been doing in the past works.
- Younger people might be more open to this than older.
- There are a lot of app with scoring systems (calculating). Hematite scores e.g. but just for calculations. They are very helpful and very easy to use. Most of the doctors are using it. Mostly young, and maybe some of the old doctors.
- Older doctors will obviously not use them, but maybe if someone teach them, they can use it.

### LACK OF KNOWLEDGE FROM PARENTS

- I don't think they know enough (parents about jaundice). Some people ignore it, although the cases are bad.
- Still home delivery is a common thing, which is a problem due to sanitary, although they are not aware of it.
- How would that baby parent know if this level is normal or not?. Level should come with a reference value. Not all people know this.

### FOREIGN COMPANY

- People might be skeptical if it is a foreign making it.

### ILLITERACY

- In nepalese society, many are illiterate, and may not know how to use the app. It could be difficult.

### HOME DELIVERIES

#### General

- Outside Katmandu, there are a lot of home deliveries.
- In rural areas, there are some home deliveries.
- But in rural areas, there are still home deliveries
- In rural areas, they might have some home deliveries.

#### Inaccessible health care services

- More than 90% in this area go to hospital. Only in emergency they do home delivery. People are aware of the importance of the health sector. This is definitely different in rural areas. It is not so accessible.

#### Parents economy

- Only births in hospitals. Most people come to health post for checks. If they are very poor, maybe not. If home delivery, its because of distance to health post.

#### Lack of parents knowledge

- Still home delivery is a common thing, which is a problem due to sanitary, although they are not aware of it.

#### Lack of follow up

- It has improved from the past, but I know that there are still many home deliveries without any follow up.

## CHALLENGES in connection to the implementation to the application

### COST FOR HOSPITAL

- There is always a problem of economy. Main factor for technology not coming is economy.
- I could be concerned about the cost of it on managerial level.
- Internet has to be free.

### DOCUMENTATION

- For the documentation purpose, we need documentation of values.
- With the documentation part it is challenging. Because everything is in paper. With a blood sample, we get a paper on it. We need to have it in paper.
- Could be connected to a data system. If the level is high, then this can be reported to the nearby government health post. Can register the local health post, which the data system can talk to and send the reports to. The local health person can have overview over the mothers, and see the results. Very difficult to make. Too expensive.

### USING MOBILE PHONE

- The phone is full of bacteria. The phone is for personal use. When many people are working in a health post, and all touch the phone to scan, it can be difficult.
- The doctors say that there are a lot of microorganisms on the phone, so there could be a risk for the baby.
- We are not using the mobile much in front of babies. If we need a torch light, we using a torch and not a mobile phone, due to the bacterias on the phone.
- The mobile emit radiation

### LACK OF FACILITIES

- Here in Duwakot, we are just here sometimes at 24 hours. This was injured from earthquake.
- We just have a OPD and emergency unit.
- Only knowing the value is not sufficient for the baby. There has to be facilities to treat it also. The baby will be put in sunlight anyway.

### GOOD DOCUMENTATION OF EFFECT / HAVE TO MAKE SURE IT WORKS

- Some might be false-positive. We cannot always accept the new techniques, and need good proof that it is working.
- But, what I see, being a doctor. I want to know how it works, if it works on spectrometry or something else. What methods are you using? It is very important for me to understand how it works, before asking my patient to use it themselves. What is the main basis of using this.
- They don't know if the application they are using are standardized or not
- It will definitely be helpful (...) if this app is accurate, then definitely everyone will use it.
- Maybe some will be skeptical because they don't know how it works.
- Whenever there is new technology invented, the will be challenges until it is accepted.
- Is it effective? I would like to do both blood sample and mobile to be sure.
- I don't think it can be use to determine diagnose.
- It can cause a false positive result (using Picterus). Blood sampling is 95-98% accurate, but not everything is 100% accurate. **There is always a problem of how accurate they are.**
- If this app (...) is reliable, we can use it.

### LOW TECHNOLOGICAL COMPETENCE

- I don't have too much practical experience with the new types of technologies. I only know what is written in the books.
- It is very poor (technological competence in hospital). Better there than government hospitals.
- There has to be some training to the medical doctors.

### DON'T USE PHONE FOR ANYTHING WORK RELATED

- We don't use any apps (for anything work related).
- We don't have too much time to use the phone when working.





