Designing The Birthing Experience For Low Resource Settings

A Human Centered Design Approach
The five dots on the front cover page is a visual representation of labour and delivery stages, shown through cervical dilation of 2 -10 cm. Cervical dilation happens as a pregnant woman gets closer to her labor and delivery.

During the first field visit at a primary health center in Bihar, India, I noticed a very simple cut out of these dilation sizes on a cardboard. It is used to train the nurses and midwife for checking cervical dilation manually. For me, during this project it was a moment of realization about how simple the solution or tool can be.
Designing The Birthing Experience For Low Resource Settings

A Human Centered Design Approach

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   A Human Centered Design Approach

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Aalto University
School of Arts, Design and Architecture
“The only important thing about design is how it relates to people.”

- Victor Papanek
ABSTRACT

Although significant progress has been made in reducing maternal mortality in last two decades, complications during pregnancy and childbirth still claims lives of thousands of mothers and newborns each year. Overcrowding, uncleanness and lack of means to support emergency or accidental deliveries suggest that for many women, the experience of birth is neither safe nor comfortable. With number of births continuously rising around the world, the health facilities must be adequately prepared to deal with both normal pregnancies and complications that requires prompt, life-saving interventions. Hence innovative and life-saving product such as the one I have designed, the Portable Delivery Stool could help to deliver high quality care to women and newborns everywhere.

This thesis consists of three phases. The first phase has been done as a part of Lab.our Ward (LW) project, which was a cross-disciplinary innovation project to design novel maternity ward services, products and spaces that are based on women’s and care providers’ needs in the context of low-resource settings. In this project I worked as a product designer and my main tasks were related to doing the research for design and exploring innovative products ideas. The second and third phase consisted of improving one of the promising design solutions (Delivery Stool) and conducting field evaluation and user testing in India.

The thesis main research question addresses how Human Centered Design methods can be used to develop innovative healthcare product concepts meant for low resource settings? The overall aim of this thesis was to understand, identify and explore the possibilities of improving the existing MNCH situations by proposing simple, durable and cost effective product solutions. At the same time emphasizing the importance of Human Centered Design and Participatory Design approach as vital methodologies to develop these solutions.

To fulfill the above mentioned goals, several sources were explored such as review of existing research project reports followed by field visits to maternity facilities in Helsinki as well as in India. Based on the research insights a series of co-design sessions were conducted with healthcare experts such as midwife, clinical advisor and designers. Later on some of the ideas were showcased as prototypes for expert comments in a co-creation event. As per the feedback received I have improved one of the promising idea (Delivery Stool) and conducted user testing in India.

Based on the project and field study experience, this thesis draw conclusions on four main aspects of design process. Firstly, emphasizing the importance of working in the same team with health practitioners for a considerable longer period of time. Secondly, testing and refining ideas all the time through quick prototyping and even role-play. Thirdly, to have frequent interactions with health experts, instead of the "standard" method in which the interaction happens in a couple of key moments during the design phase and lastly, to do the evaluation of the concepts in the right context for designing meaningful solutions.

Keywords: Product design, Healthcare, Low and medium income countries, Human Centered Design, Maternal and Newborn Child Health, Co-design.
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<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
</tr>
<tr>
<td>SDG</td>
<td>Sustainable Development Goal</td>
</tr>
<tr>
<td>MDG</td>
<td>Millennium Development Goal</td>
</tr>
<tr>
<td>ANM</td>
<td>Auxiliary Nurse Midwifery</td>
</tr>
<tr>
<td>ASHA</td>
<td>Accredited Social Health Activist</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organisations</td>
</tr>
<tr>
<td>AIIMS</td>
<td>All India Institute of Medical Sciences</td>
</tr>
<tr>
<td>MNCH</td>
<td>Maternal, Newborn Child Health</td>
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<tr>
<td>MNH</td>
<td>Maternal and Newborn health</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>WHS</td>
<td>World Health Statistics</td>
</tr>
<tr>
<td>MMR</td>
<td>Maternal Maternity Rate</td>
</tr>
<tr>
<td>PHC</td>
<td>Primary Health Center</td>
</tr>
<tr>
<td>LW</td>
<td>Lab.our Ward</td>
</tr>
<tr>
<td>LMIC</td>
<td>Low and Middle Income Countries</td>
</tr>
<tr>
<td>M4ID</td>
<td>Marketing for International Development</td>
</tr>
<tr>
<td>ANM</td>
<td>Auxiliary Nurse Midwifery</td>
</tr>
<tr>
<td>GNM</td>
<td>General Nursing and Midwifery</td>
</tr>
<tr>
<td>BMGF</td>
<td>Bill &amp; Melinda Gates Foundation</td>
</tr>
<tr>
<td>ANC</td>
<td>Antenatal Care</td>
</tr>
<tr>
<td>PNC</td>
<td>Postnatal Care</td>
</tr>
<tr>
<td>BOLD</td>
<td>Better Outcomes in Labour Difficulty</td>
</tr>
</tbody>
</table>
Chapter 1
Introduction

1.1 THE ISSUE: MATERNAL AND NEWBORN HEALTH

Substantial progress has been made in reducing the maternal and newborn mortality in the last two decades, which is indicated by the fact that globally, *Maternal Mortality Ratio (MMR)* fell by nearly 44% (from approximately 532,000 in 1990 to an estimated 303,000 in 2015) over the past 25 years (WHO | Trends in maternal mortality, 2015). Yet the Millennium Development Goal 5A (WHO | MDG 5, 2015) of improving maternal health by reducing maternal mortality by 75% before end of 2015 was not met. Complications during pregnancy and childbirth remain the leading cause of death amongst women of childbearing age globally.

* Maternal Mortality Ratio (MMR)

Number of maternal deaths during a given time period per 100,000 live births during the same time period.

As per (WHO | Maternal mortality, 2016) maternal mortality is unacceptably high. About 830 women die from pregnancy or childbirth-related complications around the world every day. It was estimated that in 2015, roughly 303,000 women died during and following pregnancy and childbirth. Almost all of these deaths (99%) occurred in low-resource settings, and most could have been prevented. The high number of maternal deaths in some areas of the world reflects inequities in access to health services, and highlights the gap between rich and poor.

Among other factors that prevent women from receiving or seeking care during pregnancy and childbirth are poverty, distance, lack of information, inadequate services and cultural practices (WHO | Maternal mortality, 2016). The key obstacle is pregnant women’s lack of access to quality care before, during and after childbirth (WHO | MDG 5, 2015). To end preventable maternal and newborn death, (Tunçalp et al., 2015) recommend that “every pregnant woman and newborn need skilled care at birth with evidence-based practices delivered in a humane, supportive environment” (p. 2). Therefore, it’s necessary to ensure that the needs of pregnant women and newborns are delivered by providing high quality of care in and across the facilities during pregnancy and childbirth.

Furthermore the grim facts and figures presented in several of the Maternal and Newborn Child Health (MNCH) reports, followed by WHO’s (World Health
Organisation) new Sustainable Development Goal 3 (WHO | SDG 3, 2015) to reduce the global MMR to less than 70 per 100,000 live births by 2030, suggests the high importance of the matter that requires urgent attention from the global health community. Recent studies shows that effective prevention and management of conditions in late pregnancy, childbirth and the early newborn period are likely to reduce the numbers of maternal deaths, antepartum and intrapartum-related stillbirths and early neonatal deaths significantly. Therefore, improvement of the quality of preventive and curative care during this critical period could have the greatest impact on maternal, foetal and newborn survival (WHO, 2016). In addition Lunze et al (2015) discusses that essential interventions can improve maternal and newborn health (MNH) outcomes in low- and middle-income countries.

Although growing number of life-saving global health innovations have been developed in recent decades, these innovations have traditionally been slow to scale up (USAID | Idea to Impact guide, 2015, p. 5). Recent case study (Design that Matters, 2012) related to designing healthcare products for developing countries suggests that often innovative solutions and products meant for low and middle income countries fails to deliver the impact. Products and / or services in combination are a lot based on incorrect assumptions and lacks the in-depth understanding of user, context, needs, and constraints of different cultural and social traits particularly in developing countries. Further it suggests that innovative ideas can also flounder when incorrect assumptions are made about users or the market itself (2015, p. 16).

In context of MNCH Lunze et al (2015) discuss that many novel medical products and health technologies for safer births and improved newborn care are in development globally, but few have been implemented. Moreover devices might need adaptations to meet needs in different countries, since they are usually not developed with a certain region or country in mind.

As discussed in Idea to Impact guide by USAID global health “Good design requires a deep understanding of end-users. Their unique needs and constraints, hopes and aspirations, can be the driving force behind inspiring innovations that improve quality of life for lower-income households.” (2015, p. 16). Therefore innovative products and services that are designed by ensuing Human Centered Design (HCD) process can yield design solutions that are truly relevant, engaging and empowering. In addition as told by Adam Reineck, design director at IDEO, “HCD is great at generating new solutions, and uncovering the nuance in these complex problems that can be difficult to understand with more traditional quantitative research methods.”

The core purpose of this thesis is to investigate how user centered design methods and participatory design approach can be effective for designing innovative products and / or service concepts meant for low and middle income countries. It further shows the usefulness of multidisciplinary collaboration in the early stages of the design process to develop, iterate and refine the ideas followed by prototyping and field evaluation in getting relevant feedback from intended users.

This thesis work has been done in three phases (explained later in this chapter). In the first phase literature review, ethnographic visits and successive co-design sessions lead to the development of four concrete design proposals (in the form of product ideas). The second phase gives more details about refinement of one of the promising ideas based on a co-creation and feedback event (Women Deliver Exhibition, May 2016) and the third phase describes the field evaluation in India and the subsequent findings.

Next in this Chapter I describe the motivation for carrying out this work, followed by mentioning a brief Introduction about Lab.our Ward (LW) project and M4ID Oy, as the company for which I had worked during the first phase of my thesis project. Later in this chapter I elaborate on the project timeline, scope, thesis objective and research questions and lastly the thesis structure are outlined.
1.2 SELF-MOTIVATION (HAVING MEANING & PURPOSE)

I believe as a student doing a master’s thesis is one of the opportunities to create a meaningful project, which has certain purpose and is close to one’s heart and self-driven.

During my second year at Aalto University, I started to think about the kind of project for my thesis. I wanted to work on a topic in which I could use my background knowledge with respect to living and growing up in a rural part of India, as well as apply some of the tools and methods I have learnt at Aalto University during my Master’s studies. In order to come up with some interesting topics I started to read books, articles and also attended few thesis seminar classes in the school. However, since I was not fully convinced and sure about those topics, I decided to give some more time to think through and went to The Netherlands for doing an internship in the summer of 2015.

During internship in Leiden one of the projects I had worked on was designing low cost hospital & Intensive Care Unit (ICU) beds for the Indian market. While I was about to complete the internship I came across the requirement for a product designer for LW project by M4ID at Helsinki and decided to do this project as a part of my master thesis.

One of the important reasons to do this project was the significance of the topic and I felt I could use my previous knowledge and experience from the internship project. At the same time this project has social relevance and positive impact in society and helps in improving the quality of life in general. A few years ago I was inspired by a graduation talk held at National Institute of Design (NID), India in Dec 2013 by Dr. Devi Shetty, who is an inspirational figure in Indian healthcare system and has done quite remarkable work in providing affordable healthcare for poor people. During his speech he mentioned about doing something which has a meaning & purpose, is of greater importance than doing work just for sake of earning money.

Apart from the above mentioned, there was one specific reason why I choose the topic - Improving MNCH in LRS, since the topic is close to my heart (as I myself come from similar background and have seen some cases in close family members who have suffered and even died due to lack of medical care).

As a designer coming from India and studying at Aalto University in Finland, it is always intriguing to know about the perception and importance of design in diverse context. Doing master’s degree thesis is the culmination of the studies and the learnings I have gone through in the last three years. This thesis represents my growth from a form based (doer) designer to a design researcher (thinker). It includes my first experience of making full-fledged hand-made prototypes and traveling more than 5000 km in India to conduct the user evaluation test. The thesis project and the important field evaluation have been followed with lot of personal motivation for self-learning and exploration.

1.3 ABOUT THE PROJECT

This thesis project has been done in three phases, over a period of around one year, starting on beginning of January 2016 (explained in the project timeline).

The first phase of the thesis (Jan-June 2016) including research, concept development and prototyping has been primarily done as a part of LW project.

LW was an innovation project to create new approaches to facility-based labour and delivery in low resource settings. The project was a cross-disciplinary innovation project to design novel maternity ward services, products and spaces that are based on women’s and care providers’ needs. (Lab.our Ward, 2017). The project was a healthcare design project combining several design approaches, including human centered design and evidence based healthcare design, in the context of facilities in resource-poor settings. The LW project took place from Dec 2015 to Dec 2016, after which the outcomes were published in the form of design proposals and strategies. The project got funding and expert assistance from the Bill & Melinda Gates Foundation. All the design proposals developed in this project falls under open source - Creative Commons 4.0 (CC) domain.

The organisation behind the project was M4ID Oy, based in Helsinki, Finland. It is a social impact company, with a mission to improve development and health outcomes of underserved and vulnerable communities. M4ID brings together creative communication, human centred design, and product innovation with development and health expertise for global development and health organisations (M4ID, 2017).

The project group consisted of product, stage, interaction, service and architectural design experts who worked together with medical advisors and health practitioners to develop many innovative concepts to improve the maternity ward experience in a low resource context. The initial research done in the LW project included preliminary observations and interviews were conducted in India, Kenya, Uganda and Nigeria. This happened before the start of the design phase.
1.3.1 MULTIDISCIPLINARY APPROACH & THINK TANKS

As mentioned before the project has a multidisciplinary approach. The aspect of multidisciplinarity occurred in two levels as explained below.

Firstly it involved three think tanks consisting of designers from product, service and architecture. Each think tank was formed by 2-5 members. I was fully involved in the project as a product designer and was part of the product think tank which was led by a senior product designer, (Nicolas von Flittner) who is an alumni of School of Arts, Design and Architecture, Aalto University.

The second aspect of multidisciplinarity occurred with interaction between designers and health experts such as one male midwife from Uganda, who came to do his fellowship for three months with M4ID and a local medical practitioner from Helsinki, Finland.

The three think tanks look at quality of care in regard to MNCH from different viewpoints as shown below.

<table>
<thead>
<tr>
<th>Products</th>
<th>Services</th>
<th>Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health care products, Furniture, Tools, Accessories, Lighting devices, Non-medical devices or equipments.</td>
<td>Interactions, Touchpoints, Experiences and Components of the customer journey map.</td>
<td>Interior spaces (delivery room, maternity wards), Ambiance, Colour and Signage system.</td>
</tr>
</tbody>
</table>

Table 1. Main domain of work for each think tanks.

1.3.2 MY CONTRIBUTION TOWARDS THE LW PROJECT

The LW project’s initial idea was conceived from June to Oct 2015. However I worked full time from Jan - June 2016. My contributions in the LW project were related to doing the research for design, exploring innovative ideas in the areas of products through benchmarking, making concept sketches, conducting field research in Finland and in India (during March - April 2016), facilitating co-design sessions with other designers and health experts, building prototype for early stage feedback and helping the team-members to set up Women Deliver exhibition in Copenhagen (explained later in chapter 5).

Most of the product ideas were developed in consultation with project members and the other designers. At each stage of the project co-creation and iterative approach was taken by inviting experts such as midwife from Uganda, maternal and child health care expert from Helsinki to refine the ideas based on their practical knowledge and experience. As per their feedback several paper and cardboard prototypes were built and then intertwined with space and service team concepts to create cross-pollination and finally come up with a final set of design proposals. In the LW Project all the three think tanks would meet once in a month to share their ideas and give feedback for further improvement to the other teams. The process of co-design sessions and the findings are explained later in the chapter 3 and 4 respectively.

As mentioned above, all the product concepts was done as team-work, however it is worth to note that after the end of the first phase, which refers to the end of WD exhibition, (see the theis timeline). The second phase (feedback analysis, and refinement of one of the most promising ideas - Delivery Stool) and the third phase (field evaluation in India) was done by myself. The motivation for doing these two phases are also described in the chapter 5 and 6 respectively.

The last two phases were done with support from Aalto Arts grant, received in Sept 2016 from Aalto School of Arts, design and Architecture to make the improved prototype (Delivery Stool 2.0) and travel to India.
1.3.3 THESIS TIMELINE

In this section I describe major three phases of the thesis work and briefly mention what was done in each of the phases (See Figure 3).

Phase one
(Jan - June 2016, Finland, India & Denmark)
- Discover - Define
  Field Research - Co-design sessions - refining and building prototypes - WD Exhibition

Phase one of the project consisted of design research which includes literature review, going through the findings from field-based healthcare project such as Better Outcomes in Labour Difficulty (BOLD) project done by M4ID, as well as referring to product based case studies done in relation to innovation in maternal health. In addition two field visits were conducted. The first visit was done at the Kätilöopisto Maternity Hospital (Finnish Maternity Hospital) with team-members from Service and Architecture think tanks. Later I did a two week short ethnographic field visit to India during the month of March - April 2016, followed by two co-design & ideation sessions.

In total around 20 product ideas were developed, out of which 9 ideas were selected to be presented for an early stage LW advisory board meeting. Based on the feedback 4 ideas were selected for making full scale working prototype. Towards the end of this phase the prototypes were exhibited at the triennial Women Deliver conference and exhibition in Copenhagen, Denmark (Lab.our Ward, 2017). The exhibition showcased more than 30 concepts from product, service design and architecture perspectives. This exhibition was done to co-create the concepts further and receive feedback from the visitors who were global health experts from around the world. In this thesis I will present only product proposals, since the service design and architecture concepts are beyond the purview of this thesis as other team members at M4ID worked on them.

Phase two
(Sept - Nov 2016, Finland)
- Develop
  Feedback analysis - refinement of Delivery Stool concept

Phase two comprises of analysis of the feedback and suggestions received from the Women Deliver exhibition and further development of one of the most promising ideas (Delivery Stool - explained later in chapter 5) in the form of an improved prototype meant for doing field evaluation in rural part of India.

Phase three
(Dec 2016 - April 2017, India & Finland)
- Deliver
  User Testing and field evaluation in India - thesis documentation

Phase three of the thesis consists of doing field evaluation and user testing in India. It was done for 3 weeks during the month of Dec 2016. The last part of the thesis work include writing and submitting a full conference paper based on the findings from the field evaluation and thesis documentation.

1.3.4 PROJECT SCOPE

This section opens up about the project scope and points out some of the guidance that were kept in mind while working on the project. Since the overall aim of the LW project was to showcase new ideas in relation to improving birthing experiences inside the facilities, some of the key aspects taken into consideration were:
The idea should fit in the context of LRS, meaning it should be cost effective, simple, and easy to produce locally and could be implemented at existing facilities as well as the new ones.

Ideas should be impactful, sustainable and implementable at large scale.

Designs were going to be published and share as open design, therefore, whoever could copy and produced them in LRS.

Products and services should support WHO recommendations, as for example, promoting the presence of the companion in the labour ward.

The number of deliveries performed in a typical facility was around 300 deliveries per month, indicating that the facility could be overcrowded.

In order to showcase the product ideas and get expert feedback, building functional prototype should be taken into consideration.

In general all the product ideas were not dealing with medical products as such, emphasizing the fact that those ideas might not need FDA (Food and Drug Administration) approval.

A note on vocabulary: Throughout this thesis the term design proposals or design solutions is used to refer to different product ideas as outcomes of the design work.

1.4 THESIS OBJECTIVES AND RESEARCH QUESTIONS

As mentioned previously the aim of this thesis is to analyse, explore and evaluate how user centered design methods and participatory design approach can be valuable for designing innovative products for resource-poor context. However important is to mention that the product proposals shown focuses on supporting woman's journey through the facility and aims to improve the comfort, safety and birthing experience from women and care provider's the perspective.

As a designer my goal was to understand the complexities in identifying the problems, cultural and contextual background, propose and evaluate design solutions for improving MNCH in LRS such as India.

To address this, I had identified following steps

- Get an understanding of the context and problems related to MNCH in LRS in order to design useful products.
- Propose and develop concepts through co-design and participatory design approach in close interaction with healthcare practitioners and other designers.
- Develop prototypes and refine it based on expert feedback.
- Conduct user research and expert evaluation in India.

This thesis addresses the following research question:

How Human Centered Design methods can be used to develop innovative healthcare product concepts meant for low resource settings?

Below mentioned are secondary questions I had identified

- How the design ideas takes shape, when designers work in close collaboration with end users and other stakeholders?
- How design research led projects that follow HCD approach, could bring values by developing innovative ideas that could fit the challenges and demand of LRS?

1.5 THESIS STRUCTURE

This section describe the thesis structure.

Chapter 2 explain some key concepts and research methods used in this thesis. Further it describes the women's maternal journey (in a representational way) starting with arrival at the facility, till discharge in five stages, and presents some innovative (product )case studies related to MNCH.

Chapter 3 describes key findings from the previous MNCH field based projects (BOLD) which provided key directions for initial ideation. Further it presents the insights from the field research work conducted in Finland and in India. A detailed description about two co-design and ideations sessions conducted are also explained.

On the basis above mentioned research work, an iterative concept work (using prototype) was carried out, involving users and health experts including a male midwife from Uganda and a local medical practitioner. Consequently, I propose a set of four product ideas through physical prototype, chapter 4 describes this in details.

The Prototypes were further exhibited in the triennial Women Deliver exhibition and conference, for expert comments, I also analyse the feedback for improvement and further refine one of the most promising idea (Delivery Stool) In Chapter 5 I give details of this work.

The improved prototype was given the name Delivery Stool 2.0 and was taken to field for user testing in India which is discussed in the chapter 6. Discussion, conclusions, and future works from this thesis project are briefly outlined in chapter 7.
This chapter explains four key concepts (as part of theoretical framework) and the methodological approach based on which this thesis work was built. In order to grasp some thoughts about the topic and context, I decided to comprehend the meaning of key words such as Maternal and Newborn Child Health (MNCH), Low Resource Settings (LRS), Positive Pregnancy Experience etc., (explained below). Further during the conceptualization phase, some of the design proposals were critically looked from these lenses.

Later in the chapter I will describe the women’s maternal journey at labour ward in a metaphorical way along with benchmarking some of innovative product and case studies from the domain of MNCH in low resource settings.
2.1 THEORETICAL FRAMEWORK (KEY CONCEPTS)

2.1.1 WHAT IS MNCH?

MNCH stands for Maternal and Newborn Child Health. Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. While motherhood is often a positive and fulfilling experience, for too many women it is associated with suffering, ill-health and even death (WHO | Maternal health, 2015).

Since 1990 the global maternal mortality ratio has declined by only 2.3% annually instead of the 5.5% needed to achieve MDG 5a; but in some countries, accelerated rates of decline were observed after 2000. This means that with continued efforts, it is possible to end preventable maternal mortality and reach the new Sustainable Development Goal (SDG). SDG 3 strives to reduce the global maternal mortality ratio to less than 70 per 100 000 live births by 2030, with no country having a maternal mortality rate twice the global average (WHO | 10 facts on maternal health, 2015).

WHO is supporting countries to deliver integrated, evidence-based and cost-effective care for mothers and babies during pregnancy, childbirth and the postpartum period. Investing in health systems – especially in training midwives and in making emergency obstetric care available round-the-clock is key to reducing maternal mortality (WHO | 10 facts on maternal health, 2015). In addition WHO (2016) standards of care and quality statements (8.2) talks about the need to design labour, childbirth and postnatal care so that every woman and newborn can be cared for according to their needs in private, to facilitate the continuity of care. In the context of my thesis MNCH is the domain in which I design and evaluate the products.

2.1.2 WHAT IS LOW RESOURCE SETTINGS?

Based on the literature review done for this thesis I did not find a concrete definition of Low Resource Settings (LRS). LRS in general is a broad concept and is often interpreted as resource-poor settings or Low and Middle Income Countries (LMIC). In relation to health, low-resource settings are typically characterized by a lack of funds to cover health care costs, on individual or societal basis, (Low Resource Settings, 2014) which leads to one or several of the following:

• Limited access to medication, equipment, supplies, and devices
• Less developed infrastructure (electrical power, transportation, controlled environment/buildings)
• Fewer or less-trained personnel
• Limited access to maintenance and parts
• Limited availability of equipment, supplies, & medication
• Note that there are Tier-I and Tier-II categories for any given country/setting

In relation to LRS, Lunze et al (2015) suggests that proven interventions that reduce maternal and newborn mortality and morbidity are well established, yet these essential interventions are not delivered at scale in low- and middle income countries. Furthermore, in order for any innovative intervention to be scaled up in low-resource settings, evaluation studies need to consider cost, feasibility, and acceptability (Lunze et al., 2015). In my thesis low and medium resource settings is the context of my design and research endeavour.

2.1.3 WHAT IS INNOVATION IN HEALTH CARE?

In the literature review, I found several definitions of innovations in general as well as innovations in the healthcare sector. For instance Omachonu and Einspruch (2010) say that healthcare innovation can be defined as the introduction of a new concept, idea, service, process, or product aimed at improving treatment, diagnosis, education, outreach, prevention and research, and with the long term goals of improving quality, safety, outcomes, efficiency and costs. Product innovation can be defined as the introduction of goods or services that are new or significantly improved with respect to their characteristics or intended uses. Process innovation is the implementation of a new or significantly improved production or delivery method. In addition there could be innovations for creating demand (for services, products, information, etc.) or improving the function of the organization.

Considering the thesis focal point was to develop innovative healthcare products from user and care provider’s perspective, therefore in this thesis, innovations have been defined from the patient’s point of view, the intended benefits are either improved health or reduced suffering due to illness (Faulkner and Kent, 2001). For example the Delivery Stool that I have designed as part of this thesis is intended to reduce the labour pain of pregnant women by providing alternative birthing position (such as squatting) and not restricting only to bed (supine position), thereby create value for the user as discussed by Satia et al (2013) useful innovations are those that create value benefits for the provider or user of healthcare.
2.1.4 POSITIVE PREGNANCY EXPERIENCE

As per the report Maternal and Newborn Health by UNICEF (2009) suggests pregnancy and childbirth are generally times of joy for parents and families. Pregnancy, birth and motherhood, in an environment that respects women, can powerfully affirm women’s rights and social status without jeopardizing their health. The enabling environment for safe motherhood and childbirth depends on the care and attention provided to pregnant women and newborns by communities and families, the acumen of skilled health personnel and the availability of adequate healthcare facilities, equipment, medicines and emergency care when needed.

The World Health Organization (WHO) envisions a world where “every pregnant woman and newborn receives quality care throughout the pregnancy, childbirth and the postnatal period” (Tuncalp et al., 2015)

According to WHO (2016) recommendations on Antenatal care for a positive pregnancy experience. A positive pregnancy experience is defined as maintaining physical and socio-cultural normality, maintaining a healthy pregnancy for mother and baby (including preventing or treating risks, illness and death), having an effective transition to positive Labour and birth, and achieving positive motherhood (including maternal self-esteem, competence and autonomy).

A positive delivery experience can be achieved in many ways. According to care in normal birth guide by WHO (1996) motivating women to have other positions during labour is beneficial because it can help women cope with labour pain and thus improve the childbirth experience. The delivery stool that I have designed and I evaluate as part of this thesis goes in line with above statement and tries to motivate women to have different birth positions and thus improve the child birth experience.

2.2 METHODOLOGICAL APPROACH

In this thesis the design process followed a human-centered design approach including Participatory design and co-design. It happened on different levels and at different stages (explained later in chapter 3 and 4).

2.2.1 HUMAN CENTERED DESIGN

IDEO describes Human Centered design (HCD) as a creative approach to problem solving. It involves developing a deep understanding of users and takes a holistic view of all the stakeholders who benefit from the product or service that is created. It involves building a deep empathy with people’s needs, behaviour and collaborating with stakeholders during various stages of design process in an iterative method. Further as illustrated in Design Kit (2015) Human Centered Design has three phases –

Inspiration – develop empathy with the user to get deeper understanding of their needs.

Ideation – identifying opportunities and making sense of the learnings by prototyping.

Implementation – reiterating whenever needed and bringing solution to life and if possible to market.

Figure 4. The three Phases of Human Centered design.
Source: https://www.ideo.org/approach accessed on 24th Feb 2017
HCD often uses many participatory design methods to invite stakeholders to actively engage in the early stage of design process, thus helping designer to not only get inspired but also co-design solutions that are feasible, viable and user-friendly. Moreover as cited by Sanders (2002) in user-centered design, the roles of the researcher and the designer are distinct, yet interdependent. The user is not really a part of the team, but is spoken for by the researcher. While participatory experiences, the roles of the designer and the researcher blur and the user becomes a critical component of the process.

A note on vocabulary: In this thesis, the term ‘human-centered design’ is used interchangeably to refer to concepts such as user-centered design, patient-centered design or women-centric experience design. I prefer to use the phrase human-centered design, because it is more inclusive of the other stakeholders that take part in the design process; including care providers, medical advisors, health experts and birth companion.

2.2.2 PARTICIPATORY DESIGN

Participatory Design (PD) is a design approach in which users and other stakeholders work with designers in the design process (Sanders, Brandt, & Binder, 2010).

Participatory Design practitioners share the view that every participant is an expert in how they live their lives and what they do, whose voice needs to be heard; that design ideas arise in collaboration with participants from diverse backgrounds; that PD practitioners prefer to spend time with users in their environment rather than “test” them in laboratories (Sanoff, 2007). Thus in this project participatory design method along with immersive co-design, role play and quick prototyping were used extensively (explained in chapter 3) and forms the core design norm for this thesis.

Further as discussed by Hussain et al (2012). The use of participatory design is often advocated when developing new solutions for economically or socially marginalised people in developing countries. It is argued that through including users in the design process designers can understand their needs better. Similarly in line with above mentioned participatory design methods have been explored in this thesis to design and evaluate the product proposals.

2.3 MATERNAL JOURNEY AT LABOUR WARD

While doing the literature review I gradually started to recognize the specifics about Labour Ward (LW) and women’s maternal journey inside a facility from a macro or bird’s eye perspective - the steps or journey through which a women goes through upon arrival, admission, labour, delivery and postpartum stages. In addition understanding how the facility and the resources available are interconnected to serve the pregnant woman in different stages, was of utmost importance to come up with design proposals.

The intention to present the maternal journey in this thesis is to communicate the use of maternal journey as a tool that was referred during co-design and ideation phase (explained in chapter 3.3.1). Each step of maternal journey was explored to gain deeper understanding of the birthing process in a sequential way. In addition some of the design proposals are focussed on a particular stage in the process while others are more far-reaching and interconnected solutions are more overreaching and interconnected solutions. Each proposals was presented accordingly, thereby illustrating the usefulness of maternal journey map as an important tool. Below mentioned is the five steps of the women’s maternal journey.

![Maternal Journey of a women presented in an infographic form and used as a tool for ideation. Source: http://labourward.org/proposal/journey accessed on 24th Feb 2017](image-url)
Arrival (also called as Reception): It’s the stage when the pregnant woman visits the facility and most often is already experiencing pain and the cervical dilation could be from 0-2 cm or more.

Admission or Check-in: During admission the pregnant woman’s condition is being checked and depending on cervical dilation and the labour stage the midwife could either ask her to wait longer or can refer to labour or delivery room.

Labour: In this phase the pregnant woman experiences intense labour pain and there is an increase in cervical dilation (2-8 cm or more). The labour to delivery phase time can vary from few hours to sometime few days. The role of companion is crucial at this stage to support her.

Delivery: This is the stage when the newborn baby is delivered and is instantly placed on the chest of the mother for first skin to skin contact. The separation of umbilical cord and the recording of Apgar score is done in this phase along with delivery of placenta.

Postnatal: Or Postpartum is the period beginning immediately after the birth of a child and extending for about six weeks. Often breastfeeding starts in this stage depending if the baby’s condition is normal and not a preterm or underweight. WHO (2013) describes the postnatal period as the most critical and yet the most neglected phase in the lives of mothers and babies; most deaths occur during the postnatal period.

Apart from the maternal journey, some other important aspects in this thesis was to get familiar was the common terminology used in MNCH such as antenatal, postnatal etc., (which refers to the phase before and after birth) and what does it actually means from user and care provider’s perspective? Moreover for me as a designer it was significant to understand the basic procedure such as how the midwife determines if the pregnant woman is in labour phase or in delivery phase, and at what stage oxytocin (meant to release the pelvic muscle) is given and so on, to design proposals that include these recommended procedures.

Note: The above mentioned description of different stages of labour is written in a simplified way to represent woman’s journey as a tool in the design phase and does not necessarily represent the actual medical conditions.

2.4 INNOVATIVE CASE STUDIES - Related works

Decline in maternal mortality ratio (MMR) over the last decade has been a slow one (Satia, Misra, Arora, & Neogi, 2013). Several developing countries including India have innovated and adopted new (product and service) models to improve the aspect of maternal and newborn care. Some of the case studies done in India demonstrate innovative approaches, overcoming obstacles such as lack of human resource, long distances, delays in referral, geographical barriers etc., and have succeeded in delivering promising results in addressing the health needs of the local populace, thereby accelerating the decline in maternal and newborn mortality (Satia et al., 2013).

Schemes such as Janani Suraksha Yojana (“JSY,” 2013) initiated by Government of India in 2005, aim at reducing maternal and newborn mortality by promoting institutional delivery where financial incentives are provided to mothers as well as to Accredited Social Health Activists (ASHAs). Another innovative model of mobile boat clinics implemented in different riverine areas, the Sunderbans in the state of West Bengal and islands on the Brahmaputra river in the state of Assam (one of the worst performing state in MMR in India) to help deliver essential services in the remote and inaccessible islands.

During this thesis I also did extensive online research to benchmark some of the existing product and case studies examples related to MNCH in Low resource settings, some of these products examples address direct and indirect causes for maternal and newborn mortality (Satia et al., 2013).

Primarily there were two reasons to do the benchmarking, first to make sure that the future design proposals has not already been done before. Secondly to get some inspiration from the innovative case studies or product examples, at the same time learn from these context based case studies. Below mentioned are some selected examples of such (product) case studies. The case studies presents innovative approaches used for health system strengthening with emphasis on improving maternal and newborn health.
2.4.1 MAMANATALIE BIRTHING SIMULATOR

Organization – Laerdal Global Health, Year 2011

MamaNatalie birthing simulator is a convincing and affordable training kit meant for nurses and midwives in maternal and newborn care. The simulator is particularly realistic for training control of postpartum haemorrhage - the number one cause of maternal death during childbirth - and communication with the mother.

It simulates very compelling simulations of normal to more complex birthing scenarios (MamaNatalie, 2011). The kit comes comprises of replica model of placenta, blood concentrate - NeoNatalie suction, blood collection tray, urine bladder etc., with a detailed instruction manual and transport/storage bag. In support of the UN (United Nations) MDG (Millennium Development Goal) 4 and 5, Laerdal Global Health, the organization behind this product has committed to providing the MamaNatalie Birthing Simulator tools to developing countries on a not-for-profit basis through to 2015 (MamaNatalie, 2011).

In contrast with the products proposals that are presented in this thesis, MamaNatalie is a product that will be used for training purpose and not in real deliveries. However I have referred to this case to understand the process of innovation in terms of user testing and certain protocols or recommendations that were taken into consideration, since birthing scenarios could be contextually different in different countries.

2.4.2 EMBRACE INFANT WARMER

Organization - Embrace Innovations, Year 2011

Embrace Infant warmer is a low cost warmer that maintains the body temperature of premature and low-weight newborn babies at the desired level even with irregular access to electricity. It can also be used for transporting hypothermic newborns.

It addresses the pressing need of low cost, portable, safe and effective infant warmer in developing countries, considering the fact that in those countries mortality for these infants is particularly high because incubators are extremely rare. Most hospitals and clinics in developing countries don’t have enough incubators to meet the tremendous need. Each year around 20 million premature and low-birth-weight babies are born (Embrace Warmer | Infant Warmer, 2011).

This product is needed after the newborn delivery and falls under postnatal conditions, the interesting aspect to refer to this product was to know and learn from the contextual know-how and inventiveness in material application. For instance this infant warmer can be used without the need of continuous electricity as it uses the wax pouch as material to transfer heat.
2.4.3 JANMA BIRTH KIT

Organization – Ayzh Health and Livelihood Pvt. Ltd., Year 2013

JANMA is a US$3 clean birth kit in a purse, containing six simple tools recommended by the World Health Organization (WHO) to ensure sanitation and sterility at the time of childbirth. By providing the ‘six cleans’ (clean hands, clean perineum, clean delivery surface, clean cord cutting and tying instruments, and clean cutting surface), JANMA prevents infections, mortality, and morbidity at the time of childbirth. JANMA not only saves the lives of mother and baby, but also gives them a happy, healthy, infection-free start to life (JANMA, 2013).

Assembled by local women in India, JANMA (which means birth in Sanskrit) is packed in a biodegradable jute bag that new mothers can reuse as a purse. Each bag contains an underpad, a surgical scalpel blade, a cord clamp, a bar of soap, a baby wiping cloth and an instruction sheet. The Organization behind Janma is Ayzh, a social enterprise, located in Chennai, India. As of year 2014, a total of 50,000 Clean Birth Kits were sold and 1,425 births were conducted using the kits, with 340 healthcare workers trained through the mobile phone training program (Ayzh, 2017).

In this case, though the product is a simple birthing kit, and would be used during delivery phase, the key aspect in this case was to assess the use of local available material. For example the kit bag is made out of jute, which is a cheap biodegradable material and locally available, since India is one of the largest producer of jute in the world. However as discussed by (Lunze et al., 2015) clean birth kits have been suggested as an innovative approach, but evidence to support their impact on health outcomes is inconclusive, particularly in the community setting.

2.4.4 YELLOWONE HANDSAFE

Organization - Yellowone -handsafe, Year 2015

Yellowone Handsafe is a single-use, wearable “point of care” alcohol-based hand rub dispenser for medical staff that can be attached to the care provider’s pocket. The solution provides essential and easy access to hand cleansing without having to leave the patient zone. The insights for development of this product were - presently, 60% of all healthcare staff does not comply with hand hygiene as recommended by the World Health Organisation, moreover hospital-acquired infections kill 16 million lives – more than AIDS, malaria, and tuberculosis combined.

There are two main reasons cited for this problem are:

1) Hand hygiene takes time.
2) The staff mobility is high, so they skip hand hygiene when an emergency or unpredictable situation occurs (yellowone-handsafe, 2015).

In this case the Yellowone Handsafe design is based on the insights gathered during in-depth field observation of healthcare staff and their everyday challenges at work, concerning hand hygiene issues. Hence the learning from this example was to understand the importance of indepth field observations and to reflect on simple, time saving and ergonomic solutions that can be effective not only for users but healthcare staff as well.

Figure 8. JANMA Clean Birth Kit in a purse, with all the essential tools required to ensure safe and sterile conditions at the time of childbirth. Source: http://www.ayzh.com/, accessed on 3rd March 2017

Figure 9. Yellowone Handsafe Pocket size disinfectant dispenser
Source: http://www.yellowone-handsafe.com/, accessed on 3rd March 2017
2.4.5 NIFTY FEEDING CUP

Organizations - A collaboration between the University of Washington, Seattle Children’s hospital, PATH and Laerdal Global Health, Year 2015

Nifty Feeding Cup is a reusable product for feeding breast milk to newborns with breastfeeding difficulties. It is a simple to use, easy to clean and culturally appropriate feeding solution which allows the infant to control the pace of feeding (Nifty Cup, 2015).

The World Health Organization calls breastfeeding “one of the most effective ways to ensure child health and survival.” In this case the challenge was feeding breastmilk to the most vulnerable newborns who have not developed suckling reflex. The NIFTY cup allows them to drink breast milk at a pace and flow that each individual infant establishes (Nifty Cup, 2015).

Figure 10. The NIFTY cup for newborns: when breastfeeding is not an option

Though this product falls under neonatal or pre-term newborn care and is not directly linked with product proposals presented in this thesis, however the important aspect in this case is that the NIFTY cup went through multiple design iterations and it took five years with several user-testings and collaboration across three continents. Therefore the learnings in this case are the iterative design process and long term collaboration is key to develop innovative solutions.

Summary Points from Case Studies:
1. Standard practice and recommendations for user-testing and field evaluation.
2. Innovative application of (commonly used) material.
3. Local use of cheap and eco-friendly material.
4. In-depth field observations not only for end users but healthcare staff as well.
5. Long term collaborations and iterative design process to develop innovative solutions.

The above mentioned case studies shows examples of innovative technology approaches and appropriate devices and medicines to promote maternal and newborn health (MNH) in resource-limited environments. However as discussed by (Lunze et al., 2015) criteria for what makes technology appropriate for LMICs are unclear, as are issues of affordability for end users in LMICs. Thereby efficient strategies to make health technologies suitable and acceptable and even scaled-down high-tech versions are often too expensive for use in LMICs, and will require user training and device maintenance. In the next chapter I will present the findings from field research and co-design sessions.
This chapter discusses the research work carried out during phase one of this thesis. As mentioned earlier in section 1.5 (thesis structure), the research part consisted firstly of going through the project (report) findings from previous field based project - Better outcomes in Labour Delivery (BOLD) related to Maternal, Newborn Child Health (MNCH). Secondly it describes the insights gathered from field visit conducted between March-April 2016. The initial visit was made at Kätilöopisto Maternity Hospital located in Helsinki, Finland and later in India, in the states of Bihar and West Bengal. The overall aim of the field visits was to build a basic understanding of the current practices, protocols followed, tools and equipment's (products in specific) used during the women’s maternal journey inside the facilities and most importantly identifying gaps and opportunities for design intervention.

Based on the research findings, two ideation and co-design sessions were conducted in order to reflect, share ideas and to come up with new design proposals. The results from the co-design sessions are briefly outlined in the latter part of this chapter.
3.1 FINDINGS FROM BOLD PROJECT

In order to gain more knowledge pertinent to MNCH in Low Resource Settings (LRS), I decided to go through the findings from BOLD project, moreover based on these insights the LW project was formulated.

BOLD was a two-year project started in 2014. Launched by the World Health Organization (WHO) and M4ID, it seeks to research and design a set of new tools to support health workers in providing appropriate care during childbirth and to increase demand for respectful, quality care among communities in LRS. (BOLD, 2017)

BOLD findings indicated several issues and needs for improvements inside the labour and maternity ward. Since I was part of the product think tank, I selected topics which were connected with products in general. The insights from BOLD project gave early evidence about the type of design proposals that could be expected as deliverables. It helped to narrow down and restrict some of the instinctive ideas, for instance products which would need expensive technology or would require specific training and maintenance to run the device, considering an estimated 50% of medical equipments in developing countries are not used, either because of a lack of spare parts or maintenance, or because health workers do not know how to use it (WHO, 2007). The insights helped to visualize the current situation in some of the low and middle income countries, and also about different kind of products used in the facilities. Further it was useful to know about constraints such as lack of trained professionals, overcrowding, no access to electricity, low maintenance of existing products to name a few.

Below mentioned are eight themes from the project report, highlighting the possible design intervention.

1. Lighting innovation: Use of fluorescent, solar powered, rechargeable or reflective wall coverings to increase or improve the labour ward lighting and visibility (many do not have access to electricity and deliveries are carried out in the dark at night).
2. Infection control: Use of new technologies, such as infra-red light and automated sprays, will be explored to address poor infection control in facilities, instrument preparation and delivery rooms.
3. Wearables and connected objects: Use of wearable technology and sensors for health workers to be better informed and empowered for decision making and action, (for example through reminders and alerts).
4. Birthing position and labour chair or bed: Exploring alternative birthing position support structures or beds with additional information such as bed board or labour stage indicators. Innovations to improve interaction between birth companion and midwives.
5. Color-coding: Instruction and path/journey guidance through color-coding connecting interfaces, objects and spaces for expectant mothers, companions and care providers.
6. Contextual information integrated spaces: Using spaces, surfaces and fabrics (e.g. curtains, walls, bed, instruments, uniform) to display information relevant to the context and situation.
7. Interactions and services: New interaction models with tools for midwives and clients to engage in more empowered dialogue about quality of care.
8. Ambience and interior: Exploration of sound design, colour, shape and materials to improve the experience in the facility.

3.2 FIELD BASED RESEARCH

As explained earlier doing field visits was a valuable part of the research work. The field research illustrates important opportunity to not only gain contextual understanding about people, place, surroundings but also I was able to touch, feel and experience some of the products that are used inside the facilities. As mentioned by Hussain (2011) to really understand the social and cultural needs, it is necessary to understand what it meant to be that person, living in rural areas through in depth interviews, and observation. Similarly as a designer it was important for me to also understand the barriers in relation to social, cultural, financial and even behavioural aspects that prevents women to get sufficient care during childbirth.

In this section I will explain the objective of field visits, methods used, and outline the significant findings. Overall two field visits conducted, the first visit was done during the month of January 2016 at Kätilöopisto Maternity Hospital (HUS) located in Helsinki, Finland. Kätilöopisto maternity hospital is the largest maternity hospital in Finland, and has been awarded a baby friendly certification for its supportive breastfeeding policy (Kätilöopisto Maternity Hospital, 2017).

The second visit was done in India during the month of March - April 2016 (explained later in this chapter). Both these visits laid a strong foundation for co-design and ideation phase.
3.2.1 VISIT TO KÄTILÖOPISTO MATERNITY HOSPITAL

The visit to the maternity hospital was done with team-members from service design and architecture think tanks. The visit was organized by the producer for the LW project. The team-members were granted a time slot of two hours to visit the facility and interact with the head nurse.

The reasons for choosing to visit this place were both practical and driven by opportunity to visit and see one of the best maternity health center in Finland. As per WHO key country indicators (2016) Finland is one of the top ranked countries in the world for providing good services in maternal and newborn child healthcare. The Finnish baby box is one such example, it serves as a starter kit for the newborn and the baby box program has helped Finland achieve one of the world’s lowest infant mortality rates (Finnish Baby Box, 2017).

The primary objectives were:

• To know and understand the process or steps of women maternal journey (starting from arrival at the facility till departure)
• How the facility and the working staff (mainly midwives) support the client and her companion
• What types of tools and instruments are used during different stages of labour
• What are the challenges faced by nursing staff or head nurse in their daily task

Lastly the aim was to benchmark and identify possible design opportunities through products, services and / or spaces used at different moments of the labour and delivery. For this thesis I will present the discoveries related to products in general.

Selected methods:

Some of the methods selected for this field research were observation, informal interview and open discussions with the head nurse. Throughout the visit notes were taken in a diary along with some pictures and videos meant purely for study purposes. During the visit the head nurse showed one particular ward (5th floor) of the facility, where normal deliveries (non cesarean) takes place. Since the team members were from five different countries the language chosen to communicate was English. Some interview questions were formed on the spot depending on the topic of the conversation.

The visit started by showing the floor plan of the facility, getting to know about the average number of monthly deliveries taking place in the facility and general procedure followed before, during and after the birth. The main spaces shown were delivery rooms, postnatal room, and open area corridor (where the pregnant woman could walk along with her companion during the labour stages), cleaning and storage space. The delivery room had almost all the tools, equipment’s and devices that are used in a modern-day maternity hospital. The head nurse also explained the full procedure related to services, usage of the space, and tasks involved in handling emergency situations. In addition she answered most of the questions that were asked throughout the visit.

Below mentioned are some of the findings:

In relation to number of deliveries: As per the head nurse, the approximate number of birth per year in the whole facility (hospital) was around 8300. In that particular ward where the team visited it was around 300 a month, which suggests that in general the facility does not get too overcrowded.

In relation to Spaces & Rooms: In total there was one antenatal, two delivery and or labour rooms, two postnatal rooms and two operation theatre and in addition a common seating area. The postnatal room was located right next to the delivery rooms, so that the pregnant woman and the newborn could be shifted easily. Both the delivery rooms were meant to be used only for single delivery at a time and the companion (usually husband or partner) could stay inside the room throughout the labour to delivery phase.
In relation to equipment’s, tools and accessories: The delivery room had a fully automated, height adjustable (remote controlled) delivery bed. It could turn into a seating position with additional add-ons such as calf support and feet support (These attachments aids alternative birthing positions). Next to bed was a closet or cupboard containing gloves, towels and supplies used during birthing. On the right side of the bed a computer and a heart rate monitoring equipment was kept for recording vital statistics (as shown in the Fig.12).

![Delivery room at Kätilöopisto maternity hospital in Helsinki, Finland. Source: LW Project 2017](image)

In the same room there was also a newborn corner with devices to measure the weight and height. Products such as gym ball (of two sizes) and a wooden delivery stool to support the client during labour stages. On the opposite side of the delivery bed, there was a medium sized bathtub for underwater delivery and a toilet with shower. A set of handy accessories such as emergency alarm, thermometer, wooden comb etc., were carried by midwife during the working hours to use in daily practices

In relation to look, feel and surroundings: The general look and feel was very ‘hospital’ like. Some decorative items which are familiar from home, were used (such as curtains, wall paper, some lamps etc.). However it felt that there could be plenty of scope for improvements, such as inclusion of natural plants and lights. Presence of rocking chair could be seen nearly in every room. All the room seemed clean, well organised, though some items were stored on the hallways, but in general all items were kept in their designated places. Regular wall clocks could be seen in almost all the rooms and corridor. One could see plenty of stickers as signage, indicating the location of different items and instruments. The cupboards doors were marked with large numbers, even products such as trolleys were marked with labels based on their use or location.

In relation to interesting product: Delivery Stool: Apart from above products mentioned, one of the interesting product that i found quite useful and interesting was a traditional wooden delivery stool (see the Fig.13). It is just a simple low height stool meant for delivery in a squatting posture. The head nurse mentioned that it is offered to the pregnant women as an option to delivery beds, to support alternative birthing posture, if she feels comfortable and easier in a squatting position rather than lying or semi reclining on a delivery bed.

![The wooden delivery stools for supporting alternative birth.](image)

Moreover she pointed out that the delivery stool was quite popular during 1960 -70’s, however the usage of delivery stool is not so common nowadays, because the current delivery bed provides many alternate adjustments. Yet they have kept it as an option since many pregnant women feels comfortable to use it as an alternative. One of the main reason that the stool is also preferred because the companion can sit on the back side and provide support to the clients during labour and delivery, in addition the pregnant woman can hold or grab their companion hands during painful moments.
Minimum product need: As shown by the head nurse, it was an eye opening information when she mentioned that ‘if the delivery is normal (non cesarean) then only 2 clips, 1 rubber string and a pair of scissor are needed’ (see the Fig.14) to conduct a delivery.

Baby cot and trolley: It was worth to note that next to the postnatal bed, there was a separate baby cot (see the Fig.15) which takes more space and there was also a separate trolley for each purpose - cleaning trolley, food delivery cart and baby cot.

3.2.2 VISIT TO INDIA

After visiting the maternity hospitals and getting to know about different products and process of newborn delivery in Finland, the next field visit was made to India during the month of March - April 2016.

India is one of the target country for global reduction of MMR (Maternal Maternity Rate), according to the Trends in maternal mortality: 1990 to 2015 report, released by WHO (2015) - India is estimated to account for 15% (Nearly 45,000) maternal deaths in 2015, second only to Nigeria with 19% (58,000) deaths in the same year. Currently as per WHO (2015) five women die every hour in India during childbirth. Based on the World Health Statistics (WHS) the MMR of India is 174/100,000 live births (MMR | Data, 2016)

Though India’s MMR reduced from 212 deaths per 100,000 live births in 2007 to 178 deaths in 2012 (WHO, 2015), adolescent and illiterate mothers and those living in hard to reach areas still have a much greater chance of dying in childbirth. Adolescent girls outside Indian cities are especially vulnerable as teenage marriage and pregnancies are very high in rural and remote areas of the country. It is further mentioned that Mothers in the lowest economic bracket have about a two and a half times higher mortality rate (UNICEF | India, 2016).

According to Healthcare in India (2010) report by KPMG, India is facing a serious challenge in matching the supply of healthcare resources with the growing demand on account of population growth, improving socio-economic drivers, and the increasing disease burden of lifestyle diseases. For instance sixty percent of rural population lack access to critical medicine and surprisingly thirty one percent of the rural population travels over thirty kilometres for medical treatment.

Because of the above mentioned facts and figures I decided to conduct the field research in India, specifically in rural India. Furthermore being an Indian and a native speaker, it was an unique opportunity for me to get familiar with the ground reality in terms of knowing more about MNCH situation in India. Apart from doing one week visit to rural India, I also visited a public city hospital in Kolkata (formerly known as Calcutta) in order to see and compare the quality of care in rural as well as in urban environment.
The places selected to visit in India were the state of Bihar and West Bengal. Bihar is one of the poor, backward states and has one of the highest MMR in India (Census India, 2011). Besides I had spent my early childhood in Bihar and can speak the local languages (Bhojpuri and Maithili). My hometown in India is Kolkata, in West Bengal, which is Bihar’s neighbouring, therefore it was easier to travel, and was able to make contacts with local health facilities through friends and family.

As a part of the field visit the following objectives were set:

- To gather insights about the local practices and methods followed during labour and delivery (in rural and urban areas)
- To know and understand the type of existing products (such as delivery bed, postnatal beds, cleaning and sterilization equipment’s etc.) inside the facility
- To know how the products are used and maintained before, during and after the delivery
- Understanding the interaction between product, services and space in general
- Knowing the problems faced by the pregnant woman, midwives and health care workers

In order to fulfill the above mentioned objective, I selected to follow a mixed method approach such as observations, field notes, informal interviews with midwives, facility staff, field based health workers also known as ASHA, pregnant women and their companion.

In total five facilities were visited, two Primary Health Centres (PHC) in the district of Gaya, one village health facility in the district of Nawada (Narhat and Sirdala). One public hospital (Kolkata National Medical College) in Kolkata, West Bengal. During the planning phase I contacted representatives from these primary health centres in order to get permission to conduct the research. The field research was done in roughly two weeks including traveling time.

Five informal interviews were conducted: two with a facility cleaning staff member and an Auxiliary Nurse Midwifery (ANM) at Manpur (Gaya), one with nursing staff in the delivery room at Narhat and one with village health worker (ASHA). In addition, an open discussion was done with pregnant woman. The observations and interview transcripts were noted in the form of field notes, complemented with photographs and videos of important moments.

The interview notes and pictures along with videos were analysed to assess the current products usage, both in rural and urban areas. The pictures were looked at carefully to identify the opportunities keeping in mind certain constraints like cost and affordability. One of the design direction thought was how to do value addition to some of the existing products with minimum changes, for example how the existing postnatal bed could be modified to accommodate more than one pregnant women or to add a storage space.
Mentioned below are some of the results:

In relation to Infrastructure & Human resource: The infrastructure (spaces and the number of available rooms) at Primary Health Centers (PHCs) in rural areas seemed adequate to handle overcrowding. For instance the PHC in Gaya (Manpur) and Narhat were recently built 3 storey building. Ironically inside the facility some of the rooms were empty and does not had any beds or furniture’s. The reason mentioned were - 'not enough patients visiting the center, and lack of funds to buy new beds.’

In each facility there was one midwife (ANM) and 2-3 support staff along with one cleaning staff. The facilities were only meant for normal deliveries, in case if the pregnant women would need to undergo operation (C-section) they would be referred to the nearest district hospital.

In relation to look, feel and surroundings: The general atmosphere inside the facilities could be termed as ‘over crowded’ there were several curious looking people (mostly relatives of pregnant woman) waiting outside the delivery room. Occasionally loud painful birthing moments could be heard from inside the delivery room. The postnatal rooms in city hospital were most crowded and could be termed as unorganized or chaotic at times.

In relation to Hygiene: Overall there was a general sense of lack of cleanliness across the facilities. Often only the delivery beds were cleaned with bleaching powder or some chemical after the delivery and not the floor surface and other equipment’s used. In one of the facility I observed - used syringes were thrown on the corridor, even though color coded plastic bags were available to separate the waste for recycling. The toilets were not cleaned and maintained properly. The situation in the city public hospital regarding lack of cleanliness and hygiene was even worse, most probably because of overcrowding, though more detailed research would be needed to make a concrete conclusion.

In relation to attitude towards Quality of Care: Throughout the visit it was observed that the actual issue might lie in the mind-set (attitude) of the care providers towards delivering quality of care. For instance while talking to one of the pregnant woman’s companions, she mentioned that her daughter in law (pregnant woman) was discharged instantly to after the delivery, even though WHO recommendation suggests - If birth is in a health facility, mothers and newborns should receive postnatal care in the facility for at least 24 hours after birth (Information, Pike, MD, & Usa, 2013). On the other hand while interviewing the midwife she casually said “here we don’t keep mother and newborn longer since we don’t provide food to them... and i am following order from facility administration”. In a nutshell this conversation suggested the current situation and care provider’s attitude toward quality of care.

In relation to existing products and usage: Most of the delivery beds were around 10 years old, looked rusty, and had no cushion and handle to grab. Only lying down or semi-recline birthing positions were attainable. The postnatal beds were ill-maintained. During visit to PHC in Narhat, I noticed that some of the beds were used inside the office space (as working tables). Most of the equipment’s such as baby weighing machines, autoclave sterilization of surgical instruments were either not functioning or were not in use. The possible reason could be lack of power supply or maintenance.

In relation to scope of design intervention: Based on the short field, one can conclude that there are plenty of need for improvements across the facilities, not only in terms of products but combination of product-services and even whole system. Considering India is vast country and has around 1.25 billion people, therefore dealing with huge number of people would require a change from every stakeholder involved in the system. As discussed in WHO’s framework for action report (2007) only limited success will result unless the efforts of other sectors are brought to bear on achieving better health outcomes.

In relation to design approach: Based on the visit to both rural and urban set up it gave the impression that the situation in urban areas (city) needs more attention, since urbanization in India is happening at a rapid pace, it is estimated that by 2030, India will have 7 megacities and 590 million people will live in cities (India by 2030, 2016) therefore a top down (urban - rural) approach could work more effectively than bottom up (specially dealing with technology driven solutions) meaning new and innovative ideas could be tried-tested first in urban areas and then gradually trickle down to rural context.
3.3 CO-DESIGN & IDEATION SESSIONS

Why Co-design?

Since co-design methods have been extensively used throughout this thesis at different points of time, it is vital to introduce the meaning behind the term. As mentioned by Sanders & Stappers (2008) co-design indicates collective creativity as it is applied across the whole span of a design process. Moreover in co-design, diverse experts come together, such as researchers, designers or developers, and (potential) customers and users—who are also experts, that is, “experts of their experiences” (Visser et al., 2005) to cooperate creatively.

Women’s journey map as the starting point

After conducting the field research work in Finland and in India and getting some valuable insights, the next step was to come up with design proposals. However as a designer I felt the scope of design intervention, referring to the task of designing innovative products for improving the birthing experience in LRS was broad and open-ended. On a personal level I was struggling to decide where to start from, which aspects of the product improvement I could look to design, and what products could fit in the context of LRS? Considering in general product development process, the design brief (carries specifications such as designing a low cost foldable chair made from plastic) helps to start the ideation, but in this project it was relatively open-ended. Therefore in order to make the ideation process easier I chose to follow the women’s journey map (see fig.18) as the starting point of the co-design and ideation, referring to each touchpoints as an area for improvement. For example - what could be the products for improving arrival, how products can help improve the waiting experience and so on. The basis of using women’s journey map in this case is similar to customer journey map (Customer Journey Map, 2017) often used in designing for services project.

This method was quite useful during co-design sessions for three main reasons:

• To explain the complex process of women’s child birth inside a facility in a logical manner.
• To discuss and point out specific moments (touchpoint) or area of interest.
• To derive several non-repetitive ideas in short amount of time.

3.3.1 CO-DESIGN SESSIONS - I
(Industrial designers and health expert)

The first co-design session was conducted at M4ID office. The participants of the workshop included team members from product think tank, three industrial designer from Finland, Hungary and China, (who were also master degree students at Aalto University) and a male midwife from Uganda. In this session my role was of a facilitator to conduct the session smoothly and to contribute with ideas.

Figure 18. Women’s journey (map) with different stages or touchpoints was used as a tool for co-design & ideation.

Figure 19. Co-design sessions (I) with industrial designer & health expert (male midwife from Uganda)
The objective of this session was to bring together industrial designers and one health expert in order to collectively reflect on some of the problems that has been identified from the field research. In addition the goal was to come up with some thought-provoking ideas. At the same time the health expert could instantly help designers to answer their questions and even get first hand feedback about their ideas.

The session was conducted in one of the rooms at M4ID office, which was also the working space of product think tank members. The participants were given a brief introduction about the LW project and more specifically explained the birthing process and insights from field visits through the women’s journey map. The first part of the session included introduction of the male midwife to the designer and having general conversation. The participants were encouraged to ask questions related to the project or in general. After the introduction they were given blank A4 and A3 size papers along with drawing or sketching materials to sketch, draw or write their ideas on improving the current products (such as Delivery Beds, postnatal beds, equipment’s, etc.,) or they can come up with new ideas on improving birthing experience. They were given the freedom to ideate and discuss without considering too many practical aspect such as cost or manufacturing. This was done to encourage them to think freely.

Although the participants were new to the domain of the MNCH and healthcare design, they quickly adapted to the scope of the design requirements. This session was also useful for the midwife to interact with the designers and perhaps in getting some understanding of how designers work (for example sketches as a medium to share ideas). The whole session was aimed to get over in one and half hour, however the interactions between the designers and the midwife made the session extend to almost three hours. From the project perspective it was good to get to know some new ideas such as:

- the postnatal beds with an integrated mosquito nets that can be folded during the daytime
- Postnatal beds with in-built storage space for personal belongings.
- Delivery bed with adjustable backrest to provide alternative birthing position
- Modular structural platform for different kind of trolleys used inside the facility

3.3.2 CO-DESIGN SESSIONS - II
(Product think tank member and health experts)

The second co-design session was done during the ideation stage, primarily within the LW project team. The participants were team member from product think tank, health experts (midwife from Uganda) and a clinical advisor who is also a public health expert in the field of MNCH based in Helsinki. In this session I was a participant as well as a facilitator.

The main objective of this session was to get deeper understanding of the user (pregnant women) during different stages of labour and delivery, for instance:

- What are different birthing positions and how a pregnant woman might feel giving birth in a squatting posture (using a stool)?
- What are the important factors to consider when designing a product that could make the delivery process less painful and support during the birthing?
- What activities are done post-delivery by midwife and other staff?
In order to gain deeper empathy towards the user’s need a mixed method approach was taken. It consisted of enacting specific labour and delivery moments through role play. Some common objects such as table, chair, cardboard box, cushion, yoga mat, rope, etc., were used as probes to create a reasonable enactment of labour and delivery situations. The reason to do role-play (see Fig. 21) was crucial as cited by Svanaes & Seland (2004) role playing takes users and developers “out of the chair” and into the physical, social, and embodied reality...combined with low-fidelity prototypes, role playing makes it possible to explore design concepts with users at a very early stage in a project.

An open discussion was done during and after the role play based on specific observation and queries. The designer could ask questions (such as what activities are done before and after the birth) from the male midwife who had previous experience of conducting deliveries in Uganda. This was done to know and understand the reason behind specific procedures, for example apart from helping the pregnant woman during the delivery the midwife is also supposed to record the Apgar score (Li et al., 2013) which needs to be done 2 times and therefore the midwife needs to perform multiple task at a time.

During this session one of the designer performed the role of a pregnant woman who was in labour stage, while the other took the role of a companion. The male midwife and the medical practitioner performed their professional roles. The contribution of the male midwife and the medical practitioner were beneficial to educate and share their knowledge with designers. For designers, including myself, it was critical to understand the medical procedure, raise questions and eliminate some pre-conceived assumptions at the same time instigate some meaningful ideas.

From this session the designers gathered not only critical insights about the steps involved during labour and delivery, but also about alternative birthing positions. For instance during this session, the male midwife explained how squatting posture helps to open up the pelvic muscles and uses gravity to bring the baby down, thereby suggesting that the idea of delivery stool for providing alternative (squatting) posture could be useful to explore further.

The method of role play and enactment helped greatly to keep the discussion fruitful since the designers were curious about the medical procedure and how the interaction between the pregnant women and the care provider affects the quality of care and can lead a positive experience. As Brandt and Grunnet (2000) describe the use of role playing as a way for designer and users to have a dialogue about design ideas.

It is worth to mention that the role play method was rewarding, not only for the designers, but also for midwife and the clinical advisor, since for them it was relatively easier to explain the nuances through acting rather than just through words.

3.4 KEY FINDINGS

Below mentioned are some of the key discussion and ideas from this session

• In relation to birthing in a squatting posture using a stool: it could be important to consider the appropriate seating angle and gripping place.
• It is important to make the task of cleaning (the blood and liquids after birth) easier for midwife or staff.
• Leaning against the wall could be option, if there is no companion available.
• The labour to delivery stages can be from 2-24 hours or even longer therefore companion support during this phase could help women reduce the need for pharmacological pain relief and thus improve the childbirth experience (WHO, 1996).
• In case of emergency situation (ad-hoc delivery) the portable Delivery Stool can be a possible solution and even to carry it outside the facility.
• The material should be durable, chemical resistant and lightweight to be carried.

Next chapter describes the ideas and the prototyping process that were generated from the above mentioned sessions.
In this chapter I present the list of product design ideas or proposals that were explored and created during the co-design and ideation sessions. In total around 20 ideas were mapped out and depicted along with woman's journey map (explained previously in chapter 3.3). During this stage, the ideas were communicated through hand drawn sketches accompanied with notes. The intention behind using sketching as a medium was to capture and share ideas in relatively short time with other project members. The number of ideas were further narrowed down for Lab. our Ward (LW) advisory board member’s feedback to select potential ideas to be developed as working prototypes (explained below).

This chapter also explain the process of refining the selected product ideas into tangible prototypes, based on expert feedback. It further discusses the importance of so called ‘quick and dirty’ prototyping before building a detailed version.
4.1 PRODUCT IDEAS IDENTIFIED

Based on the field visit research and successive co-design sessions a list of around 20 design opportunities were generated. All the ideas were presented in the form of hand drawn sketches with notes. Though I had made most of the sketches, the ideas were refined in consultation with senior product designer.

During this stage my aim was to refine and iterate as many ideas as possible and not restrict myself with certain constraints such as feasibility or even if some of the ideas were not entirely product based and could overlap with product-service or space domain. In addition I was encouraged by project members to share the ideas (with other team members) as often as possible. The reason being other think tanks (service and architecture) could get inspired from those ideas and even could spark a conversation with other stakeholders and users. Considering the whole aspect of the LW project was to rethink the maternity ward experience in a multidisciplinary design collaboration (Labour Ward, 2017), the practice of sharing and discussing ideas was a meaningful process followed to evolve some of the ideas. Fig.22 on next page shows the list of product ideas which are further categorized in three - supportive packages and tool-kits (in red), furnitures (in blue) and medical tools (in yellow).

4.2 SELECTED IDEAS FOR PROTOTYPING

During this phase all product design ideas were shared with LW project team, in an idea-merging session, held at M4ID office. During this session the project team collectively decided to narrow down and select 9 product ideas for presenting it to the LW project - advisory board meeting for early stage feedback.

LW project had an advisory group (Advisors, 2017) which included a team of leading professionals with expertise in MNCH from different parts of the world. LW advisory group meeting was a significant landmark to get early stage expert feedback on individual as well as collective ideas. The advisory group meeting was held in March 2016 at BMGF office in London.

Note: Since I did not attended the LW Advisory board meeting, the details about the meeting such as specific feedback and idea evaluation criteria is outside the purview of this thesis, however information about the advisory board members can be obtained from the Lab.Our Ward Project website.

Figure 22. Summary of product ideas identified and presented as per Woman’s Journey Map. Source: Labour Ward 2017
Based on the advisory group feedback and recommendations, the LW project team further shortlisted four potential ideas. The specific criteria for shortlisting were predominantly - uniqueness of the idea, potential impact, technical constraints, and matching with requirements of LRS in general. The selected ideas were:-

1. Portable Delivery Stool
2. Delivery Bed with improved comfort and feeling of security
3. Multipurpose Trolley and
4. Bed-Add ons

The main objective of selecting these ideas and transforming into tangible prototypes was to showcase the design ideas at the Women Deliver (WD) conference and exhibition, which is an international event addressing the issues related MNCH. The basis of exhibiting not only the product ideas but also along with service and architecture was to gather feedback from the health experts and visitors. The specifics about the WD conference and feedback received are explained in the next chapter.

It is worth to mention that the rest of other product ideas (mentioned in appendix section) were also presented in the form idea cards for receiving comments. However for the purpose of this thesis I will describe the specifics related to the above mentioned four ideas. These ideas are explained with key insights along with sketches, renderings and prototypes.

1. Delivery Stool
   (Mobile delivery stool with improved ergonomics cleaner environment)

A Portable delivery stool with improved ergonomics and a cleaner environment. The stool concept combines a traditional squatting birth position with low cost furniture to increase capacity and preparedness for ad hoc deliveries (Delivery Stool, 2016)

Key insights: Women are often not given a choice over their delivery positions. In addition, facility level preparedness for roadside or in-facility accidental deliveries tends to be low.

Being the first response pack for accidental and normal deliveries, the mobile delivery stool is a portable delivery pack that can be used for normal deliveries in the delivery room and emergency situations across and outside the facility. The stool supports different positions that allow women to sit, kneel or squat, providing space for the companion to help. The (stool) box is light-weight and made of plastic. Inside the box there is space for a clean delivery kit.

The stool could be stored in the entrance of the facility or easily accessible in the facility for emergency situations when women need to be attended to suddenly. The stool can also be used in remote or rural areas in smaller health centres. The stool is wrapped in a mat that unfolds as the stool is opened and offers a clean delivery surface.

Figure 23. Concept sketches showing different positions that the women can adopt.
Figure 24. The Delivery stool is a solution for accidental deliveries or ad-hoc moments. A birth simulation using the Mobile Delivery Stool prototype. Source: LW Project 2017

2. Delivery bed
   (Enabling alternative birth positions)

The delivery bed design proposal provides alternative birthing positions for women during delivery. It is a shift from the healthcare provider's perspective towards more woman-centred ergonomics (Delivery bed, 2016).

Key insights: Delivery beds can be uncomfortable. They look hostile and don’t feel safe to use and many existing models don’t allow alternative delivery positions or even designated place to grab during painful moments.
The design of the bed is aligned with World Health Organization (WHO) guideline that suggests that pregnant women should be given possibility to choose any position during childbirth. “Apart from support during labour (the most important factor) there are several other methods to alleviate labour pain. The first is the opportunity to assume any position the woman wishes, in or out of bed, during the course of labour. This means that she should not be restricted to bed, and certainly not to the supine position, but that she should have the freedom to adopt upright postures such as sitting, standing, or walking, without interference by caregivers, especially during the first stage of labour”. (WHO | Care in normal birth, 1996, p.18)

The design of the bed is lower and wider than normal delivery beds, enabling the woman to rest comfortably after the delivery and enjoy skin-to-skin contact with the new born baby. Additional elements in the bed concept include easy measurement of blood and other liquids loss. The bed can also be flattened for ease of transition to another bed or emergency surgeries.

Design objectives guiding the design:
• Comfortable
• Safe and welcoming
• Provides alternatives
• Functional

3. Bed Add-ons

(Low cost extensions for better care and comfort, upgrades to existing furniture)

Bed add-ons as low cost extensions aim to increase comfort, hygiene, storage space and safety of the facility's existing beds.

Key insights: Privacy, parent/newborn co-bedding, personal storage and malarial and other forms of mosquito protection are often challenging to provide to clients in resource and space constrained facilities. In addition, furniture replacements can be a time consuming, laborious and ultimately infeasible process.

The bed add-on concepts aim to make existing beds more user friendly, focusing on increasing safety and comfort of already existing resources rather than investing in full replacement of bed structures. With simple solutions such as a mosquito net holder, a baby bay, a privacy tent and storage add-ons, an existing bed becomes more flexible and adjustable to enable high quality of care (Bed add-ons, 2016).

This design proposal introduces bed add-ons like a baby cot next to the mother's bed, mosquito net and storage space next to existing bed frames, which will provide a better experience for the mother. The tent offers a simple solution for private space especially in crowded facilities to support privacy, bonding and rest after the delivery. Baby cot attached to the mother's bed fosters better bonding and increases breastfeeding possibilities especially among C-Section patients.

Design objectives guiding the design:
• Functional
• Safe and welcoming
• Adjustable
• Low cost

Figure 25. The Delivery Bed offers a variety of birth positions and better comfort and safety. Source: LW Project 2017

Figure 26. Baby cot, personal belongings box and storage space integrated to the existing postnatal bed, which could provide a better experience for the mother. Source: LW Project 2017
4. Multi-purpose Trolley  
(*Flexible and modular trolley structure*)

A flexible and modular multipurpose trolley eases a woman’s journey through the facility.

**Key insights:** In many low resource setting facilities, space for women to adopt comfortable positions during labour, store her personal belongings or find a place to rest may be a challenge.

The trolley was envisioned to offer the woman a physical support tool along the journey through the facility by addressing several challenges at the same time: resting or leaning over during labour, walking aid, newborn transportation and luggage storage. Equipped with wheels, the trolley is easy to clean, requires low maintenance and has a simple assembly structure. The trolleys can double as a work aid for facility staff carrying cleaning equipment of medical supplies.

The trolley idea was inspired by a facility manager in Uganda recognising “there is nothing here for the woman”. Apart from offering functional support for the woman during labour, delivery and the postnatal period, the trolley aims to give the woman the feeling that there is something just for her (Multi-Purpose Trolley, 2016).

Design objectives guiding the design:
- Functional
- Modular
- Flexible

The flexible structure of the trolley allows for a variety of usage possibilities:
The structure can be used as a moving station for healthcare workers to carry instruments and other medical equipment. After delivery, the baby can be transported to the postnatal ward accompanied by the woman, who can use the trolley as a walking aid.

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**4.3 WHY TO USE PROTOTYPE?**

In this section i will explain the process of transforming the selected ideas as prototypes, however at first it is valuable to discuss the need to do prototyping. As discussed by (Kronqvist, Erving, & Leinonen, 2013) the connection between our bodily sensations and thinking processes is evident in many historical design practices. They situate design within studios in which design activities are physical and knowledge is embedded in physical artefacts such as prototypes or other kinds of inspirational material. Their reflective conversations with the materials are especially evident in the practice of prototyping. Similarly in this project doing hand-made models (scaled version) helped to refine the thinking process.

In addition the quick prototyping (often referred as quick and dirty) method was beneficial not only to develop the intricate details but also helped to understand the importance of user participation (in this case health experts) even during early prototyping stage. Though the design sketches depicted the ideas in terms of functionality, overall shape and size, still several crucial details (such as handle grip diameter and appropriate seating angle in case of Delivery Stool) were missing. In order to figure out those details i made more than 10 small scale foam board models followed by 2 full scale models of the same. The full scale models were further tested with health experts (male midwife from Uganda and a local clinical advisor) for usability related feedback.

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![Figure 27. The flexible and modular structure of the trolley allows for a variety of usage possibilities.](image)

![Figure 28. Small scale prototypes as a way to understand and define details.](image)
4.3.1 PROTOTYPING AS AN ITERATIVE PROCESS

Physical prototyping has been used in participatory design to support non-designers abilities for expressing personal experiences in various projects (Kronqvist et al., 2013). Similarly in this case, the process of prototyping was approached from the perspective of healthcare experts to share their knowledge and personal experiences in order to define important aspects which might not been considered earlier. Furthermore in this case the work done by the designer was similar to the work of ‘language innovators’ whose aim is to create objects that generate such experiences (Kronqvist et al., 2013).

During this phase special emphasize was given to translate the usability and ergonomic related feedback not only from users (pregnant women) perspective but also from care providers such as midwife, nurse and even companion. Since the companion and the nurses are end users for the trolley, the bed and the baby cot and they would need to operate or manipulate it during usage.

It is vital to mention that the feedback discussion during prototyping phase was engaging and at times even challenging to test my designer (problem solving) skills. For instance during this session the male midwife enacted and explained how the pregnant woman would use her full body strength during (painful) delivery moments in a squatting posture and how (at times) her legs might be raised in the air, therefore the design of the delivery stool should have good ergonomic hand -grips and she can choose where to grip. In addition the seating angle and companion sitting stance should be thought carefully for supporting the woman’s lower body (spinal) part.

The models which had moving parts (such as Delivery Bed) were tested in similar manner, without fully fixing the moving parts (backrest, squat bar, leg support), so that it was easier to alter and not down the appropriate angles in relation to body position. The full scale models of Delivery Stool and Delivery Bed were shown and tested two times in order to achieve the best possible results. The prototype of multipurpose trolley and Bed-add ons does not needed too many iterations since the design was simple and did not possess many finer usability related particulars.

Figure 29. Collage of prototyping stage, each rows (from top to bottom ) show process per product.

> Male midwife testing the Foam board prototype of Delivery Stool.
> Evaluation of backrest support of early Delivery Bed with clinical advisor and male midwife.
> Male midwife reviewing the foam board prototype of Baby-Cot.
> Office chair as a quick prototype to test Trolley and ergonomic testing.
Source: LW Project 2017
4.3.2 BUILDING 1:1 PROTOTYPES

Once the details including the usability and ergonomic aspects were finalized, the next step was to build full scale (1:1) functional prototype. The place selected for building the prototypes was Aalto University, Arts and Design school wood and metal workshop.

Before starting the construction work, 3D CAD (Computer Aided Design) models of all the product ideas were made for precise dimensional reference. Also it’s important to mention that during this phase a brief comparative analysis of existing Delivery Beds, Delivery stool, Trolley and Bed add-ons were done to consider the cost, materials and manufacturing process. In addition I also did a short online search on the history (evolution) of using birthing chair and stool to develop more learning on this subject matter. However in order to keep this thesis more compact, the above mentioned process part are not discussed in detail.

During this phase some challenges were encountered, firstly, the lack of available time to complete all the four prototypes. The usual time to utilize the workshop machines was 8am to 4pm, in addition only three weeks were left, before the start of Women Deliver exhibition. Therefore in order to complete the prototypes including building, finishing, painting, two of my classmates helped to build the prototypes, and were equally compensated for their assistance from LW project. The senior product designer also contributed extensively with logistics and practical matters.

The second challenge was what kind of materials to use, considering that prototypes needed to be 1:1 scale to present the idea entirely, sturdy enough to should sustain the wear and tear during transportation to the exhibition place (Copenhagen) and fully functional and finished, meaning the visitors could try the prototypes without hurting themselves during the exhibition. Therefore it was critical to consider sturdier materials (such as wood and steel) at the same time it needed to be durable, practical, easy to handle yet well finished. The final selected materials were MDF (Medium Density Fibre) board, plywood and stainless steel.

Overall building, finishing and packing of all the prototypes took three intense working weeks. However as a designer it was a good learning by doing experience, since at times it was challenging to incorporate and balance all the aspects of product design such as form, functionality, materials and mechanism. Also its worth to mention the team-work with batch-mates was beneficial since they not only contributed in building the prototypes but also with useful suggestions on detailing and aesthetics. Next chapter will describe the feedback received on theses prototypes from Women Deliver exhibition and further improvements.

Figure 3.0. All the four finished prototypes (from left top to right - Delivery Stool, Delivery Bed, Multipurpose Trolley, and Bed-Add ons. Source: LW Project 2017
This chapter marks the beginning of phase two, it comprises of analysis of the feedback and suggestions received from the Women Deliver (WD) conference. The positive comments received lead to further refinement of one of the most promising product design proposal (Delivery Stool) in the form of an improved prototype (DS 2.0) meant for carrying out field evaluation in one of the target countries - India.

This chapter further describes some general as well as concrete feedback on the four product ideas that were exhibited for the visitors (health experts) to test the prototypes and give their comments.
5.1 FEEDBACK FROM ‘BIRTH IN PROGRESS’ EXHIBITION
(Women Deliver, Copenhagen, Denmark 16-19 May, 2016)

The exhibition which was given the name ‘Birth in Progress’ (BIP) took place in Copenhagen, Denmark on May 16-19, 2016 as a part of the global women’s health and rights conference, Women Deliver (WD). It showcased Lab.our Ward design proposals and was a hub for inspiring interaction with visitors and the project team.

Women Deliver conference is an international triennial event. The WD 2016 Conference, was the largest gathering on girls’ and women’s health, rights, and wellbeing in more than a decade, and one of the first major global conferences following the launch of the Sustainable Development Goals (SDGs). It was visited by almost 6000 people from 169 countries (Women Deliver, 2016). It brings healthcare providers, MNCH experts, policymakers and NGOs and several others stakeholders, from different countries under one roof. Hence it was a very good platform where the project team could evaluate the design proposals and collect valuable feedback.

The exhibition’s central theme was co-creating better experiences for mothers and newborns. Exhibition visitors were invited to take part in the co-creation of the design proposals and concepts. During the exhibition, visitors came to the exhibit and got involved in the design and communication world. Their discussions was enriched by what they were seeing, touching and trying out.

My contribution and role during the exhibition:

Alongside with other project members, I too worked on the construction of the BIP exhibition. The whole project exhibition (stall) was built on the spot with modular frame system (Earth wall). The total area for setting the exhibition was around 54 square meters and there were around 12 people involved in setting with the walls, roof, flooring, and panel and over 30 design proposal. The whole construction work took around two and half days.

Apart from helping in the construction of the exhibition, my role during the event was to show and explain the product ideas (prototypes) to the visitors, provide further answers to their queries (if there was any) and get feedback and development comments that could help to design a new version of the products.

During the event there were many visitors who had a deep look at the exhibition and spent more than half an hour at the stand, these deep conversations provided several opportunities to interact and get valuable feedback. On a personal level it was a great feeling to see that people were genuinely appreciating the concepts and giving positive feedback, and also a sign of encouragement to develop some of the ideas further.
5.1.1 METHODS USED TO COLLECT FEEDBACK

Below mentioned are some of the specific methods used for collecting feedback. However it is worth to note that these methods were designed and developed by other designers (team members) working on LW project. In this thesis I decided to present those in order to show the procedure used to collect the critics.

The first method was using feedback cards, and the second one was using stickers. These two methods, gave the possibility to gather different kind of feedback, explained below and initiate conversations with the visitors.

Feedback cards

![Feedback cards](image)

Figure 33. Usage of feedback card as a method to collect comments during the exhibition

The questions in the cards were:

- What would require more focus?
- Which design proposal sparked your interest?
- What area should be further explored?

There were also blank cards for designers to document feedback that visitors did not bother to write themselves. These cards were used to collect feedback and document the main points of the conversations. With the cards, visitors could make an individual reflection and explain their thoughts in their own words.

Stickers

![Stickers](image)

Figure 34. Usage of stickers as a method to collect comments during the exhibition.

There was three type of stickers that visitors could attach to the design proposals: great (in pink), has potential (in yellow) and it is complicated (in blue). The initial reactions were gathered using these stickers, it also allowed to raise question like - why do you think so... and open up the discussion on certain proposal.

5.2 FEEDBACK ANALYSIS

After coming back from the WD conference, the three think tanks (architecture, service and product design) analysed the results of the feedback gathered with the help of a senior design researcher, who was also working for the same organisation, and was present during the exhibition.

![Analysis of comments](image)

Figure 35. Analysis of the comments (in relation to product ideas) received during the exhibition.
The general feedback could be divided into:

**Opportunities:** visitors pointed the possibility of using the design solutions such as Delivery Stool for training midwives and wanted to see them in the countries where they were working.

**Practicality:** Visitors reminded the team to assess the practicality of the products in relation to maintenance, hygiene and durability. Considering the fact that in LRS the products need to go through rough wear and tear conditions and lack of spare parts or maintenance could be a hindrance (WHO | health systems strategy, 2007)

**Implementation:** Some issues discussed with visitors relate to local materials (praise that local materials were used), local environment (concerns of how the design could be modified to very low resource environments) and sustainability. Some visitors commented that local manufacturing might also mean low quality and shorter life span, and therefore the production of these proposals should be carefully planned.

### 5.2.1 PRODUCTS RELATED FEEDBACK

Overall all the four product design solutions received encouraging and positive responses in terms of acknowledging the concepts. Most of the visitors were impressed with the exhibition and the variety of multidisciplinary ideas showcased together. There were hardly any negative comments, however few visitors raised some concern such as - if this product (Multipurpose trolley) is really relevant or not. Visitors also commented that having flexible furniture (Delivery Stool) helps to mobilize women during birth and emergency situation. Mentioned below are suggestions received for improvements.

#### Delivery Stool
- To avoid that the stool is not upside down when opening the cover.
- To fix the seating height and angle.
- To have more rounded corner in the front part of the seat.
- To have a more sturdy carrying handle.
- To design a handle that can better guide, the user to carry the stool.
- To rethink the stool placement in relation to health practitioner working posture while attending the pregnant woman.
- To evaluate how easy is to clean the stool and integrate with a sterilization or delivery bowl.
- To make it lighter to carry yet sturdy, since it needs to take the weight of the pregnant woman (approx. 120 kg)

#### Trolley
- To consider more comfortable seating for example a soft cushion.
- To propose a dedicated space to place the feet, while transporting the pregnant woman.
- To have adjustable optional handles on both the side.
- To have the possibility for the pregnant woman to lean against the handle in a seating posture.

#### Delivery Bed
- To improve the squat bar and handle grip.
- To have option to incorporate leg (calf) support.
- To improve the hinge mechanism - as one side lock could be easy to operate and adjustable.
- To evaluate the possibility that the pregnant woman can adjust the backrest angle by herself.
- To make the bed and the floor underneath easy to clean and apply disinfectant
- To reduce sharp edges by increasing the corner radius.
- To optimize the bed width as per general standard.
- To have the handles closer to the pregnant woman
- To review the storage space as an option.

#### Bed Add-ons
- To improve the attachments parts as a universal solution (fitting to different types of beds).
- To have the possibility to perform the rocking movement of the baby cot
- To integrate the IV bag hooks (2 to 3) to the mosquito net pole.
5.3 FURTHER IMPROVEMENTS

This section discusses the phase two of the thesis which was designing and developing one of the promising ideas (Delivery Stool).

5.3.1 WHY TO DO FIELD EVALUATION?

After building the first prototype (Delivery Stool 1.0) and testing it in the professional conference with global health experts, I realized that there is also need to conduct user evaluations in real settings. Considering the fact that many characteristics of the Delivery Stool such as transportability needed to be evaluated in situ. The Delivery Stool is easy to carry (it could be moved by a walking person or taken in the ambulance), it saves space when compared to bed based deliveries (which in some overcrowded rural facilities might be an urgent need), and as a product promotes a squatting birthing position - which is cited as one of the optimal labour and birthing positions (Birth Positions, 2017). Further it has been associated with less instrumental deliveries and extension of episiotomies and perineal tears (Nasir, Korejo, & Noorani, 2007). In some cultures (such as in India) women squat daily in their normal routines and therefore could easily adapt the same for birthing.

As Christian, J.L. (2014) states that experience from design practice suggests that user feedback should not always be taken to the letter, and that the particular context in which a prototype is presented can greatly influence a user's perception of the concept. This is why, even though valuable feedback was gathered in the Women Deliver event, there was still the need to test the prototype in real settings. In addition it is possible to design concepts for low income settings remotely, however when there is a need to define the intricate details of the product for final implementation, it is important to consider contextual and cultural differences, therefore I decided to do user testing and field evaluation in India.

5.3.2 FIELD EVALUATION PLAN

As mentioned earlier after the phase one which ended with the completion of the WD exhibition and feedback analysis in end of June 2016. I was no longer working for LW project and the phase two (prototype refinement) and three (field evaluation) were done by myself.

In order to design and build a new prototype version of the Delivery Stool and to conduct the field evaluation in India, I applied for Aalto ARTS grant in the month of August 2016 from the School of Arts, Design and Architecture to cover the material and travel cost. Fortunately I received the grant and the next step was to make a plan for the field evaluation and design a new prototype version of the Delivery Stool. Though the first prototype (1.0) which was shown in the Women Deliver conference was good enough to be carried and tested in India, I decided to make an improved version and named it as Delivery Stool 2.0.

Figure 36. Comparison of first prototype (left picture) and second prototype (right picture) of Delivery Stool.

The most important reason to build the second prototype was to incorporate some of the feedback received during the WD exhibition. Apart from the ergonomics improvement, one of the significant changes done was to integrate the delivery or sterilization bowl which measures the loss of blood (see Fig. 36). At the same time the amniotic fluids would fall into this bowl making the stool easier to clean after birth. This improvement came after the analysis of the feedback received in the conference. Some of the other improvements were making a sturdy handle and buckle to carry the stool comfortably. Other critical aspects were matching some of the stool dimensions as per Indian Anthropometric dimensions (P95) (Norris, 2001) and integrating with a wheel trolley which would make the stool easier to carry for longer distances.
5.4 MAKING OF DELIVERY STOOL 2.0 (DS 2.0)

Design and development of the DS2.0 started in the beginning of October 2016. The place chosen for doing the prototype was wood workshop at Arabia campus. Even though the basic outlook of DS 2.0 was kept same as the first prototype the intention was to incorporate the previous mentioned changes while keeping the same appearance. In this prototype the starting point was to find a medium size stainless steel bowl (as sterilization tray or delivery bowl) which could fit in-between the gap (as shown in the figure 36).

The next step was to make dimensional drawings followed by getting other materials such as PU (polyurethane) foam block, MDF board (Medium Density Fibre), plastic cover, soft PVC (polyvinyl chloride) cushion / paint, foam putty, sterilization or delivery trays 2 pcs.

The process of making the second prototype was similar to the first prototype and not new for me, since I had made the previous version and being an industrial designer, had undergone training of building hands-on prototypes with different materials.

Since the grant received from the school was not sufficient to buy the expensive rexine cover in Helsinki and to pay for the stitching work, therefore I decided to make the cover in India. In addition, I had previous experience of making similar leather cover prototype in India.

The process of making the cover was lengthy and time consuming. Though the person (local craftsman in Agra) who helped in the stitching is an expert in making car seat cover, but was handling this kind of prototype for the first time. As the cover needed to match precisely with the outer shape, therefore before reaching India, I had made cardboard templates, to cut the cushion in exact size and to save time during stitching work. In addition pictures of the first prototype was shown to him to communicate the dual functionality of the cover.

5.4.1 MAKING OF THE OUTER COVER

Similar to the first prototype, white color and semi-matt texture were deliberately chosen so that it would resemble as plastic which is the intended materials for the Delivery Stool. After finalizing the overall shape, and finishing the painting work, DS 2.0 prototype was almost complete, however it was only half of the work done, as the rexine cover which form an outer covering and unfolds to become a mat was yet to be made.
5.4.2 DESIGNER AS FACILITATOR

One of the interesting aspect that came up during discussion made me realized the importance of participatory design approach and role of designer as facilitator even while doing prototype. As discussed by Burr & Larsen (2010) role of ‘crossing intentions’ among participants involved in innovation processes with users can create new insight that may become a driver of innovation. For example similar to the first prototype (as shown in the Fig. 39) in which the outer cover is not fully enclosed, the anticipation was to develop a look-alike model. However during discussion he (local craftsman) suggested to make a fully enclosed one which was an excellent suggestion because the dust won’t go inside the stool while carrying or traveling. This was a surprise as I had not expected him to think about the cleanliness aspect. This was an eye opening experience to reveal the importance of participatory and collaborative approach that could bring value addition to the creative outcome, and designers can benefit from similar approach even during prototype development phase.

Within one week the outer cover was ready, however there was still one additional part missing, before DS 2.0 would be ready for testing. It needed a wheel trolley onto which the Delivery Stool could be placed, locked along with elastic ropes and can be easily carried (much like a wheel trolley suitcase, see Fig. 40).

Although it can be argued that the usage of wheel trolley could be optional. However while carrying it at the airport and even while bringing it to the rexine cover stitching shop, it occurred that it is much easier to drag on wheels than to carry by lifting it for longer distances, (taking into consideration that prototype itself weigh around 5 kilogram and was slightly bulky to walk freely). Therefore having the wheel trolley as an alternative support was a valuable addition. In next chapter I will explains the details of the field evaluation and relevant findings.
Chapter 6
Field Evaluation & User Testing

This chapter discusses phase three of the thesis project. This phase primarily deals with the most important user testing and field evaluation of the improved prototype - Delivery Stool 2.0. After the field evaluation detailed documentation was done to complete the thesis work. Additionally during this period I wrote a paper that was accepted in an international design conference REDO Cumulus Kolding (as first author) based on the field evaluation methods and findings in collaboration with Dr. Mariana Salgado and Charlotta Liukas. The article title is: User Evaluation of a Healthcare Product Design in Rural India. When Methods run short. (See Appendices)

The following sections gives detailed outline about the field evaluation process, starting with explaining the reasons for places selected to visit, followed by outlining the methods used, describing the objectives, finally discussing the results.
6.1 FIELD EVALUATION OF THE DELIVERY STOOL 2.0

As mentioned earlier, India was the country chosen to test and evaluate the DS 2.0 prototype. The places visited in India, were the state of Uttar Pradesh and Bihar, two of India's most populous and poor states. The reasons for choosing these two states were related to practicality in terms of finding local contacts of health facilities and driven by opportunity to visit some of the same facilities (in Bihar) where the first field research was done.

In addition as Jasmine Florentine (2015) claims that when designing products for emerging markets, a better understanding of the user can improve the success of the product, however, formal user research approaches designed for conventional markets may not be effective in emerging market scenarios. In line with her I decided to develop a mixed method approach to test the prototype of the Delivery Stool.

6.2 EVALUATION METHODS & OBJECTIVES

The below mentioned specific methods were selected, taking into account ergonomic, functional and aesthetical insights. It is important to clarify that testing did not happen during labour, but I had interviewed people after or before actual labour and when there was no rush in the facility (Shaw, Salgado & Liukas, forthcoming 2017).

This methods included:

Field observation with ethnographic elements: understanding the context, usage pattern and usability (Discussions with midwives and auxiliary nurse midwifery (ANM) and accredited social health activist (ASHA),
Interviews: with end users (pregnant women) and with local healthcare providers in the facilities,
A comparison: with other existing forms of birth delivery aides typical in the context, such as such as delivery bed and cot, and
Ergonomics validation: backrest support, handle, grip, leg support and seating angle. Also, the carrying, cleaning, storage convenience

As part of the plan for the field work in India, the following objectives were set.

- Validation of concept in terms of acceptance and motivational factors for usage.
- Evaluation of the aesthetics and functional details of the product.
- Evaluation with different user groups and Maternal and Newborn Child Healthcare experts (midwives, ASHA (community activist working in health in rural India), health providers in different type of facilities (private and public sector), pregnant mothers as well those who have given birth in normal delivery bed (in lying down position).
- Gathering critical insights for prototype development for pilot testing, and
- Gaining a better understanding of contextual requirements and hidden user needs.

Figure 41. This is the Delivery Stool 2.0 tested in a primary health center near Agra, Uttar Pradesh, India.
An informal interview and open discussion was done with one expectant mother in Agra at her residence (Fig. 42) and another woman who has been pregnant before. The interviews were conducted after they were asked to imagine and demonstrate a scenario through role play. During role play a female companion was also asked to join which could perform the role of a traditional birth attendant or Community health worker (ASHA) or simply as a nursing staff.

6.3 RESULTS OF THE EVALUATION

In relation to Product positioning (usage in Home birth): in principle the Delivery Stool could be used for home deliveries, which is a relatively common phenomenon especially in rural areas of the two states. However, the Indian health system has been consistent in its efforts to eradicate home deliveries as delivering at home without adequate medical access is a significant factor in maternal mortality. For instance Janani Suraksha Yojana (JSY, 2013) an incentive based scheme by several state government, offer monetary benefit to pregnant women for encouraging them to deliver at the nearest health center. Therefore, this thesis does not discuss this option.

Figure 42. Expectant mother performing role play with a companion.
In relation to the concept: the Delivery Stool could be used in different places in the health facility, especially for emergency or rushed delivery situations. The stool could be placed beside the beds in a normal delivery room for promoting alternative birth positions. It could be carried around the facility depending on the willingness of pregnant women to test it. Therefore, the hospital does not need to have one Delivery Stool per room, but pregnant women could be informed about its availability and ask for it if she considers alternative positions (Shaw et al., forthcoming 2017).

In addition to the above mentioned, having the stool inside the facility is a way to align with World Health Organization (WHO) guideline that emphasize on methods to alleviate labour pain by providing choice for pregnant women “to assume any position the woman wishes, in or out of bed, during the course of labour. This means that she should not be restricted to bed, and certainly not to the supine position, but that she should have the freedom to adopt upright postures such as sitting, standing, or walking, without interference by caregivers, especially during the first stage of labour.” (WHO | Care in normal birth, 1996, p.18)

In relation to the acceptance and motivation to use: using the Delivery Stool for birthing is a new concept therefore in the user testing and evaluation sessions, during the testing I needed to show how it works and explain the benefits. Interviewees gave positive feedback but it can be understood that this could be biased as I was explaining the benefits. Most of them agreed that the full usefulness of the stool could be seen in the public sector hospitals where a huge number of deliveries (more than 300 per month) take place, because the private facilities visited have less deliveries per month and hence e.g. overcrowding situations happen rarely.

In relation to the functionality: the Delivery Stool is envisioned to be used when the pregnant women is in a squatting posture with her feet getting support from the ground, which means that the midwife or the nurse would need to bend down or sit in order to perform their tasks. Midwives who were slightly overweight showed concern by saying that “I won’t be able to bend down”. Other concern was the cleaning of the stool and the cover, since they mention that the delivery bed (as it is a flat surface) is easier to clean.

In relation to the design characteristics: all of the interviewees thought that the materials, shape and the aesthetics look was good. They even appreciated the fact that it is white in colour and would help them to spot the blood and other stains clearly, however they noticed that this means they would need more effort to keep it clean.

Suggestion for improvement: most of the interviewees thought that having some kind of backrest support as an option would be needed in order to help the pregnant women relax during the labour stages. Placing the delivery stool against a wall was not seen as a comfortable since they pointed that the back support would make them feel more secure. Most of the discussions ended with the feedback that it needs to be tested further to confirm as the concept is so new and the care providers were giving feedback based on their own experience with other products while not having tried the stool out. The feedback from the health professionals and midwives indicates increased acceptance and motivation towards new ideas and willingness to accept new ways of performing childbirth and delivery in low resource settings, however as mentioned by Hussain et al. (2012) more engaging participation is needed to empower midwives and pregnant women on interactional and behavioural levels.

6.4 FIELD EVALUATION CHALLENGES

The fieldwork proved valuable for gathering relevant feedback, yet several challenges were encountered in the planning and execution of the testing.

Connecting to health facilities and providers ended up being challenging. During the planning phase I had contacted two Non-Governmental Organisations (NGO) and two social impact companies that have been working in India and have done projects in the Maternal, Newborn Child Health (MNCH) sector before. I even asked for contacts with local health centres as well as recommendations for how to pursue the testing. However, the initially positive conversations didn’t materialise into direct contacts or ‘opened doors’. Despite this slight disappointment I decided to continue to carry on the field evaluation on my own.

Getting permission from the head of the facility was a laborious process. In most of the facilities, the process of showing and explaining the prototype happened two times. This was a time and energy consuming process. I had to first show and explain the prototype to the head of the hospital (not dealing with childbirth) in order to get the permission to conduct an interview with the health providers who work in the same hospital.

Although I had received a small amount of funding for making the improved prototype and traveling to India, it was not sufficient to pay the participants or interviewees for their time. This could have affected their motivation to participate in the activities proposed by the designer. As a consequence, I tried to reach out for some interviewees through personal contacts. Another important constraint was the lack of time to travel, considering the fact that train traveling in India from one state to another, requires advance booking of seat which needs to be done months in advance. In next chapter I will present the conclusion, discussion and reflection from this thesis work.
This chapter concludes the previous chapters. Starting with discussion about the need to integrate the Delivery Stool with a training program for midwives and nurses in order to highlight the benefit of alternative birthing positions. Later in this chapter a brief summary of the process followed and the results are presented to answer the thesis research questions. The last part of the chapter discusses the limitations and future work. Finally the personal learnings from this thesis project are mentioned at the end.

Low Cost Portable Delivery Stool With A Clean Birthing Kit. Portable Delivery Stool Is A Low Cost, Ergonomic And Cleaner Alternative To Normal And Emergency Deliveries.
7.1 DISCUSSION

**Seed (ideas) should be nurtured for positive impact.**

As with most global health challenges, improving birthing experience in low resource settings is a complex problem that is interlinked with health provider practices, the presence of companions and change acceptance across different cultural settings. Therefore, product design for better birth experience needs to be considered from a holistic perspective and align with international healthcare guidelines (Shaw, Salgado, & Liukas, forthcoming 2017).

Although the positive results from the field evaluation (in terms of acceptance towards testing the Delivery Stool for actual birthing) indicates the possibility to propose and design innovative solutions that can tackle some of the challenges dealing with MNCH in low and middle income countries. However based on my field research it should be kept in mind that designers or design alone cannot solve some of the complex problems without the support from global health community (including health providers, companies and NGOs working in the field) embracing practices such as design evaluations and support design work in all its capacity as discussed by Shaw et al (forthcoming 2017).

The concept of Delivery Stool along with other products presented are only seed (ideas), it needs to be nurtured, embraced and supported from all quarters in order to be a true innovation as discussed in Idea to Impact guide (2015, p. 15) human-centered design research can demand considerable time during the design and prototyping phase of project initiation, thus adequate time and resources should be allocated to working with the end-users while designing the solution.

The concept of Delivery Stool is a new product in maternal and newborn child health. It implies alternative birthing positions (such as squatting) which is a relatively a new concept at least in rural India, therefore in order to use it, first it should be taught how to use. My recommendations, based on my fieldwork, is that the stool cannot just be placed in the facilities and used, but it needs to be integrated within a program that would train midwives and nurses to use it and understand the benefits of the different birth positions.

The Delivery Stool could be further envisage as a part of training toolkit that could help nurses and healthcare workers (ASHAs in India) to promote the benefits of alternative delivery positions and presence of companion during delivery. At the same time the existence of the stool (inside the facility or in a village community center) could aid pregnant women during emergency situations, similar like having a first-aid kit to handle unexpected moments.

7.2 CONCLUSIONS

As mentioned earlier in chapter 1, this thesis investigates how Human Centered Design (HCD) methods and participatory design approach can be effective for designing innovative products and / or service concepts meant for low and middle income countries.

In order to fulfill the above mentioned goal, in depth literature review including going through previous project reports was done to grasp understanding of problems associated with Maternal, Newborn Child Health (MNCH) in LRS. After literature review, two field visits were conducted using mixed methods approach such as in depth interviews and ethnographic field study. The results from the field based research formed the basis for a series of co-design sessions with designers and healthcare experts to develop product design proposals. The design proposals were further developed and refined in the form of working prototypes based on experts’ advice. Lastly field evaluation and user testing of one of the improved prototype was done to conclude the thesis work. The following section answers the thesis research questions.

**How Human Centered Design methods can be used to develop healthcare product concepts meant for low resource settings?**

**Developing ideas through long term interaction:** Throughout the thesis project participatory and co-design sessions helped to develop and refine the ideas consequently. Co-creation happened at different stages with people from diverse country, culture and background, some of them were directly involved while others were supporting the cause. One of the methods applied in this project was immersive co-design, where medical fellow and context experts worked with designers in the same place for months at a time. It is significant to mention that in this project, long term interaction with health experts was fruitful, not only in co-creating ideas but also for designers to develop deeper understanding of the contextual issues which are based on health expert’s personal experiences.

**Refining solutions through quick prototyping:** Physical prototyping have been used in participatory design to support non-designers abilities for expressing personal experiences in various projects (Kronqvist, Erving, & Leinonen, 2013). Similarly in this project use of physical prototyping was done extensively in order get feedback and further refinement.
During the early design phase, it was crucial to make prototypes to understand the need and start a conversation by showing the idea through tangible prototypes (even if the prototype material is just a cardboard or any readily available materials). In this project the first prototype done to share the idea of Delivery Stool was just a stack of office-cushions, later on I made more than 10 foam board models to refine the ergonomics and usability aspects. In this project, I am extremely satisfied with building several hand-on prototypes to share early stage ideas with project members.

**Evaluating the proposed solution contextually:** In line with the statement by Erik Simanis, Center for Sustainable Global Enterprise at Cornell University “Just because it works in the lab, doesn’t mean it will work in the field. There is a lot of variability in people’s homes.” Similarly in regard to developing proposal for low resource settings, it is most essential to evaluate the design concepts in the same place where it is intended to be used. Since more learning happens in the field than sitting in the studio. For example during the field evaluation at AIIMS, Patna I almost felt clueless when medical professors asked questions and challenged the usefulness of the proposed solution contextually. Their question was how useful is the concept in rural India, where neither the midwife nor the pregnant woman knows about alternative birthing positions? These type of confrontation was challenging yet useful, not only for the improving the solution but (also for me) to think critically about ways of thinking in design alternatives, for which I do not have an answer but many questions to reflect upon. The testing and field evaluation was useful to reflect on these aspects.

Further according to my experiences during user-testing and concept evaluation, I realised the significance of evaluating ideas in the initial stages of design process and not necessarily after the completion of the design work. For instance the Delivery Stool is intended to be used when the pregnant women is in a squatting posture, with her feet touching the ground, which means the midwife or the nurse would need to bend down or sit in order to perform their task. However during interview some midwives who were slightly overweight showed their concern by mentioning “I won’t be able to bend down”. Therefore it is recommended to evaluate the idea with end users as early as possible.

**Eliminating Assumptions:** As told by Augusta Meill, Vice President, Continuum Design “It’s not are we solving the problem with the right solution, but are we even solving the right problem?” in agreement with her and based on my field experience, it can be deduced that in order to propose right solution the designer needs to know the right problem by developing the right contextual understanding of the people, places, culture and most importantly to questions assumptions (and even challenge them). Since assumptions are often based on preconceived notions and can be futile. As was the case during field evaluation, it was observed that pregnant women while giving birth does not have a companion inside the delivery room, therefore the intention of using delivery stool along with the companion, who can support the women during painful moments would not be beneficial (Shaw et al., forthcoming 2017).

**How the design ideas takes shape, when designers work in close collaboration with end users and other stakeholders?**

Based on the process followed in this project, it could be argued that the ideas could be improved distinctly when designers work in close collaboration with end users. However it is important to have frequent interactions, instead of the “standard” method in which the interaction happens in a couple of key moments in the design phase. For instance during prototyping phase the continuous and close interactions with male midwife and clinical advisor was pertinent to refine the intricate details and usability factors. Though it is well validated that prototyping is beneficial to get feedback and refine the ideas, however more crucial is to have close and frequent interactions so that designers can ask for feedback as often as possible.

**How design research led projects that follow Human Centric Design approach could bring values by developing innovative ideas that could fit the challenges and demand of LRS?**

As discussed by Ramachandran et al (2007) local stakeholders can contribute cultural information relevant to design such as needs and practices through interaction with technology artefacts. Comparably in this project the involvement of local craftsmen during the making of rexine cover in India was effective to bring added value in developing the idea to fit the local conditions. For example it was craftsmen who suggested to make a fully enclosed rexine cover, considering that in India dust could easily make the prototype dirty during travel. Even though as a designer I should have considered the practicalities and local conditions, yet it is worth to mention that the collaboration with local craftsman in a participatory approach was useful not only to the creative outcome but also an opportunity for the designer to learn from their local experiences. The added value in this case was the fact that the Delivery Stool could be remain protected from dust and moreover having fully covered does not bring un-necessary attention, which I had experienced while traveling with it. (Once the stool is fully covered it resembles a suitcase).
Designer as translator: Although the idea co-design sessions is to involve end users, however during the initial co-design sessions, due to practical constraints the involvement of end users (pregnant women) could not be done. Yet the evaluation and feedback was done with end users. In this case the role of designer could also be termed as translator, not only for getting feedback from the end users and health experts but also to communicate (translate) the findings with other stakeholders, who might not be fully aware of the local context. I think in this project the role of designer as translator worked well but I cannot draw full a conclusion on how significant the role was in this.

7.3 LIMITATIONS AND FUTURE WORK

Though the overall outcome of this thesis work was good considering several product ideas were produced and showcased, in addition I was able to improve the first prototype and did user testing. However below mentioned are some of the limitations specific to the Delivery Stool concept evaluation.

The field evaluation was done without ‘actual’ user testing - meaning delivery under real-life conditions, thus the results should not be generalised without further studies. Even though the initial response from the users were positive but it can be biased since before testing I needed to show and explain the advantages of using Delivery Stool for birthing, therefore further user testing would be needed to define specific results.

Due to time and funding constraints only one handmade prototype was developed, the prototype has not been analysed in details from manufacturing and cost perspectives, therefore these factors are needed to be estimated before going forward. Similar aspects are emphasized in Idea to Impact guide (2015) because end-users are not the only stakeholders involved in a product's success, designers need to consider the entire ecosystem of stakeholders such as manufacturers, donors, when identifying needs. This ecosystem can include manufacturers, donors, ministries of health or public-sector programs and others.

In regard to future work and possibility to continue the development, the Delivery Stool concept is currently being sent as an entry for different international design awards. The last entry was sent to Index: Design to Improve Life Award, which is the biggest design award in the world, worth €500,000, and is commonly referred to as the ‘Nobel Prize of design’ (INDEX: Awards, 2017) in the month of March 2017. Besides I had created an online free portal website (Portable Delivery Stool, 2017) to share the idea and get feedback from wider stakeholders (users) across different countries and cultural context. Recently I was contacted by Yanko Design (About YD, 2007) which an international web magazine publishing company with millions of readers to disseminate and publish information about the Delivery Stool concept.

7.4 ENDING THOUGHTS

I am grateful to have gotten an opportunity to work on LW project as a part of my master’s thesis. The complexities of it was challenging and really pushed my skills as a designer beyond anything I have done before. I was able to utilise a wide range of methods (learned during last 4 years of studies at Aalto and relevant experience from living and working in India), as well to question and modify them in order to serve the purpose.

In the beginning I had next to no knowledge regarding the domain of Maternal, Newborn Child Health (MNCH) and lack of field experience made me felt that I am working on assumptions. Even at one point i was thinking to drop this project since i felt being a male i cannot relate to pregnancy or birthing and might not produce good results, however i was inspired by the story of Mr.Arunachalam Muruganantham (2017) who is social entrepreneur from India and he has designed a low cost sanitary pad making machines after doing self-testing with using a bladder with animal blood.

Although working in a multidisciplinary team (during phase one) was a great learning experience, yet at times I felt more workload on my shoulder considering the fact that the product think tank has only 2 designers as compare to 5-6 members in service and space think tanks. It was also very challenging to define what are the actual problems? What I am trying to solve? Even though literature and several WHO reports broadly specify the problems in terms of statistics and general causes, however as a designer I was questioning myself if it’s a problem because of lack of products, services, space or simply on account of behaviour, mind-set or attitude towards healthcare.

The learning curve was steep, and I feel I had to sometimes take steps in the process purely on instincts and self-motivation in order to take the project one
more level up. For instance after the end of first phase I took a conscious decision to improve the prototype (Delivery Stool) and do user test in India, knowing that it might take longer time to complete the thesis work and even might not get the support from company side with whom I worked during the first phase. Also during the field evaluation in India it was challenging to get permission, (being a male) to enter in a female ward (delivery room, while the deliveries are happening), a huge amount of improvisation was required to understand and react to the context (Shaw et al., forthcoming 2017). However reflecting back I feel it was a rewarding commitment purely because of the results, and motivation shown by the users towards acknowledging the new concept which is indicated by comments such as - “if you leave the stool with us, we can do actual test in our facility and give specific feedback”. These findings are extremely meaningful for the future development of the stool.

Beside the problems of contacting relevant organisations and people during the field evaluation, I am proud of the work I did during this project. I feel I carried out the research work followed by prototyping and field evaluation successfully and I am very satisfied with the outcome of the project. I believe the outcome (Delivery Stool) can truly help in improving the quality of care from the perspectives of women and care providers. I am excited about exploring the potential to take this forward.

“if you leave the stool with us, we can do actual test in our facility and give specific feedback”.

Feedback received from head nurse at community health center in Barauli district (20 km from Agra), India
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Table 1. Main domain of work for each think tanks.
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1. List of other product ideas
2. User Evaluation Plan and Questionnaire (Dec 2016)
3. Publication - Conference paper (REDO Cumulus Kolding 2017)

1. LIST OF OTHER PRODUCT IDEAS

**Focal light**

Problems:
- Due to blackouts midwives need to work without sufficient light
- Focal lights occupies space and are on the way
- Flashlights gets stolen and their batteries might be empty

Design ideas:
- LED light with battery pack
- Can have several attachments (bed, wall, ceiling)
- Can be detached from the feet and used as a torch

**Toolset for personnel**

Problems:
- Midwives and other staff members are the most important asset but they are not appreciated enough
- They might lack the needed professional support
- They are not sufficiently equipped

Design ideas:
- Personalized toolset to welcome the new member to the work community
- Feeling appreciated helps to improve the professional network and support
- Improve efficiency with basic tools

**Furnitures to increase the capacity**

Problems:
- Small and crowded wards
- Clients might wait long times just to get a seat to rest

Design ideas:
- Series of foldable furnitures which doesn’t take much
- space and can be opened to accommodate more clients when needed

**Wearable Hand Hygiene dispenser**

Problems:
- Sufficient hand hygiene routines are not necessarily followed inside the facilities due to non-availability or when the dispenser are kept outside the delivery room.

Design ideas:
- Pocket dispenser for sanitiser
2. USER EVALUATION PLAN & QUESTIONNAIRE (DEC 2016, INDIA)

Objective – Understanding the Acceptance / Motivation factor for usage. At the same time throwing the idea as a seed to know and understand the importance of the alternative birthing positions.

Participants – Doctors / Experts / Midwife Traditional Birth Attendants, expectant mothers.

Locations – 1-2 locations in City / Urban set up (Hospital / Nursing home) at Agra and 1-2 location in rural areas (Bihar)

What is a birthing stool concept? (Short explanation in for participants)
It is a simple and cost effective solutions for alternative delivery of babies. The Portable stool concept combines a traditional squatting birth position with low cost furniture to increase capacity and preparedness for ad hoc deliveries.

AIM of the Project
To provide simple, durable, clean, ergonomic and cost effective alternate birthing position. To have a portable delivery pack that can be used for normal deliveries in the delivery room and emergency situations across and outside the facility.

Questionnaire for the Participants
1. What do you think about the concept in general? Will it be useful / interesting to develop further?
2. How do you feel about deliveries of babies in lying down v/s in squatting posture?
3. Where would you keep it? Where would you use it? In which situations do you think it is meaningful?
4. Who will know about this stool? In which situation would you present to the mothers? In antenatal care, or only when they arrive to the hospital? And why?
5. What do you think about the motivation / acceptance in Indian context?
6. What do you think about the ergonomics of the stool? What more could be improved?
7. Consider one of these scenario’s and use the Stool as a mean to perform the activity (of Delivering or using the stool)
   A. There are only two delivery beds and both are being used. If there is a woman who is in pain and the baby would come out at any point of time. Would you consider this to use the stool as an alternative (If yes / No – why?) & how you would use it?
   B. If there is a pregnant woman (Client) and she is using ambulance / local transportation to go to the nearest Primary health center. However the baby get delivered in the ambulance itself – will it be useful to have the stool inside the ambulance as an alternatives? How will you use it? (what steps) Does it need to be attached to a certain part of the ambulance? Do they think it is feasible, when? How? What extra part does it need if it need at all any extra part?
   C. As a part of tool kit for Dia (village ANM) or (ASHA) for performing home birth or Emergency birth. When there is no/ less time to take the client to the nearest delivery center and the local Dia could use this as an alternative. In this case how the stool could be used?
   D. Are you aware and motivated to support variation in birthing positions? Do you find it useful and interesting to use the stool if it is further developed? How much would you pay for it? Who would pay for it? (Hospital, health centres, an international program? Why? How many of them would you like to have in your facility? Do you think that we need to have one in the Anganwadi centres?
   E. Any suggestions for improvement? Related to variations in position.

3. PUBLICATION - CONFERENCE PAPER (REDO Cumulus Kolding 2017)

User Evaluation of a Healthcare Product Design in Rural India.
When Methods run short.

Amar Nath Shaw*, Mariana Salgado**, Charlotte Liukas***

Abstract:
User evaluation plays an important role in the early stages of the design process, especially when the products are targeted towards low and medium income countries. However, design research evaluation methods might at times overlook cultural and contextual sensitivities. In this paper we present a case study where a mixed evaluation method was used to test the prototype of a Delivery Stool, a childbirth aide concept. It provides an alternate birthing position and can be used both for normal deliveries in a hospital facility or in accidental deliveries outside the facility. The paper suggest that under current circumstances it might be beneficial to test products as a part of the implementation program and not detached the two., if the global health community would readily embrace and support design work in all its capacity, design initiatives such as the Delivery Stool could make a more valuable contribution to public health programs.

Keywords: product design, healthcare, low and medium income countries, user research, maternal and newborn health.

1. Introduction

Maternal death, or mortality associated with pregnancy, childbirth and postpartum, is a massive public health challenge, despite the global progress in the last decades. Globally, an estimated 289 000 women died during pregnancy and childbirth in 2013, a steep decline of 45% from levels in 1990. Many, if not most of the deaths, are attributable to a lack of access to skilled routine and emergency care (WHO, 2015a). Innovative products and services designed especially for the maternal and newborn health sector in low and middle income countries could in part contribute to making care more equitably available to all women and newborns.

This paper shares a case study of an evaluation of one product, a new kind of a Delivery Stool concept that was the output of a design project initiated in 2015 with the aim to decrease maternal mortality during childbirth. Lab.our. Ward, the project within which the Delivery Stool was designed, followed a human centered design approach and intended to involve health providers and pregnant women in the design of products and services that could positively influence the childbirth experience.
In this paper we seek to answer the following research question: How can user evaluation work in low and medium income countries, such as India? During the user evaluation of the Delivery Stool's second prototype we repeatedly perceived how methods fell short in this context and through this paper, we wanted to reflect on this.

Salgado et al (2015) discuss instances where methods might fall short when designing with immigrants. In their opinion critical success factors for research projects include the recruitment efforts, group dynamics, facilitators' attitudes, and the choice of venue for the meetings. In fact, many decisions regarding the design of a participatory research evade strict instructions on techniques and implementation. Participatory design defines the research context and therefore, the types of discussions that eventually do or don't take place. In the case of Salgado et al's immigrant research project, participants were asked about their migration stories in settings that were either familiar or neutral to them. The design researchers listened to participants' thoughts, opinions and reflections on their migration experiences. The techniques they used demonstrated that working with people from different cultural backgrounds is not straightforward and that the atmosphere influences results, perhaps even more than the techniques themselves.

In order to contribute to this methodological discussion, we wanted to analyse the planning and implementation of the Delivery Stool's user testing and evaluation in the states of Uttar Pradesh and Bihar in India. In addition, we aimed to unfold how the local practices and cultural sensibilities could possibly influence the design process, especially the evaluation of prototypes.

2. The case study

The case study described in this paper is the user testing and evaluation of one of the product concepts, a Delivery Stool, within the Lab.our Ward project. The Lab.our Ward project was a healthcare design project combining several design approaches, including human centered design and evidence based healthcare design, in the context of facilities in resource-poor settings. The Lab.our Ward project mostly took place from December 2015 to December 2016. The project group consisted of product, stage, interaction, service and architectural design experts who worked together with medical advisors and health practitioners to develop many innovative concepts to improve the maternity ward in a low resource context.

The organisation behind the project, M4ID Oy, is a social mission company with an aim of improving development and health outcomes for underserved and vulnerable populations. M4ID provides people-centred design and creative communication solutions for global development and health organisations. The project got funding and expert assistance from the Bill & Melinda Gates Foundation. The authors of this paper were involved in the project and working for this company. The first author was a part of the product think tank, and has worked as an industrial designer, the second author was involved as a design researcher and the third author was the general producer of the project. The project team visited Nigeria, Kenya and Uganda during the development of the concepts. The team used participatory research methods during the research with healthcare experts to identify the problems in the facilities and further develop concepts and early stage prototypes. Afterwards, the first author visited India for field research from March to April 2016 to gather user insights on the Delivery Stool.

An important milestone to the Lab.our Ward project took place on the last week of May 2016, when the team exhibited various prototypes and design proposals for future and existing maternity wards as a part of the triennial Women Deliver conference and exhibition in Copenhagen, Denmark (Lab.our Ward, 2017). The team showcased around 30 different ideas in the form of work-in-progress concepts and prototypes. This exhibition was done to co-create the concepts further and receive feedback from the visitors who were global health experts from around the world. During the conference many product ideas, such as an Ergonomic Delivery Bed, simple Bed Add-ons to existing delivery and postpartum beds, a Multipurpose trolley to be used by different users in the facility as well as the Delivery Stool (Fig. 1 &2) discussed in more detail in this paper, received extremely positive feedback.

The focus of this paper, the Delivery stool is a low cost, portable piece of furniture made of plastic and rexine that can be used for additional support during childbirth and delivery or as an alternative to a delivery bed. The stool can be used for normal deliveries in the delivery rooms of different maternity facilities and as well during emergency and accidental delivery situations across and outside the facility. The stool concept combines a squatting birth position with low cost furniture to increase capacity and preparedness for ad hoc deliveries.

Except few slight ergonomic suggestions for improvements in the maternal health conference, the overall positive feedback received gave us early indication that the Delivery Stool, could be easily adopted by the MNCH community and it might have the potential of being impactful in low resource settings.

After building the first prototype and testing it in the professional conference with global health experts, we realized we also needed to have user evaluations in real settings. Many characteristics of the Delivery Stool such as transportability needed to be evaluated in situ. The Delivery Stool is easy to carry (it could be moved by a walking person or taken in the ambulance), it saves space when compared to bed based deliveries, which in some overcrowded rural facilities might be an urgent need, and the stool as a product promotes a squatting birthing position which has been associated with less pain and an increased sense of empowerment during birth.
James Loren Christian (2014) states that experience from design practice suggests that user feedback should not always be taken to the letter, and that the particular context in which a prototype is presented can greatly influence a user’s perception of the concept. This is why, even though we consider valuable the feedback gathered in the Women Deliver event, we still felt the need to test the prototypes in real settings. The conference was an inspirational environment to talk and elicit good conversations with midwives and doctors, but we believe that contextual information coming from health facilities, especially located in rural areas could be crucial in this moment of the design process. In our opinion, it is possible to design concepts for low income settings remotely, but when we want to define the details of the product for final implementation, it is important to consider contextual and cultural differences.

3. Evaluation of the Delivery Stool 2.0

We choose to test and evaluate the Delivery Stool prototype in India, in Uttar Pradesh and Bihar, two of India’s most populous and poor states. Reasons for this were both practical and driven by opportunities for impact: India is the home country of the industrial designer pursuing this work and who is a native speaker of regional languages such as Hindi, Bhojpuri and Maithili. Another reason for choosing India as a place to conduct this evaluation was that India is estimated to account for 15% (Nearly 45,000) of maternal deaths globally in 2015 (WHO, 2015b). This evaluation of the Delivery Stool 1.0 with end users was not part of the funded project, but was an initiative of the designer and an essential part of his master thesis.

Jasmine Florentine (2015) claims that when designing products for emerging markets, a better understanding of the user can improve the success of the product, however, formal user research approaches designed for conventional markets may not be effective in emerging market scenarios. In line with her we decided to develop a mixed method approach to test the prototype of the Delivery Stool. These specific methods were selected because we considered them a good combination, taking into account ergonomic, functional and esthetical insights. Important is to clarify that testing did not happen during labour, but the designer interviewed people after or before the labour, when there was no rush in the facility.

This included:

Field observation with ethnographic elements: understanding the context, usage pattern and usability (Observations with midwives and auxiliary nurse midwifery (ANM) and accredited social health activist (ASHA),
Interviews - with end users (pregnant women) and with local healthcare providers in the facilities,
A comparison: with other existing forms of birth delivery aides typical in the context, such as such as delivery bed and cot, and
Ergonomics validation: backrest support, handle, grip, leg support and seating angle. Also, the convenience of carrying, cleaning and storage.

The next step was to make a plan for the field evaluation and design a new prototype version of the Delivery Stool. Though the first prototype (1.0) which was shown in the Women Deliver conference was good enough to be carried and tested in India, the designer improved this prototype and call it Delivery Stool 2.0. One of the important improvement incorporated was to integrate the delivery bowl which measures the loss of blood (Fig. 3). At the same time the amniotic fluids would fall into this bowl making the stool easier to clean after birth. This improvement came after the analysis of the feedback received in the conference.
As part of the plan for the field work in India, we set the objectives:

Validation of concept in terms of acceptance and motivational factors for usage,
Evaluation of the aesthetics and functional details of the product,
Evaluation with different user groups and Maternal and Newborn Child Healthcare (MNCH) experts (midwives, ASHA (community activist working in health in rural India), health providers in different type of facilities (private and public sector), pregnant mothers as well those who have given birth in normal delivery bed (in lying down position),
Gathering critical insights for prototype development for pilot testing, and
Gaining a better understanding of contextual requirements and hidden user needs.

The locations for fieldwork were primarily selected because of ease of traveling, logistics, knowledge of local language, and personal contacts. During the planning phase the designer contacted two social impact companies and two Non-Governmental Organisations (NGO) who have worked on several projects in the field of Maternal, Newborn Child Health (MNCH) in order to get some support by providing contacts of health facilities for the evaluation.

The field evaluation was done in roughly three weeks in December 2016, including traveling time, with approximately 5000 km of distance covered using different modes of transportation such as train, buses, autorickshaw bicycle and walking. In total four different facilities were visited, including a Railways hospital (private center) in Agra Cantt, meant for Indian railways employees, a community health center in Barauli district (20 km from Agra), Shri Jay Prakash Narayan Hospital in Gaya, (public health center) and the All India Institute of Medical Sciences (AIIMS), in Patna, Bihar.

Seven individual interviews were conducted: two with a Health expert and an Auxiliary Nurse Midwifery (ANM) at Agra, one with nursing staff in the operation theatre (delivery room) at Gaya and two interviews with an assistant professor and the head of department from obstetrics and gynaecology at AIIMS Patna, one with a pregnant mother and one with a women that was pregnant before. In addition, a group interview and discussion with a professor from the Department of community and family medicine took place in AIIMS, Patna.

The Delivery Stool is a new product in maternal health care, which entails a description challenge while testing it. In addition, the Delivery Stool requires a behavioural change, as it implies a different birthing position than the conventional one in a facility. This squatting position is part of the recommended positions to childbirth according to Gottvall, et al (2007), who call it the most natural position and suggest that it is used by women if left alone to choose their own position for birth. Further research suggest that the squatting position is helpful in opening the pelvis and allows the baby to find the optimal position for birth. However, according to our experience while interviewing health providers in India, only a few people know about its usefulness and to some extent it was a surprise for them to know that they can perform delivery using a stool.

Since the idea of alternative birthing positions is relatively new in India, carrying and showing the prototype during interview was critical. This was also perceived by Hussain, et al. (2012) that remind us that presenting prototypes makes it easier for participants to be critical and suggest alternatives. During the first interview held at Railways hospital in Agra, with two female health care providers, a brief document (in the form of printed A4 pages) consisting of mainly images and text was first shown and explained to convey the concept of the Delivery Stool, its usage and benefits firstly to the head of the hospital and later to the interviewees. After this, the prototype was shown which made the conversation and explanation more engaging. The feedback and critical comments regarding its acceptance, motivation, usage, ergonomics and scope of improvements were noted in the form of field notes in a diary that was carried by the designer throughout. These field notes were complemented with photographs, audio and videos of important parts of the conversation or the testing (role playing) and audio of the general soundscape of the facilities.
be carried around the facility depending on the willingness of pregnant women to test it. Therefore, the hospital does not need to have one Delivery Stool per room, but pregnant women could be informed about its availability and ask for it if she considers alternative positions. Considering that the Delivery Stool implies new practices such as the squatting position, which is not only a new position for the pregnant women, but also a new working position for the midwife and the doctors, we recommend to include this product as part of the future trainings to midwives. Based on our experience, if an industrial designer goes with the proposal of a new position for delivery, it is not well-received. When, however, a public health expert tells about the advantages of the position in delivery, the Delivery Stool might be more readily accepted as an option. Finally, care provider training is required to create the necessary change to embrace an innovative product such as the Delivery Stool.

In relation to the acceptance and motivation to use: using the Delivery Stool for birthing is a new concept therefore in the user testing and evaluation sessions the designer needed to show how it works and explain the benefits. Interviewees gave positive feedback but we understand that this could be biased as the designer was explaining the benefits. Most of them agreed that the full usefulness of the stool could be seen in the public sector hospitals where a huge number of deliveries (more than 300 per month) take place, because the private facilities visited have less deliveries per month and hence e.g. overcrowding situations happen rarely.

In relation to the functionality: the Delivery Stool is envisioned to be used when the pregnant women is in a squatting posture with her feet getting support from the ground, which means that the midwife or the nurse would need to bend down or sit in order to perform their tasks. Midwives who were slightly overweight showed concern by saying that “I won’t be able to bend down”. Other concern was the cleaning of the stool and the cover, since they mention that the delivery bed (as it is a flat surface) is easier to clean.

In relation to the design characteristics: all of the interviewees thought that the materials, shape and the aesthetics look was good. They even appreciated the fact that it is white in colour and would help them to spot the blood and other stains clearly, however they noticed that this means they would need to more effort to keep it clean.

Suggestion for improvement: most of the interviewees thought that having some kind of backrest support as an option would be needed in order to help the pregnant women relax during the labour stages. Placing the delivery stool against a wall was not seen as a comfortable since they pointed that the back support would make them feel more secure.

4. Results of the User Evaluation

In relation to Product positioning: In principle the Delivery Stool could be used for home deliveries, which is a relatively common phenomenon especially in rural areas of the two states. However, the Indian health system has been consistent in its efforts to eradicate home deliveries as delivering at home without adequate medical access is a significant factor in maternal mortality. Therefore, we did not want to discuss this option.

In relation to the concept: The Delivery Stool could be used in different places in the health facility, especially for emergency or rushed delivery situations. The stool could be placed beside the beds in a normal delivery room for promoting alternative birth positions. It could

Figure 4: Expectant mother performing role play with a companion. Source: Amar Nath Shaw

An informal interview and open discussion was done with one expectant mother in Agra at her residence (Fig. 4) and another woman who has been pregnant before. The interview were conducted after they were asked to imagine and demonstrate a scenario through role play. During role play a female companion was also asked to join which could perform the role of a traditional birth attendant or Community health worker (ASHA) or simply as a nursing staff.
Most of the discussions ended with the feedback that it needs to be tested further to confirm as the concept is so new and the care providers were giving feedback based on their own experience with other products while not having tried the stool out. The feedback from the health professionals and midwives indicates increased acceptance and motivation towards new ideas and willingness to accept new ways of performing childbirth and delivery in low resource settings, however as mentioned by Hussain, et al (2012) more engaging participation is needed to empower midwives and pregnant women on interactional and behavioural levels.

5. Analysis

5.1 Planning the user evaluation

The fieldwork proved valuable for gathering relevant feedback, yet we went through several challenges in the planning and execution of the testing.

Connecting to health facilities and providers ended up being challenging. The designer contacted two Non Governmental Organisations (NGO) and two social impact companies that have been working in India and have done projects in the Maternal, Newborn Child Health (MNCH) sector before. He asked for contacts with local health centres as well as recommendations for how to pursue the testing. However, the initially positive conversations didn't materialise into direct contacts or ‘opened doors’. Despite this slight disappointment the designer decided to continue to carry on the field evaluation on his own. In one case, the designer met with an NGO director in Patna, Bihar. This person was keen on knowing who is involved in the project and what is the big picture, but not in supporting the designer's work. It seemed to be challenging to convince higher authorities and to get support in product design testing if the designer does not come with the right credentials or isn’t affiliated with a well known organisational entity. In this case, the designer was not anymore working for the company that did the first version of the prototype, but wanted to move the project forward as part of his thesis work.

Getting permission from the head of the facility was a laborious process. The designer had to first go through process of showing and explaining the prototype two times. This was a time and energy consuming process. He had to first show and explain the prototype to the head of the hospital (not dealing with childbirth) in order to get the permission to conduct an interview with the health providers who work in the same hospital.

Though the designer received a small amount of funding for making the improved prototype and traveling to India, it was not sufficient to pay the participants or interviewees for their time. This could have affected their motivation to participate in the activities proposed by the designer. As a consequence, the designer reached out for some interviewees through personal contacts. Another important constraint was the lack of time to travel, considering the fact that train traveling in India from one state to another, requires advance booking of seat which needs to be done months in advance.

The designer also face problems with false promises. In one case, one of the professors in a health facility in Patna, promises him that she will support the evaluation by doing the actual testing of the Delivery Stool, provided the delivery stool is left with at their facility for few days. Taking this as a great opportunity to get some user insights the designer travelled more than a thousand kilometers in order to drop the delivery stool at the health center. He sent several reminders to the professor in relation to the testing. However, in spite of his effort the testing did not happen. The possible reason in this failure was the lack of interest and motivation from the person, along with not enough support from higher authorities.

5.2 Contradictory views

The Delivery Stool was envisioned to be used with a companion and hence the backrest was not added to the current prototype. However, during the field evaluation the designer noticed that no male companion was allowed to enter inside the delivery room or operation theatre. Only occasionally a female companion would enter if there is need. The husband and other relatives would wait outside during the delivery. The Delivery Stool, in contrast, was originally designed with a birth companion in mind. Not having a backrest has the advantage of making the product easier to transport, but also, it was a way to align with World Health Organization (WHO) guideline that promotes the presence of the companion during childbirth: “Empathetic support, before and during labour, from caregivers and companions, can reduce the need for pharmacological pain relief and thus improve the childbirth experience” (WHO, 1996: 18).

Faced with this contradiction the designers asked themselves what to do? Should we follow user insights or experts inputs? We wanted to make an innovative product, but if we go too far, stretching the limits of what the user is accustomed to and would actually use, then the product will not be accepted. We might gain recognition in the design community, but it will not have a real impact in low and medium income countries. Our design space is the thin line in which the Delivery Stool could be socially accepted in context and at the same time be aligned with international global health guidelines. Given these constraints, a sensible designer would probably compromise and add a small backrest that does not disrupt transportability. However, making evident the emptiness, the absence of the companion, might make health providers and pregnant women ask for their presence and in this way we would be promoting WHO's guidelines. Or perhaps the absence of the back rest might make a pregnant woman feel miserable by highlighting her lack of a companion during the stressful and painful process. These type of concessions challenge our values and our ways of thinking in design alternatives. We do not have an answer but many questions. The testing was useful to raise these questions.
6. Discussion

Dindler and Iversen (2014) claim that personal and professional relationships are crucial to design outcomes and that designers’ responsibilities include awareness of these dynamics. This is referred to as designers’ relational expertise. In the context of India we discover that often reaching the right user group is dependent on the rapport with higher authorities (both in a governmental level and in the health facility) and personal recommendations. The relational expertise while doing field work in low and middle income countries can include being agile and smart not only with effective verbal communications but also when reading in between the lines and navigating hierarchical organizations. In addition, the relational expertise includes to be aware and prepared for certain unexpected situations such as false promises.

A huge amount of improvisation was required by the designer to understand and react to the context. This is why, we agree with Light and Akama (2012, 61) when they state that participatory methods cannot be seen in isolation from the person or people engaged in them. They are “[m]ethods and techniques [that] require embodiment”. In this case, the male designer was not supposed to enter in delivery room because his presence would be consider as an act of disrespect towards the women giving birth. But the designer needed to contact the female midwives working inside the delivery room and he entered the waiting room trying to be as less disruptive as possible and showing, with his gestures respect for the situation. His cautious presence and respectful manners allow him to be in the waiting room of the delivery room interviewing the midwives.

7. Conclusion

As with most global health challenges, improving birthing experience in low resource settings is a complex problem that is interlinked with health provider practices, the presence of companions and change acceptance across different cultural settings. Therefore, product design for better birth experience needs to be considered from a holistic perspective and align with international healthcare guidelines.

We understood that we cannot innovate in design without having the support of the public health expert community, not only for the development of the concepts, but also for the implementation of them. We recommend that in future, user evaluation will be carried on as part of programmatic implementation and capacity building endeavours.

Our conclusion points out to the fact that methods run short. It is not only a question to pay attention to the details of an evaluation protocol but to set up the evaluation in collaboration with other organizations. Otherwise, the risk is that the user evaluation does not give good and rich results, because the participants do not commit to the project. Their insights are dependant of the perception of the project in the future and in this case the fact of not having the right credentials make them perceive as a student’s project instead of a real and possible industrial design development.

It was a surprise for us that though the project was targeted toward improving global health, the designer did not get the necessary support from companies and NGOs with a similar mandate. The designer had to struggle with several hierarchical and socio-political issues in quest of evaluating with the end users. For example while approaching some health facilities for getting permission to do the user testing the designer introduced himself by mentioning that he is working in an international NGO even when this was not the case. We might argue that it is ethically questionable, to give the wrong information, however the designer knew that he would be turned away if he does not mention working with an NGO. In countries such as India, designers need to consider several other factors such as hierarchies, social classes, status, casts and gender issues while planning for evaluation. In addition, designers might face ethical dilemmas that are difficult to deal with.

In addition, products alone will not promote behavioural change in health facilities in low medium income countries. They have to be assisted and embraced by health systems and health providers. The Delivery Stool alone is only a drop in an ocean. For making the Delivery Stool an innovation, we need to really understand the health system in the country of implementation, and coordinate a series of interventions such as trainings and campaigns to promote for example the benefits of alternative delivery positions and having a companion present during delivery. There is a need for overall improvement in the Maternal, Newborn Child Health Care sector and it has to done in a logical way, minding cultural backgrounds and practices of the people involved in the process. Design solutions can make a difference only if the global health community (including health providers, companies and NGOs working in the field) embrace practices such as design evaluations and support design work in all its capacity.
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