

Supporting Ongoing Training of Community Health Workers through Mobile-based Solutions in Rural India

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Doctor of Philosophy

by

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Certificate

This is to certify that the thesis titled as “**Supporting Ongoing Training of Community Health Workers through Mobile-based Solutions in Rural India**” submitted by Deepika Yadav to the *Indraprastha Institute of Information Technology Delhi*, for the award of the degree of *Doctor of Philosophy*, is an original research work carried out by her under my supervision. In my opinion, the thesis has reached the standard fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted in part or full to any other university or institute for the award of any degree or diploma.

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To all the women in my family and those outside who stand, voice, support, or fight to let women in their next generation dream and set on to a challenging path for change.

Abstract

Community health workers (CHWs) in low- and middle-income countries play a vital role in public healthcare. CHWs particularly assist in improving maternal and child health conditions of the poor and vulnerable who often remain unaware of the available services and face sociocultural barriers in accessing the health services. India, which is still undergoing a burden of high child mortality, implements its CHW program as a flagship program with close to a million CHWs appointed across its states.

However, under-training significantly limits the ability of CHWs to provide quality services. We address the training problem in India by designing and deploying low-cost mobile training tools that can complement the existing face-to-face training mechanisms. Our system adopts a hybrid architecture to use Interactive Voice Response for facilitating online audio training sessions. Thus, allowing CHWs to access training from anywhere through their feature phones, a key need that has been well recognized by HCI4D research. We contribute on the following aspects: (1) Testing the feasibility and efficacy of our training tool through a controlled field experiment (2) Unpacking the training needs of CHWs by analyzing a question and answer record of 1178 and mapping it back to the existing reference material through a large-scale deployment on 500 CHWs, (3) Investigating the potential for peer-to-peer learning models to address the challenge of experts availability through a controlled field experiment, and (4) Finally, exploring the potential for automated techniques in this domain by proposing a semi-automated NLP approach for curating generated learning content and exposing CHWs and women to Chabot-based education for the first time. By using a range of mixed methods and field experiments, this dissertation expands the focus of HCI4D and mHealth research on CHWs competence development in low-resource settings, an area that has long been neglected.

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Glossary

HCI: Human Computer Interaction, a sub-field of computer science

HCI4D: Human Computer Interaction for Development

ICTD: Information and Communication Technologies for Development

IVR: Interactive Voice Response, automated voice calls

mHealth: Mobile Health, general term for using mobile phones in medical care

SMS: Short Message Service protocol for sending a text message

NLP: Natural Language Processing

WHO: World Health Organization

LMICs: Low and Middle Income Countries

CHW: Community Health Worker

ASHA: Accredited Social Health Activist

ANM: Auxiliary Nurse Midwife

AWW: Anganwadi worker

HBPNC: Home-based Post-Natal Care

NRHM: National Rural Health Mission

NHM: National Health Mission

PHC: Primary Health Center

CHC: Community Health Center

WoZ: Wizard-of-Oz

SWACH: Survival for Women and Children, an NGO in India

Chapter 1

Introduction

Maternal and child deaths have declined remarkably globally since 1990; however, they remain high in many low- and middle-income countries (LMICs). India is among the five countries of the world that contribute to nearly half of the deaths [1]. Of the 5.1 million under-five deaths in 2019 and 295,000 maternal deaths in 2017; 824,448 and 35,000 deaths occurred in India [2, 3]. Due to high disparity in the access to simple and affordable life-saving interventions, women and children in the rural areas continue to die from preventable causes [4, 5, 6].

A key strategy that India adopted to address the condition was the commissioning of the National Rural Health Mission in 2005 that involved expanding its Community Health Worker (CHW) program at a national scale [7]. Local village women are selected and trained as community health workers to compensate for the shortage of health professionals and broken links between the primary health system and rural communities. The CHWs are known as Accredited Social Health Activists (ASHA) [7]. The ASHA program is one of the largest CHW programs in the world with 970,676 current appointments [8].

ASHAs help in averting maternal and child deaths by improving access to health services, recognizing danger signs and making timely referrals, and promoting health behaviors [9, 10, 11]. However, ASHAs face challenges in delivering quality services, and their performance have been reported to be sub-optimal [12, 13, 14, 15]. One of the causing factors is inadequate training and supervision. We address the problem of training ASHAs by designing and deploying a mobile-based training tool that is suitable for settings with limited technology infrastructure and literacy levels. We extend the intersection of HCI and frontline health by expanding the focus to the skill development of CHWs through the following three contributions:

1. *We propose a low-cost mobile training tool for supporting ongoing training of ASHAs in a complementary manner.* Typically CHWs belong to settings that are constrained in terms of internet access, literacy, affordability, and infrastructure. Users in these settings mostly own feature phones and prefer voice applications. Relevant to these constraints, there is a rich body of HCI4D literature around Interactive Voice Response (IVR) systems [16, 17, 18, 19]. In particular, interactive voice forums, which allow users to actively produce and consume information with peers through asynchronous discussion forums, have demonstrated impact for various applications [17, 18]. We extend this body of work by employing IVR for synchronous communication to facilitate online training sessions over feature phones. We propose and test the efficacy of the mobile training tool for
2. *We identify the training gaps by understanding the information needs of ASHAs.* The existing studies on ASHAs substantially report on the lack of training support, the challenges in the implementation and the lack of skills of ASHAs [20, 14]; however, they do not inform the information needs of ASHAs from ASHAs' perspective. We fill this gap by collecting and analyzing ASHAs queries through the large-scale deployment of our tool. We further map the queries with the reference material of ASHAs to understand the efficacy of the material.
3. *We explore the potential of automated techniques in the training and curation of training material in this domain.* Due to the constraints of voice-based communication in local languages and lack of automated techniques for the curation, learning material collected from training sessions such as question and answers between ASHAs and experts remain under-utilized. We attempt to address this challenge by proposing a semi-automated approach of categorizing and tagging voice data from low-quality transcripts using natural language processing techniques. The research contributes to the content moderation problem of IVR voice forums in general, which

face sustainability challenges due to dependency on manual methods [21].

Further, we explore the potential of conversational agents for the education of ASHAs and women on Breastfeeding who are first-time chatbot users and have limited digital literacy. Our study uncovers social-cultural influences on breastfeeding information seeking and informs useful design guidelines.

CHWs represent an important user group for HCI and CSCW research. CHWs are mostly low-literate, marginalized women who work informally or as paraprofessionals with the need for continued on-the-job support and skill development. CHWs' position in the communities is instrumental for both the health systems and their communities. Designing for CHWs opens avenues to understand the needs of low-resource settings better.

1.1 Dissertation Outline

We divide our dissertation work into five chapters, starting from the proposal of the tool and its field studies followed by the large-scale study and studies exploring automated techniques for the content curation and using a richer interface for training.

1. **Proposing and field testing a mobile-based training platform.** Based on the literature review on technology-based solutions for the capacity building of CHWs in low-resource settings, we discuss the research gap in chapter 3, followed by the understanding of the design requirements for mobile-based training platforms and development of the tool “*Sangoshthi*” in chapter 4. We present our results of the field study that evaluated the feasibility and efficacy of the tool by providing a training intervention to 20 CHWs in North India. The study was conducted in collaboration with an implementation partner, an NGO, which designed the training content and hosted training sessions. From this pilot study, we collected positive indications for knowledge gains; there was 16% increase in the test scores of the intervention group

as compared to the control group and for the acceptability of the application by the CHWs.

2. **Investigating opportunities for system-supported peer-to-peer learning.** To address the problem of the scarcity of skilled trainers that causes a bottleneck in providing periodic training, we investigated a peer-to-peer learning model. We removed the explicit role of trainers and allowed ASHAs to self-direct their learning using scaffolded group tasks. We evaluated the effectiveness of the design by conducting a between-group study across four health centers (120 CHWs) covering urban slum areas of Delhi state, India, described in chapter 5.
3. **Investigating the training needs through a large-scale deployment.** We further investigated the training needs of CHWs by deploying our system for the training of 500 CHWs. In a period of five months and one week, 144 training sessions were conducted with the collaboration of our implementation partner. We qualitatively probed into the information seeking of CHWs by analyzing 1178 questions asked during the sessions and mapped it with the gaps in the knowledge and skills of CHWs. We also performed a content analysis of the learning reference material of CHWs to understand its efficacy for the sought questions. Along with collecting CHWs' training experiences, we provide design implications for HCI4D researchers for mobile learning platforms targeted towards CHWs. We also provide policy-level suggestions to improve the training of CHWs in India or a similar context. The study is presented in chapter 6.
4. **Proposing a semi-automated approach for the curation of generated learning material.** Our training system is primarily based on voice communication like IVR voice forums, which generates audio data in local languages. Curation of such data is challenging due to the absence of accurate automated transcription methods for non-standard language and hence becomes an impediment in scaling the use. We

proposed a semi-automated approach for clustering and tagging audios that used topic modeling and basic natural language processing techniques on low-quality transcripts. To evaluate the quality, we collected and analysed ratings from 48 community health workers for machine-curated and human-curated audio data presented in form of IVR accessible digital library. The corresponding chapter is 7.

- 5. Exploring the potential of chatbot-based education for breastfeeding in Indian context.** Chatbots are increasingly being seen as democratizing technology. Chatbots provides benefits for digitally low-literate and education purposes. In this study, we explored the potential of chatbots for the education of ASHAs and mothers on Breastfeeding. We understand the initial reactions of the first-time users of chatbots and understand their perceptions on chatbot-based assistance through a Wizard-of-Oz experiment. We involved 22 participants: 12 ASHAs and 10 mothers. In addition to the focus on chatbot-based education, we also develop preliminary understanding on the potential of chatbots for breastfeeding support in Indian contexts by analyzing mothers queries and mothers contexts of information seeking. Chapter 8 discusses the experiment details and our findings.

Chapter 2

Background

This chapter provides background on the CHWs, CHW profile and roles in India, and training challenges associated with CHWs performance.

2.1 Community Health Workers

One of the challenges in providing equitable access to proven life-saving interventions to end preventable deaths is the acute shortage of health workforce in high burden countries. Data for 2013–2018 showed that almost 40% of all countries have fewer than 10 medical doctors per 10 000 people, where 90% of low-income countries suffer from such shortages compared to only 5% of high-income countries [22]. Further, according to the estimates of the WHO Global Strategy on Human Resources for Health: Workforce 2030, it is predicted that by 2030, there is going to be a global shortfall of 18 million health workers, primarily in low-income and lower-middle-income countries [23].

To address this challenge, a global strategy is to increase the capacity of the existing health workforce through “task-shifting” approach [24]. This involves rational delegation and redistribution of tasks among health workforce teams. Specific tasks where appropriate are shifted from highly qualified professionals to less qualified workers to make efficient use of available human resources for health. In this context of task shifting that community health workers are gaining recognition [25, 26]. WHO defines CHWs as “Members of the community, selected by and answerable to the community they work for, and supported by the health system but with shorter training than professional health workers” [27]. Although the fundamental characteristics of the definition are universal, depending on program goals, variations may be found across and within countries in the roles, responsibilities, training, recruitment, and compensation. For example, CHW can be men or

women, salaried or volunteers, literates or illiterates depending on the conditions and contexts of different regions [27]. CHWs, in some cases, are involved in a wide range of tasks of types- preventive, curative, and developmental; in other cases are appointed for very specific interventions. Some of the titles used for CHWs are frontline health workers, lady health workers, accredited health social activists, lay health aides, community midwives, health promoters, volunteer health workers, etc. [27].

Literature conceptualizes two roles of CHWs. First is that of service extension workers, whereby CHWs assist health professionals in rendering basic services to under-served settings such as immunization, treating minor illnesses and making referrals in case of serious problems, and promoting health [28, 26]. The second is that of activists, whereby CHWs act as social and cultural intermediaries between the existing health system and the community [29]. CHWs mobilize their communities in addressing social and cultural barriers to health.

Maternal and child health is a core focus area for CHWs in low- and middle-income countries [30, 11]. As fellow women in the same community, CHWs are seen as a vehicle and trusted partner to women in navigating health systems and overcoming socio-cultural barriers. Studies evaluating the contribution of CHWs across different settings have reported a positive impact in reducing child morbidity and mortality, increasing uptake of immunization, and promoting breastfeeding practices [11, 10]. CHWs have also been recognized to improve utilization of antenatal, perinatal and post-partum services , and preventing perinatal maternal deaths and early recognition of complications during pregnancy [11, 31, 32, 33]. Based on these successes and the urgency to respond to the crisis of human resources for health CHWs, there is a renewed focus on CHW programs [34, 24]. There are increasingly global calls for improving support systems for CHWs and accelerating efforts to fully tap the potential of CHWs. As a result, CHW programs are expanding and formalized. Many countries in Southeast Asia and Africa, including India are implementing CHW programs at large scales [35].

However, there are a multiple challenges with CHW programs. Some of the common concerns that have been voiced with regard to the performance of CHWs in the literature are: (i) despite the evidence that CHWs improve coverage of health services and can implement effective interventions, the services provided are not consistent in quality and often sub-optimal [12, 14, 20]. (ii) There is a high need of improving the selection, training and on-the-job support to enable CHWs make effective contribution [36, 12, 15, 37]. (iii) Working on the peripheries, CHW programs are vulnerable and need firm methods for the institutionalization and mainstreaming of community participation and thereby recognition of CHWs work [36, 13] (iv) Volunteerism and remuneration of CHWs has remained debatable. Given that CHWs mostly are of poor backgrounds, volunteerism has been questioned for its sustainability [36, 13]. Lack of expected compensation for CHWs services which usually are equivalent to full-time duties has been reported as a motivation issue and cause for high dropouts [13].

We will focus on the training challenge in the context of India.

2.2 Context of Study

Our study is based in India, which is among the bottom five countries with the maximum number of child deaths and has substantial variations in the magnitude and rate of decline in mortality across its regions. The rural areas where 70% of the population lives, faces the greatest burden of mortalities. According to National Family Health Survey-4, under-five mortality rates for rural areas is 56 deaths per 1,000 live births as compared to 34 deaths per 1,000 live births in urban areas [38]. The difference between the richest and the poorest is threefold with 23 per 1000 live birth in the highest wealth quintile to 72 deaths per 1000 live births in the lowest wealth quintile [38]. There is also a high disparity in health coverage. For instance, 92% of women in Andaman Nicobar state made at least four antenatal contacts (the minimum number recommended by WHO) compared to 14% in Bihar, nearly 100% deliveries in Puducherry state were institutional compared to around

50% in Meghalaya [39].

Further, the acute shortages of health workers and their uneven distribution make health-care challenging to access. According to Rural Health Statistics, the density of doctors, nurses, and midwives in urban areas (13.9 and 15.1 per 10000 population) are three times higher than in rural areas (3.9 and 4.1 per 10,000 population) [40].

In response to the poor condition of maternal and child in rural regions and prevailing inequities in healthcare access, the government of India launched National Rural Health Mission (NRHM) in 2005 [41, 15]. As part of this, the country revived its CHW program by creating a new band of CHWs known as ASHA (Accredited Social Health Activist) [7, 15]. An ASHA is a village woman turned into a health worker to meet the health needs of the community. The program was first started for 18 high focus states out of 28 states and later expanded for the rest [42]. Currently, on average, an ASHA serves a population of 1000 that typically corresponds to a village. With nearly 1 million ASHAs (970,676), it is one of the largest national community health worker programs in the world [43].

The Indian rural healthcare system exists in three tiers as shown in the table 2.1, the ASHAs work at the lowest level.

2.3 ASHA

An ASHA is a village-level worker, a woman recruited on a voluntary basis from the village by the local government and village representatives. Typically, an ASHA is in the age group of 25-45 years and educated up to middle-school level (10th grade) [7]. However, wherever the education criterion is not met, ASHAs with low education are also selected. The primary responsibilities of an ASHA lie across three functions: promoting access to health services, building awareness on healthy behaviors, and providing basic curative care [7]. Examples of some of the related activities are registering pregnant women, facilitating antenatal contacts, counseling women on birth preparedness, and providing escort services for delivery; making home visits to new mothers during the postnatal period to monitor the

Table 2.1: Indian Public Health System

Health Facility	Description	Staff
Sub-Centre (SC)	Most peripheral unit and the first contact point between the primary health-care system and the community. A SC covers a population of 5000 people (approx 5-6 villages)	one ANM and a Male Multipurpose Worker (MPW).
Primary Health Centre (PHC)	4-6 bedded and acts as a referral unit for 5-6 sub-centres, covers a population of 25000-30000	1-2 doctor, nurses, ANMs compounder and other staff
Community Health Centre (CHC)	30-bedded hospital, acts as referral for 4 PHCs, covers a population of 120,000	5-6 doctors including specialists nurses and paramedical staff more than PHC
District Hospital	One per district 75 to 500 beds depending on the size, terrain and population the district of	Specialists for different types of healthcare with adequate number of nurses and paramedical staff

health and making referrals when necessary; facilitating immunization drive and monthly village level meetings for health promotion [7].

ASHAs do not receive any fixed salary but are paid performance-based cash incentives, the amount of which differs according to the nature of the service, e.g., 700 INR or US \$11 for mobilizing and accompanying a pregnant woman for institutional delivery, 250 INR or US \$3.4, for undertaking each home visit during the first 40 days after childbirth (total six visits) [44].

To become an ASHA, the woman receives an induction training of 23 days in five episodes which completes within a year [7, 45]. The first round ends in seven to eight days, followed by four rounds of four days each. The induction training is followed by a periodic training of 12 days (for about two days once every alternate month) for upgrading and refreshing knowledge and skills [7, 46]. The general training model follows a cascade approach that involves training layers of trainers at different health system levels to train ASHAs at the lowest level finally.

2.3.1 Other Cadres of CHWs

There are two other female cadres of CHWs who work closely with ASHAs, Auxiliary Nurse Midwife (ANM) and Anganwadi worker (AWW). ANMs have been part of the

health system since 1950, work at the sub-center level, the lowest of the three-tier primary health care system of India (covers a population of 3000-5000, which is typically four-five villages). ANMs are permanent government employees and receive fixed salaries. They receive 1.5 to 2 years of midwifery training. Almost all functions of ASHAs are associated with ANMs [45, 15]. ASHAs report their task details to ANM. Depending on the area size of a sub-center, each ANM is supported by four or five ASHAs. ANMs are supposed to take weekly or fortnightly meetings with ASHAs to review work done and guide ASHAs [45, 15]. Unlike ASHAs, ANMs do not reside in the villages that they serve; instead travel to villages on different days, particularly for outreach sessions such as monthly village meetings, etc.

Anganwadi workers (AWWs), on the other hand, were introduced later in 1970 under the Integrated Child Development Service (ICDS) program to improve the nutritional status of children [45]. An AWW works at a village level where she is primarily responsible for running a center called *Aganwadi*. At this center, AWW provides pre-school education to children between 3 and 5 years old and food supplements to children below the age of six, adolescent girls, pregnant and lactating women [45, 15]. Like ASHAs, AWWs are selected from the villages they serve; however, they receive monthly salaries.

ASHAs are the newest addition to the cadres of CHWs who were primarily introduced to fill the gap. Before ASHAs, ANMs were heavily overworked at the health centers with a limited scope of directly reaching the communities, and AWW responsibilities were mainly tied to center-based activities. These three cadres work together in various activities with a key role in facilitating Village Health, Sanitation and Nutrition Days (VHSND), which are conducted once a month in every village to bring multi-sectoral convergence as an interface between the community and the health system [47]. The ASHAs, AWWs, ANMs, along with other village representatives, mobilize villagers, mostly women, and children, to assemble at the nearest Aganwadi center to interact with health personnel, obtain information and services.

2.4 Potential and Challenges in Realizing ASHA Role

In this section, we will elaborate on the potential and strengths of ASHAs in addressing child morbidities and mortalities through a salient activity of home visitations and how these remain under-realized due to lack of skills.

Based on the strength and supporting evidence from studies that showed that home-based newborn care interventions could prevent up to 30-60% of the mortalities [48, 49, 50], WHO and UNICEF jointly issued a statement in 2009 for incorporating home-based newborn care strategy for preventing newborn deaths in high mortality settings where access to facility-based care at birth is low and the quality of care is poor [50].

India implements the home visitation approach for both pregnancy and postnatal period [46]. Once a woman is identified as pregnant, an ASHA is supposed to make contacts with her to ensure she receives minimum ante-natal checkups, make an appropriate birth plan for institutional delivery, and avails associated cash incentives [45]. After child-birth, an ASHA is supposed to make 6-7 postnatal visits to help new mothers with postnatal complications, exclusive breastfeeding, newborn care practices, and keep a check on danger signs and provide extra care to pre-mature and low birth weight newborns. [46]. Home-based Postnatal Care (HBPNC) is a central part of the ASHA profile.

While several trials provide clear evidence in favor of home-based postnatal visits impacting mortality reduction, the effects have not been translated to programs delivered at scale yet [51]. The two most prominent difficulties in achieving the effectiveness are lack of high coverage and sub-optimal performance of CHWs in ensuring the quality of care. Various studies assessing the quality of HBPNC provided by ASHAs confirm it to be poor [12, 52, 53, 14, 54]. The study by Sinha et al. observed 19 home visits of ASHAs and assessed the quality on 15 parameters [55]. The study found less than 50% of the ASHAs to follow the practices of washing hands before handling babies, advising mothers on danger signs, Kangaroo care, and eye care. None of the ASHAs used the pictorial flip chart

to explain safe practices to the mothers. Das et al. observed that ASHAs failed to perform newborn assessment comprehensive and under-diagnosed severe illnesses in more than 80% of instances [56].

A primary reason behind the poor performance of ASHAs is the lack of sufficient opportunities for knowledge and skill development. The current training mechanisms lack in upgrading ASHAs skills on a continued basis. After the initial fixed training, the ongoing training that is “in-service” or “refresher” training is not delivered regularly. Some of the highlighted problems are poor infrastructure, lack of skilled trainers, institutional problems in implementation, and training strategy [57]. For instance, inadequate fund release, lack of coordination with third parties, and space constraints cause inordinate delays in training schedule [57]. Sometimes ASHA batches become operational in the fields with no training for a long period of time. The cascade training strategy of training multiple layers of trainers affect training quality and duration [57].

Further, the on-the-job supervision is also in poor condition. Although formally it is articulated that ASHAs supervisors routinely guide ASHAs by occasionally accompanying them in their home visits and meeting frequently, it does not happen in practice. Dedicated forums such as monthly meetings in which all the ASHAs under a PHC (around 30) meet their supervisors are not effectively executed. The meetings miss out on the skill development component and remain driven towards supervisory activities [58]. The scope of interaction with doctors in the facilities is limited as they are overburdened with patients. Overall, ASHAs do not have access to dedicated forums to get answers to their queries or improve their knowledge and often rely on each other in an ad-hoc manner to conduct their duties [58]. This leads to ASHAs handling the field cases with limited knowledge and skills, which in turn hamper their confidence and ultimately credibility in the eyes of communities [59].

Chapter 3

Literature Review

Mobile phones offer multiple opportunities to address the barriers to accessing digital services in constrained environments. Now more than 97% of the world's population has come under mobile network coverage, with 5.2 billion unique mobile subscribers and 8 billion total subscribers [60, 61]. This provides a critical infrastructure to reach those people who have remained dis-connected till now. However, the major challenges in enabling state-of-the-art digital services are low-literacy, unaffordability, and limited or lack of internet connectivity. Smartphones have started to penetrate in poor settings, but still, it is the feature phone that most people own [62]. Technologies that are available on feature phones have been therefore proved more feasible and relevant, e.g., Interactive Voice Response and SMS. There are diverse areas of applications where services for feature phones have been designed. In this chapter, we will discuss the related HCI4D, ICTD, and mHealth research that influence this dissertation work with a focus on CHWs and the existing gaps.

3.1 Emergence of Voice Applications

Unlike the increasing dominance of the Web in developed settings, rural and poor settings still accrue benefits from traditional modes of communication - radio, TVs, and print to obtain global information. Recognizing that oral communication has an intuitive appeal to low-literate people, researchers have investigated various voice-based services. Initial services focused on improving access to static information sources by allowing users to retrieve desired information by giving voice commands or touchtone input [63, 64]. Subsequent services enabled users to also produce and share information in the form of voice forums. In this line of work, Avaaj Otalo was a seminal work that contributed to understanding the applicability and use of online communities for rural populations [17]. The

study proposed an interactive, asynchronous voice forum for farmers in rural India. The field deployment found the question and answer service as the most used feature wherein the farmers frequently posted and listened to others' questions on a range of agriculture topics. The simple design of calling a toll-free number and recording and listening to others' voice messages received wide acceptance, letting even the non-literate users participate in informative dialogues with peers and experts.

The later works extended to cover other important areas of information needs such as civic engagement [18, 65, 66], health [16, 67, 68], employment [69], education [70], and social network [21].

However, despite the demonstrated effectiveness of IVR systems, no work addressed the training and education needs of non-qualified workers such as CHWs. We will discuss in detail the state of prior work on education in the next sub-section.

3.2 Mobile Technologies in Educational Contexts

As computers ventured into developing countries, there was widespread enthusiasm to revolutionize education in low-resource settings. Many ambitious, techno-centric initiatives were laid to equip rural schools with low-cost computers, e.g., One Laptop per Child [71, 72, 73], Hole in the Wall [74], ClassmatePC [75], etc. However, the projects did not attain the expected outcomes and faced criticism for not integrating with the existing infrastructures well [76].

Mobile phones offer the convenience of expanding learning opportunities to more informal forums and a wide range of learners. Several literacy interventions have been designed using mobile devices. Kam et al. performed multiple studies designing game-based applications for language learning of rural children [77, 78]. Madaio et al. studied the use of an IVR literacy system for children by engaging parents [79, 79]. Several other studies have focused on using e-readers, tablets, and smartphones in the classroom and after-school environments [80, 81, 82] and how teachers perspective should be considered in designing

educational technologies [83, 84]. However, despite the fact that feature phones are still the most preferred choice for learning in low-resource settings [85], and demonstrated success of IVR systems for information exchange, there are few investigations in educational contexts. Moreover, educational technologies in low-resource communities have primarily concentrated on students. Adult learners, particularly para-professionals like CHWs who have low-education backgrounds and need in-service learning opportunities have remained under-studied.

3.3 Mobile Technologies for and around CHWs

The ubiquity of mobile devices is increasingly being recognized as a scalable way to improve healthcare functions and health access disparities [86]. Given that CHWs play a key role in frontline healthcare and often have to work in fields with minimum supervision, mobile-based tools hold a great scope to assist CHWs in a range of services [87, 88]. We discuss this and the related mHealth projects by categorizing the prior work in five categories as follows.

3.3.1 Data Collection

Collecting data is one of the most frequent activities that CHWs perform. There are many forms of data collection such as conducting household surveys, routine reporting to clinics, and supervisory reports. Typically, the data is first collected on paper-forms and then transferred into a computer database. This process is time-consuming and prone to errors at the steps of storage and aggregation [89]. To overcome these, a variety of mobile interfaces have been explored. Among the early works on digitization, PDA-based systems became popular for survey management [89]. These applications provided benefits in implementing branching logic and reducing transcription errors. However, these were still mainly proprietary and not flexible for adapting to different requirements [90]. Parikh et al. addressed the limitations by offering a first programmable system, CAM, that used camera

phones and visual codes for facilitating users in data collection in offline and online modes [90]. As the mobile devices advanced in computing capability, this design space was expanded by Hartung et al., who proposed Open Data Kit (ODK), an extensible, open-source suite of tools designed to build information services for developing regions [91]. Leading into a series of academic evaluations on scanning [92], data entry, and sensing [93] and real-world deployments [91] and commercial products [94]. Commcare [95] was another popular platform for Java-enabled feature phones for data collection that has been used a number of studies [96, 97, 98].

Digitization has also been applied to improve supply chains. Maintaining good supply chains has been a core challenging area for the health systems in LMICs. The use of inexpensive SMSs in data collection and reporting has been found to be effective. Perrier et al. proposed a system for Cold Chain Information System (CCIS) for monitoring vaccine stocks and status in Laos [99]. Another study, SMS for Life, used text messages to track stocks of anti-malarial drugs in Kenya [100]. Multiple projects in African regions have been actively using SMS as a component in managing supplies, e.g., Tanzania's Integrated Logistic System (ILS), Kenya's Mission for Essential Drugs, and Supplies (MEDS), Benin's Cola Life, etc. [101], and RapidSMS, a platform providing comprehensive services for data collection, and streamlining workflows [102].

Together these and recent other studies highlight digitization of data collection to be a challenging task. Going completely paperless is difficult and sometimes not relevant. Factors - workplace practice change, lack of comfort with digital devices, low education levels, and the complexities of contexts in which data collection activities are performed need close attention [103, 104].

3.3.2 Adherence to Clinical Guidelines

Studies have shown that job aids and decision support to health workers improve their performance. Specifically, they help improve adherence to clinical guidelines, which in turn

has a direct impact on reducing mortalities. Integrated Management of Childhood Illness (IMCI), a child survival strategy, has shown a significant reduction in several countries [105, 106]. However, clinical guidelines are commonly not fully followed [107, 108].

Mobile applications can guide health workers through complex decision-support protocols and clinical algorithms by presenting questions systematically. The study in Tanzania that used an e-IMCI program over PDA found significant improvement in clinicians' adherence to protocols compared to the traditional methods [109].

Further, mobile-based assistance is also considered as a cost-effective strategy to complement existing methods to address non-adherence - in-service training, auditing, and quality improvement schemes [110]. Zurovac et al. assessed the effect of the text-message reminder system on the adherence of CHWs to treatment guidelines for outpatient pediatric malaria in Kenya [110]. The randomized control trial found a substantial effect on the completion of dispensing and counseling tasks. To investigate the drivers of the change, their follow-up study analyzed perceptions of the health workers [111]. The results suggested active delivery of up-to-date information in an on-the-job setting as an important factor influencing the practice.

3.3.3 Communication and Supervision

Supervision has been reported as one of the most neglected and under-resourced components in community health programs [112]. The key causes include lack of recognition of CHWs' role, lack of tools, transport difficulty, and overburdened administrative duties of supervisors [112].

Researchers have employed mobile technology to improve the communication workflow and monitoring of duties. Derenzi et al. proposed an automated SMS-based reminder system that reminded CHWs daily for the visits and escalated to supervisors in case of overdue [113]. The randomized control trials showed the effect of the system in reducing the overdue visits by 85%. Till this time, the majority of the SMS-based information systems

were one-way in communication, with no feedback mechanisms for CHWs [110, 111]. The later studies attempted to close the feedback loop by enabling CHWs self-track their performance [114, 115] using IVR and mobile-web application. The intervention noticed a 21% improvement in the visits.

3.3.4 Health Promotion

Even where healthcare services are adequately and freely available, the persistence of low utilization is a key impediment to make progress towards target SDG goals. Lack of awareness delays care-seeking and increases the risk of deaths.

Health messaging has been identified as an effective strategy to directly educate families. Numerous projects have used one-way or two-way text messaging to provide health information [116, 117, 118]. One of the largest mHealth projects in maternal health is MomConnect, a flagship program of the South African National Department of Health [119]. The project has reached over 1.5 million pregnant women. The program registers pregnancies into the central system and provides a service that sends stage-based health messages on pregnancy, postpartum, and infant care. Similar to this, other examples are Kilkari [120] and mMitra in India (IVR-based calling system) [121], and Aponjon in Bangladesh (SMS-based) [122].

CHWs are a key player in health promotion in India and have participation in a variety of community health programs. Increasing we are seeing HCI researchers attempting to unpack the potential and vital role of CHWs. Ismail et al. shed light on the situated knowledge of CHWs in their ability to understand partial knowledges of their community members and the barriers to healthcare [123]. To assist CHWs in their dialogue with families on health behaviors, mobile videos have emerged to be a prominent technique. Ramachandran et al. investigated mobile videos as a means of persuasion and motivation [124]. CHWs were provided short instructional health videos on their phones for augmenting their home visits. The study found a positive impact on the motivation of CHWs and conversation with

the families. The study by Fiore-Silfvast et al. further confirmed the usefulness of such videos in the workflow of CHWs by understanding their perspective on technology adoption [125]. It discussed in detail the complexity of nurse midwives' experiences in their working environment, pedagogical aspects of video watching, and issues of authority and patient trust.

While most of the prior works around mobile videos provided expert-made videos to CHWs, Molapo et al. focused on empowering health professionals in rural areas to create and distribute their content [126]. The authors proposed a PC-based software application that allowed to creation of non-textual digital content. In their later work, the authors conducted a longitudinal study to understand consumption patterns of videos, attrition causes, and the role of CHW engagement on long-term usage [127]. Kumar et al. studied the integration of the model community-led video (CVE) education being used in the "Projecting health" initiative within the communities practices and existing social-cultural configurations [128]. Within the context of this project, in their other related studies, the authors investigate trade-offs associated with localization approaches of video-content production [129] and the practices of mobile media consumption and sharing [130].

Mobile Kunji, a notable mHealth project in India, innovatively uses flashcards to design an audio-visual aid accessible over feature phones [131]. It is a toolkit covering information on 11 life-saving maternal and child health behaviors. The interface has two components: a deck of 40 cards with illustrations and unique codes imprinted on each card. During home visits, the CHWs augment her dialogue with women by following the cards and dialing the given codes to play out pre-recorded audio messages spoken by a doctor.

3.3.5 Training

WHO suggests that to enable CHWs function successfully, they must receive regular training and supervision [27]. However, as highlighted by several studies conducted across multiple geographic contexts, the provision of training is currently inadequate, and the

most neglected phase of training is ongoing training [37, 132, 133]. Ongoing training includes ‘in-service’ or ‘refresher’ training, defined as “follow on training received after a period of initial training”. In-service training has varied in frequency, method, and quality. For example, a study assessing ongoing training of CHWs in Uganda reports that despite the guidelines of USAID Health Care Improvement Project of providing refresher training at least once every six-month [134], yet in many areas, CHWs did not receive for five years [135]. Similar kinds of delays have been observed in India [57].

Alternative training methods supported by technology can be good alternatives to understand the gaps and support existing training deficiencies. However, there is a paucity of research in this direction. The works discussed so far, while aim towards improving the functions and performance of CHWs, still do not address the problem of ongoing training directly. A recent study provides an evidence mapping for the period between 2000 and 2018 on the use of mobile technologies to train community health workers (CHWs) in LMICs across nine areas of global healthcare [136]. Even though the study interpreted the definition of training to be broad, also including workplace-based learning activities such as decision-support, provider-provider communication, collaboration, provider work planning and scheduling, and data collection and reporting, some of which we discussed in the above subsections, the resultant evidence-map showed clear gaps in training. 53% of the areas covered by the evidence map only have a single or no study at all.

When we started our research in 2016, there was no study in the academic setting targeting the training and education of CHWs. In 2017, two studies came, one by Javaid et al. that examined the effect of animated video-based learning on the knowledge levels of CHWs in Pakistan [137] and another by Bhowmick et al. that designed and evaluated a virtual-reality interface for training in India [138]. However, both these were limited to studying the usability of the interface on a small set of users.

The main work in this space has been non-academic, the mHealth projects run by non-profit and government organizations. These applications commonly address the access

to information and provision of supplementary training (e.g., refresher training courses). For example, the Millennium Village Project in Uganda facilitates continuing education to CHWs by making training modules available in mobile file formats [139]. CHWs can reinforce their learning by reading the modules, taking tests, and receiving immediate feedback. TulaSalud in Guatemala provides distance education through digital learning material and teleconferencing to community auxiliary nurses [140]. Mobile Academy in India aims to upgrade CHWs' knowledge on healthy life-saving behaviors through an IVR-based audio training course [141], and CapacityPlus project deliver refresher training in spaced education format in Senegal through an IVR-based mLearning system [142].

Overall the role of mobile technology in the training of CHWs in LMICs remains poorly understood. Despite the fundamental role CHWs play in addressing healthcare gaps in LMICs and the urgent calls for improving the weakness in training and supervision of CHWs, HCI research has lagged. This dissertation addresses this lacuna by proposing a mobile-based training and learning platform for CHWs in India and investigating the training needs through real-world deployments.

Chapter 4

Proposing and Field Testing *Sangoshthi* Training Platform



Figure 4.1: Photograph of a live training session, the doctor is sitting in the middle with the host and two staff members.



Figure 4.2: A monthly meeting of ASHAs in a Primary Health Center in Haryana, India

In this chapter we introduce *Sangoshthi*, a low-cost mobile-based training platform for ASHAs in India. We present the results of a month-long training intervention provided to 20 ASHAs using our platform ¹. Total 12 sessions were conducted on the ten topics of Home-Based Postnatal care. Figure 4.1 is a photograph of one of the training session. All the photographs presented in the thesis were taken with the consent of the participants with permission to publish in the thesis.

Through this study, we make three contribution. First, for the first time, we use and demonstrate the effectiveness of IVR in facilitating live interaction sessions for training and learning purpose in a constrained setting. So far, prior studies in similar environments have used IVR in supporting asynchronous modes of communication e.g. voice forums [17, 18] except our own previous study Kazakos et al. where we proposed the synchronous

¹Deepika Yadav, Pushendra Singh, Kyle Montague, Vijay Kumar, Deepak Sood, Madeline Balaam, Drishti Sharma, Mona Duggal, Tom Bartindale, Delvin Varghese, Patrick Olivier. 2017. *Sangoshthi: Empowering Community Health Workers through Peer Learning in Rural India*. In *Proceedings of the 26th International Conference on World Wide Web, WWW*, 499–508.

use of IVR for community-led chat shows. Second, we show that low-end, contextualized technological solutions can produce positive learning outcomes in resource-constrained settings. And finally, we inform about the perceptions of the trainers and ASHAs on the use of such mobile-training alternatives.

Since the underlying communication structure of the system is derived from audio conference call, we named our platform *Sangoshthi*, a Hindi word that means a conference meeting.

4.1 Need Assessment

After identifying the research gap of the lack of tools for supporting the training and learning of CHWs, we set out to understand the requirements. We aimed to understand the settings in which ASHAs work, ASHAs' views on existing modes of training and associated challenges, and the scope for technology-based solutions. To do this, we collaborated with a non-profit organization - SWACH, in the Haryana state of North India [143]. SWACH has been working in the area of maternal and child health since 1988 and has led a range of projects relating to improving the quality of childbirth and newborn care practices in primary health centers, capacity building of ASHAs, assisting high-risk pregnancy cases and birth defects, and raising awareness on maternal health. SWACH works to strengthen the implementation of government programs by working hand in hand with the government functionaries at different levels ranging from ASHAs, ANMs to district hospital level doctors. The population covered by SWACH is 1.5 million (approximately 100 villages) spanning across two districts - Ambala and Yamuna Nagar, and the total number of ASHAs associated are 1650. The executive director of SWACH, also the founding member, is a pediatrician doctor with 54 years of extensive experience in medical practice, teaching, training, and consulting, including serving WHO southeast Asia Region as a director.

Our discussions with the SWACH team identified important factors to consider for a technology-based design. Two key components in conducting face-to-face training are

the creation of a standard content and its delivery to the ASHAs timely and uniformly. Traditionally, this is achieved by calling batches of ASHAs at their nearest health centers (as shown in the figure '4.2). Three prominent factors of consideration here are cost, time, and transportation. The cost at the organizers' end to arrange for the training space, trainers fees, incentives for ASHAs for attending sessions, and other logistics. Time management for ASHAs who, in addition to their duties, are overloaded with household tasks. Since a single day of a training session, on average, spans over 6-7 hours, the frequency needs to be planned carefully. Further, commuting to the training center is not a trivial task for some ASHAs who live in areas having infrequent and inconvenient mediums of public transport. Further, the training quality gets hampered by the cascade model of the training that is 'train the trainers'. One group trains another group, who then go on to train others to train ASHAs ultimately. While this approach is necessary to manage the shortage of human resources, it leads to considerable loss of quality in training.

Further, we conducted a focus group with 15 ASHAs to collect ASHAs views on the training, monthly meetings, and existing training materials. We found that although the ASHAs liked the training material, they considered that better understanding comes from the discussion of these materials. They also reported that the allocated time for meetings is not sufficient to address all their queries individually. As a result, 'peer ASHAs' become the first point of contact for discussion. These peer discussions are sometimes face-to-face, when ASHAs encounter one another in the field, but are also mediated through phone calls. Phone call communication among ASHAs happens actively, also because they are provided official SIM cards with a monthly free recharge of 100 INR talk-time.

4.2 Design Rationale

Based on our need assessment, we could identify three requirements to design a technology-based solution. First, a distance learning approach to avoid travel overhead for ASHAs and save overall training cost. Second, use mobile phones as the primary medium as all ASHAs

have access to atleast basic phones and are provided SIM cards for official communication. And third is to leverage peer-to-peer learning, which is the primary source of learning for ASHAs in their routine. These three factors have been also well-recognized by the prior studies that used mobile phones for CHWs in similar contexts, for instance, mobile videos for client counselling [144], mobile-based data collection [96, 109], and mobile applications for improving the workflows [112, 114].

Combining these would mean designing a peer-based mobile-learning system. The key constraints to be considered here are the low-literacy of ASHAs and the type of phones owned by ASHAs. The education levels of ASHAs are low, typically an ASHA has schooling up to 10th standard, but this can go as low as being illiterate. So, the minimum standard that was appropriate to assume is number-literacy. The phones owned by ASHAs is basic, which mainly supports calling and messaging. Thus, suggesting employing technologies that are universally available, e.g., IVR and SMS.

As discussed in the previous chapter, prior work on IVR and SMSs in applications for constrained environments is rich. IVR allows for the delivery of richer information than SMS and support peer-to-peer network as demonstrated by voice forum applications - Avaaj Otalo [17], CGNETSwarra [18], etc. So far, IVR had been used for supporting asynchronous communication whereby users could access voice information sources and interact with other users through voice message boards in an offline manner. Adopting this design for a teaching and learning environment would limit supporting a passive form of learning. However, we instead wanted to incorporate elements of active learning by allowing live interaction between the trainers and learners in a fashion similar to classes where instructors and students engage in discussion.

This particular idea of using IVR for synchronous communication originated from our prior study in which we explored the use of telephony to facilitate the creation of community radio chat shows for discussion on health topics in rural India [145]. The system customizes the usual conference call and uniquely integrates it with a smartphone applica-

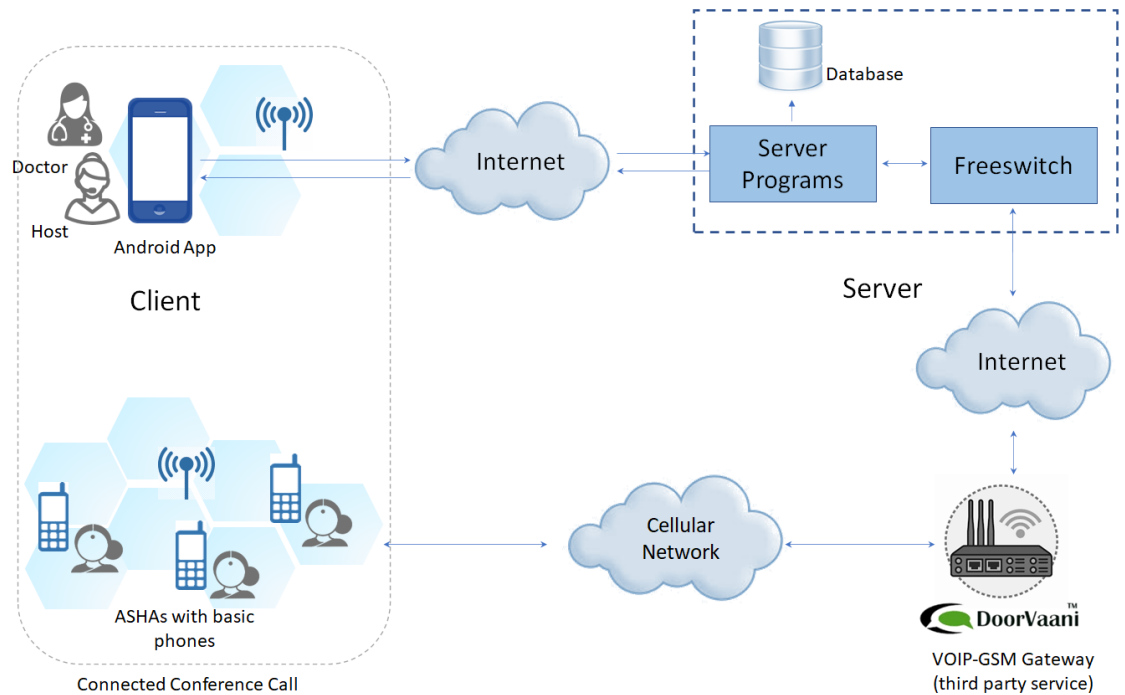


Figure 4.3: System Architecture

tion to provide a low-end mobile interface for creating and hosting chat shows. Like a radio chat program, there can be three kinds of participants - a show host, a show guest, and listeners. Through the smartphone app, the show host connects with the listeners, broadcasts audio content and moderates discussion between the show guest and the listeners.

Feature-wise, the system supported two of our essential needs. First, the system was affordable, easy to set up, did not impose the need to procure any additional digital device. Running the system required a single smartphone, a computer, an internet connection on the trainer's side, and access to ordinary phones (either landline or basic phone) on the ASHAs' side. We built upon this platform by using it and then enhancing it further for the training and learning purpose.

4.3 Architecture

Sangoshthi is based on a client-server architecture (see Figure 5.2) and has two different types of clients: trainer host and participant ASHAs. The trainer host client is an android

application that runs on an android-based smartphone or tablet and requires Internet connectivity. The aim of this application is to manage the training sessions and ASHAs' participation in the sessions. The trainer host client allows the host to: (i) create sessions and register ASHAs, (ii) start an online training session; (iii) broadcast and control media play in an ongoing session; (iv) monitor the duration of a training session; (v) view the number of connected ASHAs and ASHAs who want to express their opinion or have a query for the trainer expert; and (vi) selectively mute and unmute ASHAs to moderate group discussion.

The back-end of the platform consists of a server that is hosted in our institute and accepts requests from the android app client over the public internet (refer to figure 5.2). The back-end is built on top of a number of open source technologies, including FreeSWITCH, MongoDB running on a Linux (Ubuntu) server. The server code written using Python language communicates with the android client app over sockets using ZeroMQ protocol. The telephony part of the system is implemented through Freeswitch, which is an open-source software-defined telecom stack [146]. Freeswitch communicates with the rest of the server programs through its event socket interface. The incoming request packets from the android app client, e.g., call participants, mute a participant, are passed to a controller program, which in turn calls appropriate callback functions of the conference module of Freeswitch using the event socket library. We use the VOIP-GSM gateway service from a third party to connect participant ASHAs in session calls over the cellular network (Doorvaani.com). The backward communication flows from the conference events (e.g., DTMF inputs, call drop, call reconnection) captured by the Freeswitch, listened by the conference event listener thread, and passed to the android app client. The server programs simultaneously log relevant events in the database and store session recordings.

To handle the challenge of low-network bandwidth, our system uses separate channels for the transfer of voice and non-voice data packets. Instead of using VOIP (Voice over Internet Protocol) through a SIP account configured in the android app client, we used the GSM channel for voice transfer. The non-voice data packets (app requests to the server),

on the other hand, transferred over the internet.

The workflow of the system for a training session is as follows. To host a session with the learners, the host, through the app, first register the phone numbers of the interested ASHAs, creates a session id for a specific day and time, and then broadcasts a trailer to inform the registered ASHAs for the upcoming session. The trailer here is a phone call. After that, on the scheduled day and time of the created session, when the host sends a start session request, the server connects all the ASHAs and the host in a conference call over the cellular network. In this conference call, by default, all the ASHAs are made to enter in mute mode and can only hear the host's voice. The host, after the delivery of the content, invites ASHAs to interact with the expert by expressing their opinion. To be able to speak, an ASHA has to press "1" in her phone, which generates a DTMF event. On the occurrence of these DTMF events, the server captures the phone numbers of the ASHAs who pressed "1" and then sends them to the android app in the order of first come first serve. The android app then displays the last three digits of these phone numbers using which the host can select ASHAs and send unmute requests to the server one by one. This way, the session allows a structured interactive session avoiding overlaps of voices happening in usual phone-based conference calls.

4.4 Research Questions

Our goal was to test the feasibility and potential of the proposed system by providing a mobile training intervention to ASHAs in rural India. We guided our study with three research questions.

- **RQ1** Is the proposed system feasible for conducting training sessions in rural India?
- **RQ2** What is the effectiveness of the Sangoshthi training in terms of learning outcomes for ASHAs?
- **RQ3** Is the system usable and useful for ASHAs and trainers?

4.5 Field Deployment

We planned to conduct a control field study to test our research questions. This involved working closely with the NGO for designing the interfaces, conducting workshops, planning, and deploying the system. Throughout the study period, I made frequent visits to the NGO, which is in Chandigarh, 244km away from our institute, and also stayed there for multiple weeks.

4.5.1 Training Topic

For the training topic, we decided to choose Home-Based Postnatal Care (HBPNC) that aligns with the official training curriculum of ASHAs and has been identified as one of the most critical areas for improving the skills of ASHAs. Under HBPNC, ten topics were selected and prepared namely (a) exclusive breastfeeding; (b) play & communication with newborn; (c) excessive crying in newborn; (d) danger signs in newborn; (e) Danger Signs in mother; (f) hands hygiene; (g) temperature control in newborn; (h) mother-child protection card; (i) depression in mother after childbirth; (j) health, happiness & contentment in mother.

The content of the topics was prepared by the head of SWACH, a pediatrician doctor, taking the official training material and WHO guidelines as the guiding reference. The distinguishing feature of the prepared content was its focus on important elements of day-to-day care which are often missed in the ASHA training.

4.5.2 Participants

With the help of SWACH, we selected 40 ASHAs from two districts of Haryana state, India. All these ASHAs belonged to the pool already associated with SWACH for at least a year under a different project and had regular conversations over phone calls with the employees. All ASHAs were tenth-grade pass. Eight of them were graduates, and one was



Figure 4.4: Android App Interface: first screen displays three options - create session, send trailer call, and start session; second screen is a snapshot of a live session with three participants.

pursuing her under-graduation course. Age ranged from 26 to 50 years, with the median age as 36 years. Eleven of the ASHAs owned smartphones, and 29 had low-end feature phones. Two SWACH female employees, selected as the training hosts, had the experience of over two years. The SWACH head played the part of the trainer expert.

We randomly allocated the selected ASHAs into two groups: the treatment group and the control group. The treatment group received the training intervention on top of their routine activities, while the control group did not. The training intervention continued for 22 days with three sessions per week. The session time was fixed to 2 pm based on the preference of the majority ASHAs. All the sessions were hosted from SWACH office. The expert and the hosts chose to be present together in-person. In addition, a dummy listener was also recruited from the SWACH staff to get help in identifying network problems during the live sessions.

4.5.3 Design Process

Android App Design

We conducted a series of workshops with SWACH team for eight weeks to discuss the current features of the app and to build on these to create an appropriate platform for the delivery of training to a community of ASHAs. Feedback on the interface of the android app was taken at each step to make it easily usable by the two hosts. Figure 4.4 illustrates the Main Menu screen (left) and a ‘live session’ screen (right) of the *Sangoshthi* android app. The three rectangle boxes at the bottom of the ‘live session’ screen indicate callers who have pressed “1” to express an opinion. The colors indicate three statuses associated with the listeners: white for waiting, pink for currently speaking and grey for already spoken. Timers detail the length of the ‘session’, the wait time for any listener waiting to speak, and the air time for a currently unmuted listener.

The SWACH office was chosen for hosting the sessions. Multiple hands-on sessions were organized for the hosts at this office to become comfortable with the app usage. The objective was to make SWACH capable of hosting the sessions independently without assistance from the authors through their physical presence. Internet slow speed emerged to be the main problem. There were two sources for the internet - the office WiFi and a reliance internet dongle. However, both did not provide adequate bandwidth. This sometimes resulted in slowing the processing of the app events, which frustrated the hosts as they would impatiently press app buttons multiple times without waiting for the effect of the previous clicks, leading to erroneous actions at the server-side, e.g., multiple broadcast of trailers, multiple initiations of session calls, abrupt session end etc. To safeguard from such situations, the app was made robust by adding more warning pop-ups, wait-time progress bars, and making the buttons with critical operations unaffected for multiple clicks.

Training Session Structure

The structure of a training session was designed to support two key components of the training - delivery of the training material and the interaction between the expert and the ASHAs. Hence, the timeline of the session was designed to contain two segments: an initial shorter segment for delivering the topic information succinctly; and a second longer segment to allow interaction between the listeners and the expert. The longer segment could be divided into multiple rounds of interactions. We limited the number of speaking turns of a participant to one in a single round to give everyone a fair chance of speaking. Further, after the first training session, the first round in the subsequent sessions would be dedicated to clarify or answer any remaining questions of the previous session since our idea was to encourage ASHAs to exercise the knowledge gained in the fields. This interaction round would help to collect ASHAs' experiences.

Our previous study [145], highlighted the role of hosting skills in the success of a session. To make the task of hosting easy for the two hosts who had no prior experience of hosting a talk session, *Sangoshthi* incorporates a feature that allows the presenter to use pre-recorded materials. In our deployment, this feature enabled the SWACH team to prepare all the topics in advance. A total of six weeks were dedicated to the preparation of the content. For each topic, the content was prepared by following the best practices of Home-Based Post-Natal Care and converted into a script of a conversation between two individuals: the host and the guest. The structure of this content was designed in the form of Q&A, recorded by two actors, who were the employees of SWACH after series of rehearsals. In all the sessions, the hosts, after greeting the listeners, directly played the content recording and thus focused on the moderation and control of the session events.

4.5.4 Data Collection and Analysis

We adopted mixed-method approach of data analysis in this study, both quantitative and qualitative. To assess the effect of the intervention on the learning gains of the ASHAs,

we conducted pre- and post-intervention knowledge tests. We used system generated logs to develop descriptive statistics about the training sessions and participation of ASHAs. These logs included call answer/drop timestamps, mute/unmute action timestamps, DTMF events, and DTMF event timestamps, etc. We also used audio recordings of the training sessions to crosscheck the statistics. Finally, we conducted semi-structured interviews after the intervention to collect the experience and feedback of the trainers and ASHAs. This included 20 exit interviews of the ASHAs in the treatment group and three face-to-face interviews of the doctor and the two hosts.

The analysis methodology is as follows. The questionnaire used for testing the knowledge of the ASHAs was developed by the expert. There were 20 open-ended questions on the training topics focusing on why and how forms. The sample questions are as follows, “*How can a mother determine that her newborn has taken enough breast milk?*”, “*Why is it important to keep newborn baby warm?*”. The answers of ASHAs were checked against the set of correct information items. For example, the correct answer of the question “*How can a mother determine that her newborn has taken enough breast milk?*” contained items as “*The newborn may fall asleep to indicate that it has had enough, the newborn stops actively suckling or stops suckling completely, the newborn may unclench its fists, arch its back, or smile or yawn, the mother will feel that her breasts have become soft.*” So, depending on the number of items present in the respondent’s answer, the score is computed (e.g. presence of 2 out of 4 items gets 50% of the maximum score).

The mode of interviews was chosen to phone call communication. This was considered the most practical approach given that the residences of the ASHAs were distributed over an area of 100 km. Following the standard guidelines of administering the questionnaire over the telephone [32], we prepared a script and a protocol to guide the interviewers. To test the ASHA understanding of the questionnaire, three pilot interviews were conducted with ASHAs unknown to the study. This resulted in improving the questions’ ordering and simplifying the questions’ language with the incorporation of more local terms. For the

final interviews, the ASHAs were briefed about the interviews at least one day before, and explicit consent was solicited for the recording of the calls. The first author and a research assistant conducted the interviews in the native language - Hindi. Since the native language of all the authors and the ASHAs was the same, we decided to analyze the Hindi transcriptions to better understand the local terms and associated nuances. However, the codes and analysis language was English. Specific quotes present in the thesis and the corresponding research papers were translated by the first author and verified by the teammates.

ASHAs responses were evaluated against an answer key developed by the expert. Each answer in the key consisted of multiple expected responses ranging from 2 to 9 depending on the question type. The maximum score for a question was set to 100 with $100/n$ score for each corresponding information item. The total score of all the 20 questions thus was 2000. For the questions with more than five expected responses, the evaluation was performed on the presence of any five. The two coders evaluated the responses independently. After the first round of independent evaluation, the results from the two authors were compiled and compared to produce final scores. The two evaluators substantially agreed with each other (Cohen's Kappa: mean kappa = 0.71, standard deviation = 0.11) with some conflicts which were resolved through mutual discussion.

The exit interviews with the trainers and the ASHAs was conducted and analyzed by the first author only. The themes were generated both inductively and deductively by taking feedback of the other authors at different stages.

4.6 Findings

4.6.1 System Feasibility

We were able to complete all the sessions but observed some network related issues:

One of the main challenges while running the sessions was frequent call drops of the participant ASHAs. This was mainly caused by poor network coverage in the villages of the ASHAs. To deal with the issue, the dropped participants would be called back immediately

on the detection of their hang-up event in an ongoing conference call. A maximum of four redial attempts was made in case of no successful response. Despite call drops occurring during the deployment, we experienced only two incidences where call drops had a duration of more than five minutes.

On average, in a session of greater than 60 minutes, 19 call drops were experienced from 11 unique listeners (see Table 4.1). From the logged data, we found that, on average, a participant experienced one disconnection per session. One of the participants, in particular, showed a persistent problem of connectivity and experienced 30 call drops in 11 session calls. The data presented in the table is from 11 out of 12 sessions.

We also observed poor network coverage on a specific day. The session on the topic *danger signs in mothers* was postponed due to difficulty in connecting to all the participant ASHAs, as we could only attain 12 stable connections. Another problem observed in the initial five sessions was a sudden loss of the host’s voice in ongoing sessions. To resume back the sessions, the host had to restart them, which affected the flow of sessions. We were able to resolve this by changing the host device from a tablet to a smartphone. A minor bug related to the session end procedure also incurred the loss of logs in a session, which was later rectified.

Table 4.1: Call Drops Summary

Call Drops	Min	Median	Max
Call drops per session	5	19	32
Unique call drops per session (unique by participants)	4	11	17
Call drops per participant per session	0	1	9

Statistics computed on the data of 11 sessions

4.6.2 Learning Outcomes

To determine the effect of the intervention on the knowledge levels of the ASHAs, we applied statistical tests on the test scores of the ASHAs. Independent two-sample t-test was run to compare the mean test scores of the treatment and the control group, and paired t-test was used to test the significance of the difference between the mean post- and pre-intervention test scores within each group. The significance level used was 0.05.

Comparing the pre-intervention test scores, we found the two groups to be not similar ($t(37.9) = 3.8, p < .05$). The average percentage of the pre-intervention test scores for the treatment group was 34% ($M = 679.0, SD = 107.0$) and control group 28% ($M = 551.6, SD = 102.9$). While we did not investigate the potential confounding variables, two factors seem plausible here - small sample size (20) and lack of complete information on the selection procedure of the ASHAs that was performed by the NGO staff.

Computing the difference between the mean post- and pre-intervention test scores, we found both the groups to show statistically significant improvements. The mean test scores of the treatment group increased by 16% ($t(19) = 8.3, p < .05$) and that of control group increased by 5% ($t(19) = 3.1, p < .05$). Thus, we can say that the training intervention had positive effect in terms of learning gains. For the smaller, unexpected improvement in the control group, we suspect two factors. First, the ASHAs were exposed to the same questionnaire two times, before and after the intervention. The natural curiosity to find the answers might have led to learning. Second, there was a possibility of some level of spillover effect. Some of the ASHAs in the two groups shared their regions and reporting primary health centers, which might have resulted into the discussion of the training intervention. This was also confirmed by some of the ASHAs in the exit interviews. Finally, significant differences were found in the mean post-test scores of the two groups having 50% ($M = 991.4, SD = 187.7$) for the treatment groups and 33% ($M = 651.4, SD = 170.4$) for the control group ($t(37.6) = 5.9, p < .05$).

4.6.3 Interaction Component

From the total 12 sessions, the first 11 sessions covered the ten topics of the training (one case spanned over two sessions due to a network problem), and the last session collected the feedback of the ASHAs and any remaining queries. Table 4.3 summarizes the interaction logs of 11 sessions, leaving out the session which experienced the network problem. Interaction with the expert was a core component of the learning environment offered by

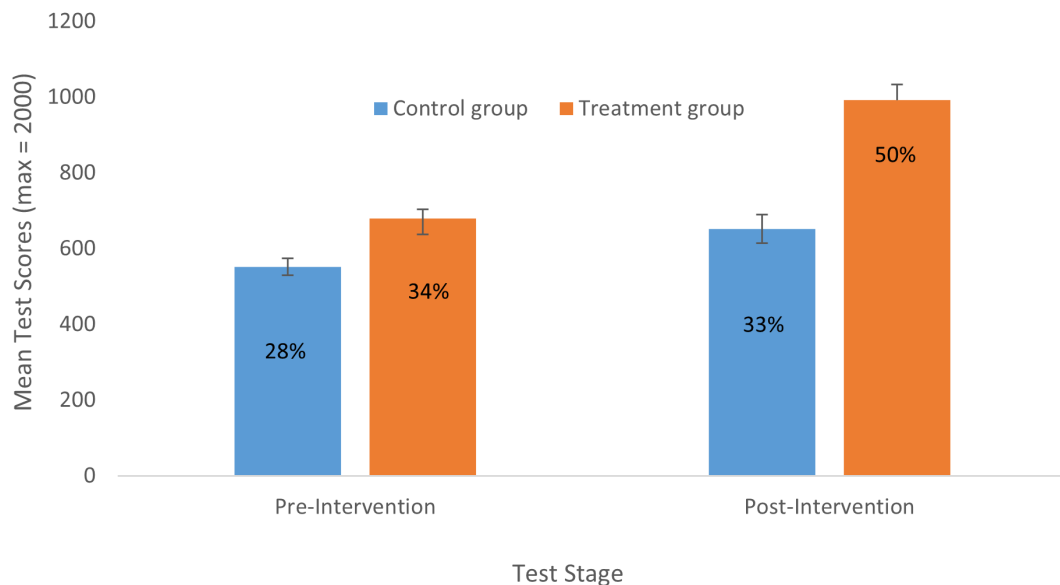


Figure 4.5: Graph showing the means and error bars in the test scores of the treatment and control groups measured before and after the intervention. The error bars represent standard errors.

the *Sangoshthi* platform. In a session (average duration: 1:08), 46 minutes were dedicated to the Q&A segments. On average, a session had 3 Q&A segments, 5 repeat speakers (listeners who expressed their opinion in more than one Q&A), and 12 unique speakers.

These speak statistics draw attention to the relationship between the interaction component and performance of ASHAs. Did the ASHAs who asked more questions learned more? From the literature, we know that classroom participation and discussion leads to higher-order learning [147, 148]. Thus, it is important to understand the role of participation in the learning environment provided through the *Sangoshthi* tool. To observe this in our data, we mapped the interaction count of the ASHAs with their test score improvements. However, as shown in the scatter plot 4.6, no clear linear relationship existed. The correlation value was low, 0.32. Further using the data, we attempted to apply a multiple linear regression model with three independent variables - attendance, pre-intervention test scores, and interaction count. The results were not significant, $F(3,16) = 1.98$, $p = 0.1576$.

Table 4.2: Training Sessions Summary

	Min	Median	Max
Session Duration (hh:mm:ss)	00:44:13	01:08:03	01:30:25
Content Delivery Duration (hh:mm:ss)	00:12:23	00:14:34	00:18:40
Session Q&A Duration (hh:mm:ss)	00:26:33	00:46:16	00:53:24
Interaction Count per session	10	20	22
Interaction Count per ASHA in 11 sessions	2	10	23
Interaction Count per ASHA per session	0	1	3
Repeat Speakers per session	1	5	7
Unique Speakers per session	9	12	18

Total 12 sessions were conducted for the 10 training topics. Table summarizes the interaction logs of 11 sessions leaving out one session which experienced network problem.

Table 4.3: Multiple Linear Regression Results

	Coefficients		
	Interaction Count	Pre-Intervention Test Scores	Attendance
Test Score Improvement	12.57	-0.26	77.70
p-value	0.08	0.49	0.13
Residual standard error	156.6		
R ²	0.27		

The coefficients for the three variables are given in the table 4.3. Therefore, from our data, we could not conclude any relationship between participation and performance.

However, from our exit interviews and sessions’ observation notes, we find two factors that might have a contribution. First, application of knowledge. At the end of each training session, the expert suggested applying the knowledge gained in the field visits. Second, self-directed learning attitude, where the ASHA makes extra efforts on her own. In our intervention, we observed the presence of these factors to some extent. Some ASHAs used to share their field visit experience using the information items taught in training. A few others mentioned activities such as note-taking, calling neighbors to attend the sessions, and initiating discussion with family members. In addition to these, call quality is also an essential factor as it can significantly impact the listener’s concentration. Our current analysis is limited in investigating these factors in detail due to the unavailability of sufficient data; however, we suggest considering these factors for future studies.

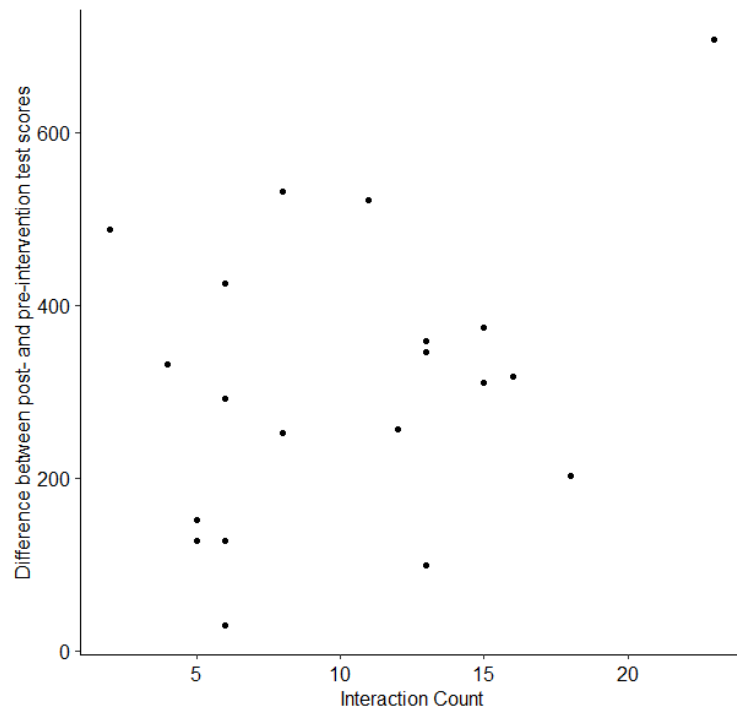


Figure 4.6: Scatter plot for the relationship between the interaction count and test score improvements, Pearson's $r = 0.32$

Peer-to-Peer learning

The prominent feature of *Sangoshthi* was its ability to foster peer learning. The act of listening and sharing was found to be fruitful by both the ASHAs and the two hosts. The following quote from an ASHA exemplifies the value of peer learning:

“The problems in my area are different from those of the others; by listening to others’ questions, we got the opportunity to develop knowledge on new issues in advance.”

Similarly, a host described her learning experience as:

“This was the first time we received an opportunity to connect to 20 ASHAs simultaneously and listen to their varying levels of issues and concerns. We were also able to deliver our messages to all in one go instead of repeating in separate one-to-one calls.”

The benefit of peer learning expanded to few community members. 11 ASHAs reported events of attending the shows with their family members or friends. Some ASHAs

even recorded show calls on their mobile phones and made notes, which they later shared with their friends and clients. An ASHA shared and discussed about the training with her supervisor also.

4.7 Usability

We attempt to understand the usability of the system on the following parameters:

4.7.1 System Usage

Contrary to our anticipation about the interaction difficulty ASHAs might face in remembering the last three digits of their phone numbers to recognize their chance of speaking, no ASHA was found to show any confusion. In all of our sessions, ASHAs promptly replied to their number identities. The protocol of pressing ‘1’ to indicate interest in speaking was found simple by the ASHAs.

Both the expert and the host appreciated this functionality for maintaining synchronicity in the communication. The expert highlighted this by saying:

“The biggest advantage of this system was that we were able to converse systematically without any overlaps.”

Further, with respect to the act of using touchtone inputs for participation, we noted two behaviors among ASHAs - eagerness to speak and pressing digits other than “1”. In every session and Q&A segment, we noted some ASHAs promptly pressed “1” to come ahead in the queue of interested speakers. These eager ASHAs would press “1” even before the host would finish speaking and invite them for interaction. Other than the set protocol of pressing “1”, our system logs showed frequent events of pressing incorrect digits. On average, the system log captured 22 such events per show out of 9 shows and 6 per ASHA for all 9 shows, leaving out an outlier who happened to do a total of 62 times who had a problem with her phone keypad. The moderation behaviors too evolved with sessions. We observed that the hosts, over a period of time, started to manage the speak priorities using

an alternative method instead of going by the first come, first serve basis. For instance, the hosts used to shift the priority order of a particular ASHA who was very prompt in pressing “1” and had already interacted for the maximum number of times in the interest of giving opportunities to other new listeners.

4.7.2 Training Session Experience

All ASHAs found the session duration of one hour to be appropriate and enjoyed the sessions’ proceedings. A supporting quote from an ASHA is *“The sessions used to be so engaging that we never realized the time.”* During the occasions when ongoing sessions had to be interrupted and restarted due to issues related to voice transfer or connectivity, most of the ASHAs demonstrated patience. Only a few shared about their inconvenience; an example quote of an ASHA is *“The problem I faced was the session call disconnection because of which one of the questions was left unanswered once.”*

The process of connecting 20 ASHAs to the session call, on average, took 2 minutes. During this time, as ASHAs would join the conference room one by one, the host had the responsibility to keep the already connected members engaged and inform them about the status of wait time. Events of session restart in case of network problem made this part of hosting quite frustrating at times. One of the hosts told us as follows:

“The most challenging part for us while initiating the conference was establishing a connection with all the ASHAs. In this phase, because of the longer connecting process, sometimes I would get upset by making repetitive announcements of - “keep patience while we connect to the rest of the ASHAs.” and worry about the session success.”

4.8 System Usefulness

In this section, we discuss the usefulness of *Sangoshthi* perceived by the stakeholders in the existing structure. We present three important factors that emerged to play an important role in understanding the future scope of *Sangoshthi*.

4.8.1 Cost

Estimation of the cost of the system use is necessary to understand its sustainability prospects. The main expense in our deployment was the call charges. We subscribed to the VOIP-GSM gateway service of the company Doorvaani to establish the session calls over the cellular network. Based on the airtime cost of an outgoing call of 1.68 INR (0.025 USD) per minute, the cost per minute for 22 parallel lines of the callers estimates to be 36.96 INR (0.54 USD), incurring the total cost for a session of 60 minutes duration to be as 2217.60 INR (32.61 USD). In our current set-up, the cost per ASHA computes to be 110.85 INR (1.63 USD), which could further be lowered if ASHAs agree to bear their call charges by connecting to the sessions through outgoing calls. In this case, the estimated cost would then be 60 INR (0.88 USD) per ASHA per hour based on the standard call charges of the regular service providers, which are much lower than that of Doorvaani. We solicited views of ASHAs on the system usefulness for this model, and the majority of them (17) agreed in support of their knowledge gains. On the other hand, both the overall expenditure and per ASHA expense in a traditional face-to-face training session are comparatively very high.

We adopted an incentive approach to promote ASHAs participation in this deployment. ASHAs in both the groups (treatment and control) were remunerated on the basis of 100 INR (1.5 USD) per interview (two interviews at pre and post-intervention stages). In addition, ASHAs in the treatment group were given 800 INR (11.8 USD) for participating in the shows. Therefore, each ASHA in the treatment group received 1000 INR (14.7 USD) and 200 INR (3 USD) in the control group.

4.8.2 Impact on ASHA Routine

Since, generally, the societies where ASHAs live follow a patriarchal regime, they are responsible for the majority of the household tasks and receive limited opportunities for leisure. We wanted to understand the impact of our training intervention on their routine. Most of the ASHAs managed to take out time easily. One favorable reason was the time

slot that was chosen according to their convenience. ASHAs acknowledged the cooperation from their family members during the training period. Following is the supporting quote from an ASHA, *“We used to finish our housework by that time and our kids used to take food on their own.”* For the training frequency, the majority suggested every 5-6 months with two sessions in a week.

4.8.3 System Benefit

SWACH expressed the benefit of the system on two parameters: usefulness of content production activity and the system’s ability to facilitate training sessions remotely. A quote from the expert: *“The system is very beneficial for us because it helped us build the capacity of ASHAs on home-based newborn care remotely which becomes difficult logistically in the face-to-face training sessions. It also helped us to standardize the content, which now can be used for reference purposes, overcoming the problem of information loss due to the cascade model of training.”*

Sangoshthi also marked its benefits in the community using ASHA as the main vehicle. 18 out of 20 ASHAs who shared their knowledge in the home visits observed the direct benefits to the families. For example, an ASHA shared her experience as:

“I had a delivery case in my area, in which the mother, on finding the birth of a girl child, cried a lot and went into depression. I soothed her patiently and explained in detail the value of breastfeeding, play and communication, and measures of reducing depression. Now she is happy and is also feeding her baby.”

ASHAs found a tremendous value of this training in their increased confidence to articulate the knowledge during home visits, an ASHA’s words are:

“Earlier, we were not able to explain the content to mothers satisfactorily, but now we explain better and are able to convince mothers. ”

Not only the knowledge empowered ASHAs in decision making but also helped them in earning respect in their society, as one ASHA mentioned:

“During my visits, while conversing with the mothers when I made references to the training session to support the information, they trust me more.”

4.9 Discussion

The three research questions around feasibility, efficacy (in terms of learning gains), and acceptability, received promising answers to some extent. Cost-wise, our platform showed a good alternative of providing refresher training than face to face, though we do not claim to challenge the quality. The system use was considered to be fit into the work and home setting by the ASHAs. The training providing agency - the NGO - found benefits in standardizing the training content and its delivery. Overall, all three users - ASHAs, training moderators, and the expert - liked *Sangoshthi* and reported a positive experience of using it. Further, considering the current time of COVID pandemic, our system has practical usefulness for supporting remote mechanisms of work in rural settings. The system can be used immediately without the need of any change in the features or functionalities. The training host and the experts too can participate remotely just like the ASHAs. The expert would have to join by receiving an incoming call with the only difference of having his/her channel be unmuted all the time.

The field deployment of *Sangoshthi* also provided us valuable experience in understanding the design requirements for a mobile platform to support the training of ASHAs in rural India. Literature suggests that providing synergy between all three types of interaction components viz, instructor-learner, learner-learner, and learner-content, is important for learning [148]. In the present version, *Sangoshthi*, predominantly supported instructor-learner interaction by having training content delivery and expert to ASHA interaction as the main components. There was limited support for the learner-learner and learner-content interaction. Our field trial highlighted the importance of the other two interaction forms, which evolved organically around our system. We found that some of the ASHAs attempted to meet their needs by recording the training content and using it in different field settings.

This included sharing the content with other ASHAs, family, and friends. Our later studies explored these components.

Our field trial also suggests to explore new strategies of moderation for improving participants' engagement. Given that we found ASHAs comfortable with touchtone-based interaction during the sessions, there can be a number of interesting ways of promoting active learning. For example, the use of clickers has been linked to better engagement and learning outcomes in the classroom settings [149]. Similar to this, we can design features to play on-the-fly touchtone-based quizzes. To improve participation, more control for content interaction can be given to the participants, e.g., an indication to pause/resume/rewind audios. There is also a good scope of incorporating functionalities to facilitate peer-to-peer learning pedagogies, e.g., group discussions, problem-solving, etc. Further, we also observed the need to enrich *Sangoshthi* platform with offline features such as incorporating feedback features for the participants, making training content and question and answers available for offline use, e.g., in the form of an IVR-accessible audio library.

This study, being the first pilot, helped us in addressing the limitations of specific features and enhance the system for our later studies. For example, as a result of our initial design work, we pre-registered the hosts' devices. This meant that it was not possible to host multiple parallel independent training sessions. To enhance the capabilities of training staff by enabling easy hosting and management, many additional features have been added which we discuss in the next chapters.

4.10 Summary

In this chapter, we described our evaluation of *Sangoshthi*, a novel training and learning platform for ASHAs working in resource-constrained settings. While there have been tools to support individual learning or to improve the efficiency of CHW, no platform was available to train a number of ASHAs together. The field deployment of *Sangoshthi* showed its potential to support existing training mechanisms. *Sangoshthi* provided a lively envi-

ronment of learning through structured interactions among CHWs and the expert. This interaction enriched the content created by the expert which can then be further used for training. Our system incorporates the four design principles [150], viz. locally relevant content, accessibility of content beyond the bound of literacy, affordability, and fitment into the community eco-system. Our deployment highlights the potential of combining feature phones, smartphones, and available internet and mobile networks for delivering content in constrained environments for critical applications.

Chapter 5

Investigating Opportunities for Peer-to-Peer Learning Model

Our first study proposed the platform *Sangoshthi* that enabled the trainers to provide remote online training served as a proof of concept for the feasibility and efficacy of mobile training platforms. The peer learning component emerged as an important feature of the system. ASHAs found value in listening to others' problems, experiences, and the expert advice on them. However, our exploration of peer learning was limited, and the learning model had a high dependency on experts who are short in numbers. The scarcity of skilled trainers is a bottleneck problem in providing quality training support to ASHAs. In this study, we aimed to investigate the peer-to-peer learning paradigm to understand alternative ways to reduce the burden on trainers and whether ASHAs can use technology to self-direct their learning ².

There is a rich literature showing significant pedagogical benefits of peer-learning approach when instructors availability is low [151, 152, 153, 154]. It has been found that through positive interdependence on one another, learners improve in their subject knowledge, problem-solving skills, critical thinking skills, and overall morale [152, 155, 156]. We increasingly see the incorporation of peer-to-peer learning strategies in online education, e.g., peer-to-peer assignment checking. Platforms like MOOCs provide a promising example of delivering authentic learning content on a scale and implementing self and group learning exercises. CSCW research has both investigated and proposed theories and interaction frameworks of peer learning in a variety of settings [157, 158, 159]. However, these largely remain oriented towards learning environments or work contexts where learners are technology users, e.g., internet users. There are limited investigations around the

²Deepika Yadav, Anushka Bhandari, and Pushpendra Singh. 2019. Leap: scaffolding collaborative learning of community health workers in India. In *Proceedings of the ACM on Human-Computer Interaction*, 3, CSCW, 1–27

use of technology to support the peer-to-peer learning of learners, especially workers in under-served communities. CHWs represent an important user group to study because of their distinctive characteristics.

We base our research around the question of how might technology-supported peer learning help CHWs in skill-building, and what kinds of peer-learning design should be adopted in their particular contexts, nature of work, and technology use. we aimed to understand whether the introduction of the collaborative learning intervention improves ASHAs' knowledge over their regular routine ³ and analyze what kind of interactions ASHAs engage in the absence of trainers. To this end, we enhanced our *Sangoshthi* platform to make it usable by ASHAs groups without any dependency on the trainers. We removed the explicit role of experts in training ASHAs and limited it to just the designing of the learning material. The android app interface was modified to act as a learning management system for ASHAs, where ASHAs can join peer-led learning courses and follow through the group learning exercises. We named this version of our system as *LEAP - Learning with Peers*.

In terms of platform accessibility and feasibility for ASHAs, *Sangoshthi* was relevant because smartphone penetration has increased amongst ASHAs in India. At the time of our previous study, the smartphone ownership was 28%, which increased to 33% by the time this study was conducted. Those ASHAs who have access to smartphones thus can act as group leaders for hosting and managing learning sessions. We framed two research questions for this study:

In particular, our research questions were:

- **RQ1** Can semi-structured, group-based learning exercises facilitated through *Sangoshthi* tool produce knowledge gains in ASHAs?
- **RQ2** What are the group learning characteristics of ASHAs?

³The routine of ASHAs involves monthly meetings with supervisors. The agenda of these meetings include incentive formalities, giving new directions, resolution of ASHAs issues, and general guidance. The meetings are supposed to have a component of training and knowledge building, but that does not happen regularly. So over time, through meetings and informal knowledge sharing, ASHAs get trained in their job while also going through formal training sessions intermittently.

We evaluated the effectiveness of the design by conducting a between-group study across four health centers (120 CHWs) in slum areas of Delhi, India. Through our qualitative and quantitative analysis, we found that, with minimal scaffolding, CHWs could participate and use the *LEAP* platform and achieved significant knowledge gains. Further, CHWs exhibited benefits of collaborative learning in terms of positive interdependence on each other and use of interpersonal skills. The informal peer-learning environment also encouraged CHWs to have discourses on deeper societal aspects, e.g., their role in society.

We contribute to CSCW, HCI4D, and education research by expanding its focus towards new groups in low resource settings who need innovative ways of collaborative tools for improving their skill sets.

5.1 Peer-to-Peer Learning in Prior Work on Constrained Environments

Prior work engaging with collaborative learning in under-served settings mainly exists as part of ICTD and HCI4D research that focused on employing technology for socio-economic development. While discussing these, we would reconnect with some of the works discussed earlier in the previous chapters.

Hole-in-the-Wall is an early work, started in 1999 that examined the effect of unsupervised collaborative learning among children in underprivileged communities of India by placing freely accessible computers [74]. The idea drew on the natural curiosity of children to learn while playing together with the computers left in the wild. The follow-on series of experiments in different settings observed that with access to information sources like the internet, children could navigate their own learning and arrive at meaningful constructs when they were guided by the right questions in the class [74, 160]. While working in this line of work of employing computers for education in rural India, Microsoft proposed new hardware - multi-mice desktop computer [161]. This solution was proposed to address the financial constraint of affording enough computers in rural schools and inequities in sharing devices. Their experiments showed that learning among children multiplied due to the

gain of more control in collaborative learning scenarios.

Further, several works have examined the digital game paradigm to promote education in a variety of settings. Lomas et al., who proposed a single-player typing game for a low-cost computing interface (TVC), demonstrated the effect of group interactions on verbal language learning [162]. The study informed design implications for participatory learning with video games in home environments. Kumar et al., in their study of game-based mobile learning in after-school environments among rural children in India, observed organic growth of peer-to-peer learning [163].

Digital green [164], a pioneering work addressed the problem of disseminating targeted agricultural information to farmers in India by leveraging a community-driven, participatory video-based education approach. This idea of community-led video education (CVE) was adopted in various later studies [128].

Later works employing mobile phones corroborated the positive effect of peer-to-peer learning through easy-to-access IVR-based voice forums [17, 21, 18]. For instance, listening to other farmers' problems and their experience was one of the most appreciated features of the Avaaj Otalo forum [17].

Given the lack of channels for discussion with experts, ASHAs rely on experience sharing for learning. Leveraging their peer network in collaborative learning practices holds great potential and was the central theme of this study.

5.2 Enhancing *Sangoshthi* to *LEAP*

We built *LEAP*—Learning with Peers—on top of the codebase of *Sangoshthi* by adding several new features. We enhanced the core platform to remove the explicit role of the expert and the host and allow an ASHA (a smartphone user) to act as facilitator and participant at the same time. The other ASHAs (feature phone users) join as peers. Given that the underlying communication paradigm is voice-based (conference call), we used group discussion as the central pedagogy. Providing good learning material, well-defined tasks,

and roles to play is an effective strategy to streamline the learning mechanisms [165, 151, 154]. Therefore, we designed the group learning session such that they have access to some learning material, preferably audio, and a task outline to follow. We now describe the learning material we used, tasks to facilitate collaborative learning, and system components and working.

5.2.1 Learning Material

We created learning material from the data of our previous study. There were two forms, 1) the ten audio recordings on Home Based Post Natal Care topic, created by the SWACH team. The duration of a single lesson was 15 minutes. 2.) the audio recordings of the question-answering interaction between the expert and the ASHAs. We extracted 175 conversations from the 12 sessions of the previous study. A single recording contained a question asked by an ASHA and the answer given by a doctor and had a duration of 2-3 minutes. All of the recordings were in the native language of ASHAs (Hindi).

5.2.2 Task Definition

To facilitate group learning, we provided semi-structuring by using the aforementioned learning material. We defined a task outline for every session that included listening to three content recordings and conducting group discussions after each recording. The first recording was a topic lesson, and the other two were Q&A recordings on that topic. The sequence and the duration estimates are shown in Figure 5.1. The first round of discussion was set to be of the longest duration, at least 10 minutes. In this round, the groups could share their understandings of the content, related experiences or clarify doubts. The second and the third rounds of discussion were of shorter duration, 5-7 minutes.

We imposed the sequence to a certain extent, i.e., in the app interface, the next audio recording could be accessed after the previous had been completely played. However, it was allowed to go back to any previously played audio or pause a recording in between

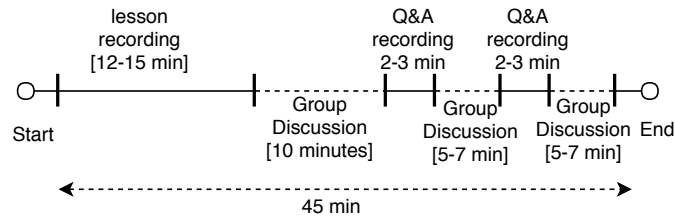


Figure 5.1: Task Outline for a Group Learning Session

to clarify doubts. Except for the recommended sequence, the groups had full freedom and flexibility to try any other alternatives in their discussions, e.g., going back to the original lesson recording during the Q/A discussion session.

5.2.3 System Components

To make the system usable by ASHAs and address the limitations we observed in our previous study; we enhanced the tool overall. We now had two main components in the *LEAP* platform.

a.) **Web portal** - This is a central system from which the learning environment of the ASHAs groups can be designed and managed. The portal is like a learning management system used in online learning programs for administration, tracking, and delivery of educational courses. The basic functions of our portal included the following: uploading and maintaining of learning materials (pre-recorded topic-wise audios), registration of ASHAs, creating and managing of peer-groups of ASHAs, scheduling group sessions, defining group roles and tasks (facilitator or listener, audio selection and their sequence), and monitoring group interaction and performance. The portal is designed for the organization concerned with ASHAs, e.g., NGO or govt. body. A single system administrator can manage multiple groups of ASHAs using the portal.

After the system administrator has designed a learning course for ASHAs, created their groups, and scheduled sessions, all of these details get automatically updated in the smartphone application of the facilitators.

b.) **Smartphone application** - This is to be used by the group facilitators, i.e., the

ASHAs who can operate a smartphone application. The application receives its group-specific data from the server, which was set in the portal by the administrator. The role of a facilitator is to conduct group sessions on a given schedule by operating the app and act as a moderator in group discussions.

The app has three main functions (see Figure 5.3): *Host Program*—shows the upcoming session details (date and time), a button to start the group call.

Tutorials—contains the gallery of audio files (topic lessons); this is designed to help facilitators prepare in advance. If any facilitator wishes to prepare herself on the content matter, then she can listen beforehand and prepare her notes. *Notifications*—displays text messages sent by the system or the administrators.

The interface of the app was designed to be simple and intuitive to use for the ASHAs. Further, for the purpose of our study, we kept the experiment design controlled and made functionalities in the app more sequential and controlled. For example, the audio lessons in the gallery are locked by default and are only unlocked only when the corresponding sessions are scheduled. Likewise, the button to start a group call is activated only 15 minutes prior to the session time.

5.2.4 System Working

For a group session, the administrator creates and schedules a session through the web portal. This action makes the details of the upcoming session (topic name, date, and time of the call) appear on the mobile application. To explicitly notify the group facilitators and the members, the administrator can also schedule automated calls (IVR-Interactive Voice Response) through the portal. After the group has successfully completed their session, the status, session statistics (connected members, speaking activities, duration, etc.), and corresponding session recordings are updated in the portal. The administrator can then schedule the next session (Figure 5.2).

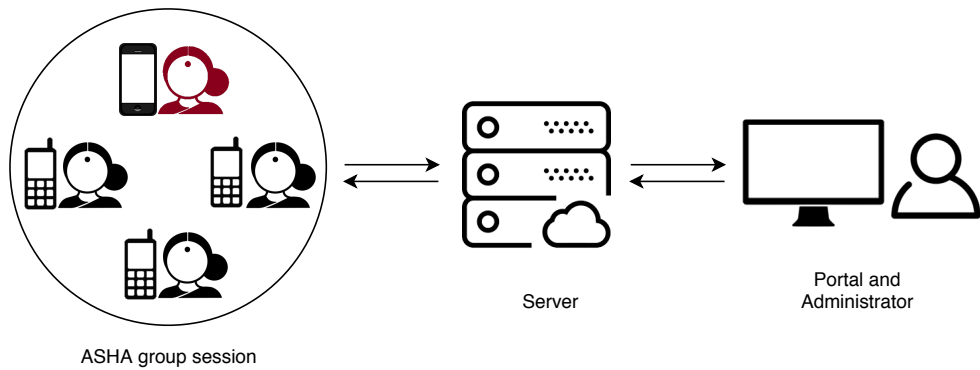


Figure 5.2: Overview of *LEAP*

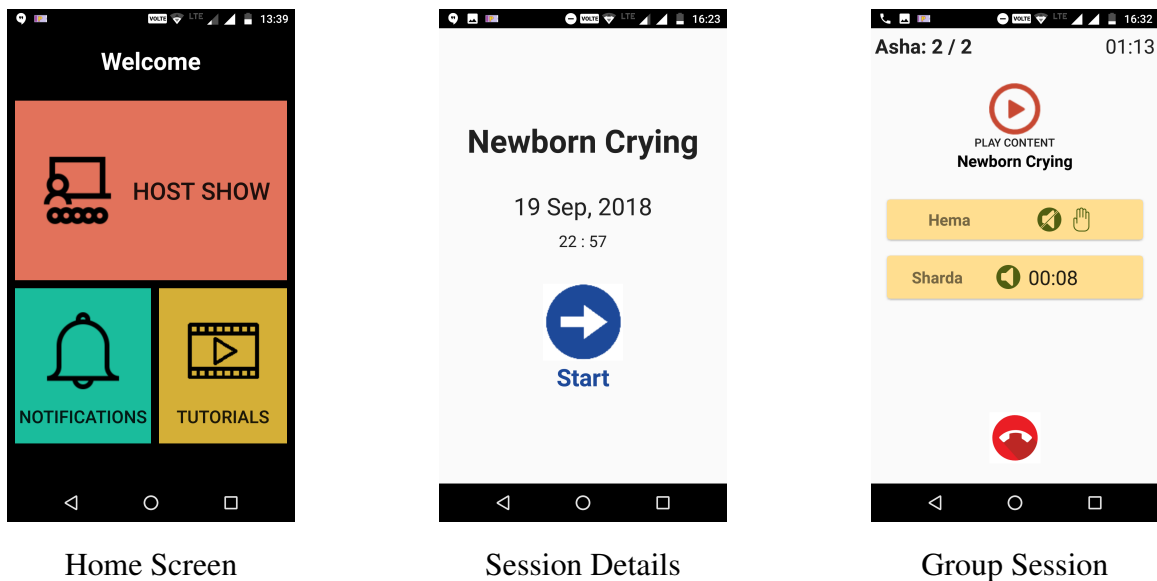


Figure 5.3: The user interface of the smartphone application showing the home screen, the screen displaying upcoming session details and a live session with two group members. Here, we show the English translated version of the actual interface which is in Hindi.

5.3 Methods

5.3.1 Study Design

We conducted a between-group design experiment study in Delhi with the cooperation and due permission of the Delhi State Health Mission (a government body under the Ministry of Family and Health Welfare of India [166]). Delhi has several under-developed areas, e.g., slums, which ASHAs serve. As per DSHM, 5000 ASHAs are placed across the eleven districts of the city [166]. We randomly allocated two districts of Delhi: south and east, comprising four health centers. While the two districts were separated by a distance of more than 30 km, the two health centers within a district were separated by only 3-5 km. Therefore, to avoid spillover effects between the participants, we used the district as the selection unit and randomly allocated one into the intervention group. There were 120 ASHAs, with 62 in the intervention group and 58 in the control group (around 30 ASHAs at each center). The intervention group received our collaborative learning intervention in addition to their routine, while the control did not. There was no placebo activity organized for the control group.

5.3.2 Participants

Within the intervention group, the ASHA peer-groups were created at the intra-health center level, where they knew each other and, therefore, could interact freely. Group creation was based on the availability of ASHAs who could operate smartphones. At every center, 8-10 ASHAs were smartphone users. Out of these, we preferred those ASHAs who were recommended by their supervisors as being sincere and active in their work. We finalized six such ASHAs at each center, thereby making six groups, which made the group size of 5-6 (total 30 ASHAs at a center). However, after a few practice sessions, the groups were rearranged due to problems relating to facilitator availability and the quality of cellular networks in their areas. Finally, we settled on a total of six groups, three at each center with

group sizes between 9 and 11 members. The average age of the ASHAs was 38 (ranging from 25 to 55), with the majority of them (86%) educated up to 12th standard and a few holding graduate (10%) and post-graduate degrees(3%).

5.3.3 Implementation

Prior to the start of the intervention, we obtained consent from the participants and briefed them about the purpose of the study, the data to be collected, and the potential risks. The participants were free to leave at any time. We gave our mobile handsets to the group facilitators for the duration of the deployment to ensure consistency in the system use. Each handset was enabled with a Reliance JIO SIM with a mobile data recharge. None of the group facilitators had a WiFi facility in their house. The six group facilitators were trained on the smartphone application features through multiple practice sessions organized at the respective health centers by the first author and a research assistant. Later, the actual sessions were conducted at the houses of the group facilitators.

One of the authors assumed the role of administrator and handled the portal. The role of the administrator was limited to monitoring the server logs during sessions in order to provide technical assistance if required. To schedule these sessions, we consulted the ASHAs and, based on the majority views, fixed the time slots for every group as per their convenience. Because of the availability of only one administrator, the sessions' timings were made mutually exclusive. The groups of one of the centers were scheduled on three alternative days in a week and the groups of the other center on the rest of the two days. The time slots were in the afternoon: 2 -3 pm, 3:30 -4:30 pm, and 5 to 6 pm. If a group could not conduct their session on the assigned day, then they were supposed to complete it on a subsequent day. In around six weeks, the groups completed all their sessions. Some of the sessions were assisted by the administrator due to cellular network issues in the areas of the facilitators.

5.3.4 Data Collection and Analysis

We adopted the mixed-method approach of data analysis in this study, both quantitative and qualitative. Like the previous *Sangoshthi* study, we conducted a pre-post intervention test to assess knowledge gains using the same questionnaire. We had two examiners, blind to this study, to evaluate the answers. Each examiner was randomly assigned one-half of the answer sheets of every center. Data of the participants present in both the pre and post-tests were included in the analysis (99, 52 in the intervention group and 39 in the control group). Using the t-test, the differences between pre- and post-test scores were examined for statistical significance.

At the end of the intervention, semi-structured interviews were conducted with the group facilitators to understand their experiences with *LEAP*. These interviews were conducted over telephone calls in the Hindi language, which were recorded for later analysis. The average duration of an interview was 10-15 minutes. ASHAs group sessions were analyzed by two coders, one was the author, and the other was research staff. The themes were generated inductively from the session's audio recordings (the native language of the participants and the coders was the same) and session transcripts (also developed by the same coders). In multiple iterations, codes were shared and refined to find the emergent themes. There were a total of 60 call recordings corresponding to 10 group sessions of the six groups.

5.4 Results

We now present the combined results obtained from the quantitative and qualitative analyses. Throughout the chapter we refer to the four health centers as I_1 , I_2 (intervention group); C_1 , C_2 (control group). The ASHA groups (total of six, three at each center) in the intervention group are referred as I_1G_1 , I_1G_2 , I_1G_3 (I_1 center); I_2G_1 , I_2G_2 , I_2G_3 (I_2 center). To present ASHAs' quotes, we have changed the names to preserve their privacy.

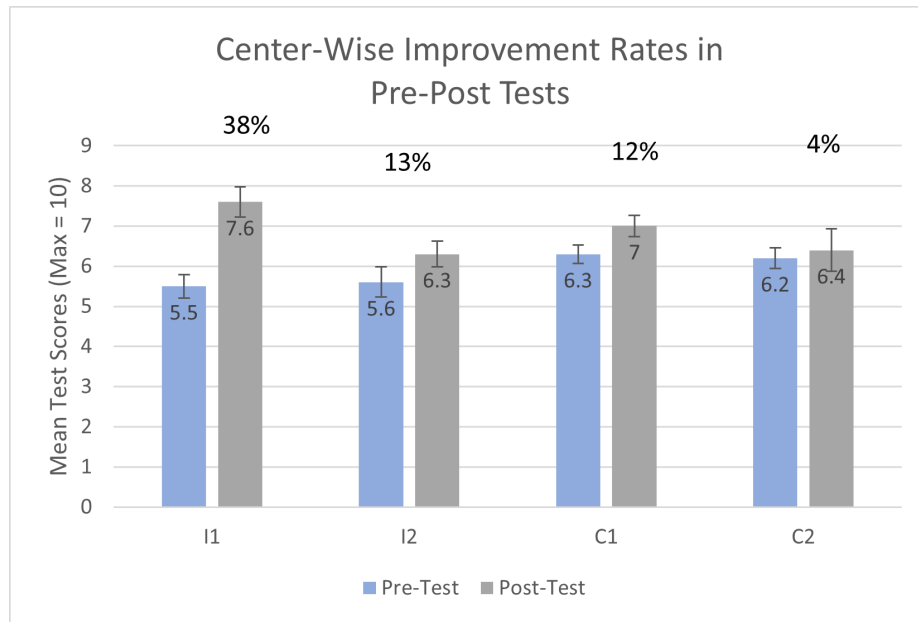


Figure 5.4: Center wise comparison

5.4.1 Effect on Knowledge

The methods used for the statistical analysis of the learning outcomes were: (1) Shapiro-Wilk to test the normality of data with a significance level of 0.05. (2) Paired Sample t-test to test the significance of the difference between post-intervention and pre-intervention test scores within each group (related groups). (3) Independent Sample t-test to test the significance of the difference between two unrelated groups.

At the baseline, the performance of the centers belonging to a district was similar. I_1 and I_2 centers in the intervention group had mean pre-intervention test scores of 5.5 and 5.6 respectively and C_1 and C_2 in the control group had 6.3 and 6.2 respectively (see figure 5.4). The differences were not statistically significant. However, the difference between the intervention and control group was significant ($t(df = 87) = -2.1916$, $p = 0.031$). The ASHAs in the control group i.e., in the south district of Delhi, had higher initial knowledge than the ASHAs of the east district. Here, we would like to note our limitations in the randomization process. First, we were allotted four health centers from two districts by the DSHM organization. Second, due to the practical convenience of coordination with the

health staff and ASHAs at health centers, we did create stratified groups by mixing ASHAs from different health centers. Further, the difference in the initial knowledge also points to the relationship between the health staff and ASHAs. Since mentoring and supervision play an important role in shaping informal, routine learning activities of ASHAs, it would be worth considering for future studies.

Further, investigating the effect of the intervention from the difference in the post- and pre-intervention scores, we found the improvement rates of the I_1 and I_2 centers to be 38% ($M = 2.04$, $t(28)=9.95$, $p < 0.05$) and 13% ($M = 0.70$, $t(22) = 3.75$, $p < 0.05$) respectively. In the control group, the improvement rates for C_1 was 12% ($M = 0.73$, $t(22) = 3.58$, $p < 0.05$), and C_2 was 4% ($M = 0.21$, $t(15) = 1.1271$, $p\text{-value} > 0.05$), shown in figure 5.4.

We were surprised by the results of C_1 center group and also by the large difference between the performances of I_1 and I_2 (38% and 13%). The C_1 center group did not receive the intervention, yet it showed statistically significant improvements in the test scores.

On further inquiry, we came to know that another training program - known as Mobile Academy - was started in parallel at I_1 and C_1 . We analyzed the contents of the Mobile Academy program and found that around 50% of their training material overlapped with ours.

We believe that this parallel training was the potential confounder that might have caused additional knowledge gains to the I_1 and C_1 centers. As the health centers have little control over the directions they receive from higher authorities, it was practically impossible for us to stop or delay any parallel interventions. Nonetheless, the positive observation is that participants were able to apply what they learned in the other training in our study showing transferability of learning.

The comparative analysis of the remaining centers (I_2 and C_2), which did not undergo any other training, still gives us a reasonable inference that the knowledge of the participants did improve from the collaborative learning intervention.

The contributing factors towards knowledge gains can be both the content and the dis-

cussion. In the next sub-section, we will investigate the factor of group discussions in the learning curve.

5.4.2 Peer Learning Aspects

ASHAs group activity consisted of listening to three audios- topic lesson, two field cases, and conducting group discussion after each. Apart from this, we did not control the interactions using any pedagogical techniques that include talking in a particular pattern or following any rules [153]. We aimed to understand the quality of interactions in their natural form. We now summarize the elements of peer learning observed.

Verbalization [153] was one of the central themes surfaced in the analysis of the interactions. The group facilitators solicited peers' thoughts in a round-robin fashion, giving an equal chance of participation to all the group members. While mostly all the present members spoke on their turn, some were more active and had higher participation. We observed that, on average, in every group, three speakers spoke with confidence and presented their ideas in coherent ways. Some of these were articulate, enjoyed speaking at length, and demonstrated characteristics of becoming group facilitators in the future. Further, their participation laid good examples for others, often helping shy peers to open up. Apart from these active members, others showed passivity in participation and spoke minimally that too upon prompting in the form of posing a question or case by the facilitators.

The second theme was *co-construction of knowledge* that included questioning, summarizing, repeated explanations and elaborations, activities that have been found to develop high-level thinking practices [167, 153]. Mainly, the facilitators exhibited characteristics of peer tutors. In the sequence of the conversation below, the facilitator tried to elicit thoughts of the peer ASHA by first framing a direct question, then modifying it into in-direct and finally into a condition-based question:

Facilitator: “*have you observed any depression case in your area?*” **Saraswati**

- “*no*”

Facilitator: *“can you identify a depressed mother?”* **Saraswati:** *yes, if the mother is not communicating with others, not taking care of her child and her personal hygiene then we need to persuade her*

Facilitator: *what will you do if the mother doesn't get persuaded?* **Saraswati:** *“textitwe will have to take her to doctor.....the mother must be happy if she is not then it is a serious problem”*

In terms of coverage of topics, we observed *chaining* in the ideas often triggered by the first speaker or an active ASHAs who generally brought new topics to the discussions. The ASHAs built on each others' ideas and collectively recalled the facts and experiences.

Kiran: *“from today's lesson, I got to know many facts related to crying like why newborn cries, which babies cry more”,* **Facilitator:...**

Punita: *“often babies cry very much at night”,* **Facilitator** - *“yeah, babies who sleep sufficiently during day time generally wake up more at night, mothers should play with their babies during the day...”*

Neelam:... *“babies should also have appropriate clothing according to the weather otherwise it can create discomfort which leads to crying”,* **Facilitator** - *“yeah, even excessive crying can also affect the mind of the babies...”*

ASHAs also showed inter-personal skills by encouraging each other, augmenting viewpoints, and resolving conflicts. This factor was reflected in the behavior of the group facilitators since they had significant control over speaking. Further, the words of praise and acknowledgment by the facilitators encouraged ASHAs to share their opinion.

We also noticed a good amount of topic adherence in the discussions. Few or no occasions were observed in which the groups deviated from the topic lessons in their discussions.

5.4.3 Reflections on the Need to Learn

While discussing a range of issues and topics, ASHAs actively self-defined their roles in society and reflected on how necessary it is to have good knowledge. After listening to lesson recordings, ASHAs often acknowledged gaps in their home visit practices and ways to improve them and apply new knowledge.

“So far, we used to ask about the babies, from now on we will ask about the mothers also, so that she can openly share the problems with us”.—Rajni, I₂G₃

Facilitator - *“if the mother is depressed and tensed, what advice should be given?”* **Santosh** - *“we should make frequent visits, and explain to her again and again that she should focus on her baby, this will engage her, we should counsel the family members also and suggest to see the doctor.”—I₂G₃*

They discussed their proximity to the families and opportunities to bring positive changes. For example, in the following dialog, the facilitator emphasizes the opportunity of developing a relationship with a mother during pregnancy to prepare for better care:

Host: *“...to counsel a mother we have so much of time, we get associated with her right from her pregnancy period, from her first trimester she starts meeting us. So, we can discuss these topics early on, how to feed baby, tell all the important things, and explain to her family too and solve the problems.”—I₁G₁*

They frequently discussed the challenges in persuading families towards healthy practices. They brought topics of prevailing myths around post-natal care, handling societal issues, e.g., women empowerment, gender discrimination among newborns, and the dynamics of power in families. As investigated in prior research, there are many mal-practices associated with post-natal care in India and are the main deterrent towards the care of the mother. Still, many Indian families practice outdated rituals and traditions. For instance, post-delivery, mothers are confined to home for a period of 40 days and are put under vari-

ous types of restriction related to diet, physical movements, and behavior, etc. [168, 169]. ASHA discussions on field cases included many such examples, one of these is as follows:

***Facilitator:** “In a delivery case, when I went to the house of a lady, I found that the mother-in-law had given Harira soup to the mother in the summer weather, which increased bleeding. So, I explained to her mother-in-law to give food according to the weather and referred her to the hospital.”—I₁G₁*

Further, the other common topic discussed amongst these challenges was related to the gender of children. In India, many families have a strong bias towards male children [170] due to which the health of mothers get affected. When the content topic was postpartum depression, the most common example discussed across groups was the birth of a second or third girl child. In these examples, ASHA discussed family attitudes towards babies and the mother and the mother’s behavior towards the baby.

5.4.4 Impact of Learning Material

In group learning sessions, ASHAs listened to two types of learning materials: topic lessons and Q&A recordings. We noted that ASHAs appreciated the quality of content and discussed the relevance of topics. At times they compared the content presentation with that of their training. In particular, they appreciated the fact that smaller details were highlighted.

***Vidya:** “ Never before did we realize how to recognize the depression of the mother, now we will be able to easily identify what is the problem, **Facilitator:** Yes, we never knew before that so much, **Vidya:** These things have never been taught to us openly before” ...—I₂G₃*

On noticing new information, the ASHAs felt good and immediately highlighted it in their discussions.

***Facilitator** - “And a new thing has come to knowledge, the blurriness of eyes*

*in mothers happens due to low blood pressure”, **Rameshwari** - “even the dizziness is also because of low BP”, **Facilitator** - “We did not know that before”*
***Rameshwari**: “were never told, how could we know when it was not explained.”*
***Facilitator**- “did you notice the new thing? It is said that when a baby is born, there is a yellowish layer on the body; none of us knew this new thing, this yellowish layer should not be removed from the skin”.*

I₂G₃, Danger Sign in Newborn

Some ASHAs expressed their interest in the continuation of the training on a regular basis.

“the recordings were very good, we want this program to continue, so that we can get knowledge from time to time. Although, we do receive training, but somehow we are not able to get adequate knowledge.”—Rajni, I₂G₃

Further, the Q&A recordings were liked greatly because they were short and contained real problems. The ASHAs were able to relate them to their field cases. During our interaction with the group facilitators post-intervention, some of them mentioned that while the lesson recordings were good but the duration of 15 minutes was too long. It required higher engagement which was found to be difficult in their household settings due to external disturbances. They suggested having multiple shorter recordings instead of one long recording.

5.4.5 Role of Group Facilitator

The communication and moderation skills of the group facilitators showed an important effect on the group discussions. Facilitators who had leadership skills and were active in eliciting conversations from their peers led good discussions. For example, the facilitator of the group *I₁G₁* was the most active one. She worked hard to prepare herself for every session. Before a scheduled session, she would always listen to the lesson recording to take

Table 5.1: Characteristics of Group Facilitators

I_1G_1	I_1G_2	I_1G_3
<ul style="list-style-type: none"> • Articulate • Acknowledging and Encouraging • Group Discussion Strategies: sharing of field experiences, problem solving, questioning and answering, case based discussions • Tutor characteristics: knowledge of topics, explanation skills • Positive Attitude 	<ul style="list-style-type: none"> • Group discussion strategies: questioning and answering 	<ul style="list-style-type: none"> • Articulate • Acknowledging and Encouraging • Group Discussion Strategies: sharing of field experiences, questioning and answering, general feedback based discussion • Tutor characteristics: explanation skills, knowledge of topics
I_2G_1	I_2G_2	I_2G_3
<ul style="list-style-type: none"> • Acknowledging and Encouraging • Group Discussion Strategies: general feedback based discussion • Humorous and Friendly 	<ul style="list-style-type: none"> • Group Discussion Strategies: questioning and answering, general feedback based discussion 	<ul style="list-style-type: none"> • Positive Attitude • Acknowledging and Encouraging • Group Discussion Strategies: sharing of field experiences, questioning and answering, general feedback based discussion • Friendly

notes and prepare herself to have a good understanding of the content. To ensure she would sound like a facilitator, she prepared her speech scripts for the initial sessions. She spoke fluent Hindi and also attempted to augment the content presentation in her own style. For example, while summarizing the content of an audio, she recited a poem to engage users. Her preparation also included constructing examples and cases for the explanation. To start a conversation, she would ask a question, cite a related field experience, or present a problem to be solved. She mentioned her personal experiences and emphasized success stories. After an ASHA had spoken, she would acknowledge her, augment the information, and encourage her. Given that no prior training was given, her efforts exceeded our expectations. Overall, all of her conversations held a good portion of experience sharing.

The facilitators of groups I_1G_3 , I_2G_3 and I_2G_1 also did a fair job. Their strategies to encourage discussions varied. For example, the I_1G_3 facilitator showed the characteristics of a tutor as she used to initiate conversations by asking questions from her peers. She would construct different types of questions around the lesson content to check the learning

of her peers. The facilitator of the I_2G_1 group used to solicit feedback over the content and queries of peers. The I_2G_3 facilitator was more flexible, trying a variety of approaches ranging from seeking feedback to experience sharing.

There were other groups (I_2G_2 and I_1G_2) in which the facilitators were not effective and showed a clear need for training. The I_1G_2 facilitator in her initial few shows took help from the I_1G_3 facilitator, who lived closeby. However, she faced difficulty in moderating effective group discussions, and the conversations were mainly superficial. The total time spent on the group discussions was the lowest among all the groups. Similarly, I_2G_2 facilitator also lacked in moderation. In her case, the groups members were quite active who tried to cover up the moderator's inefficiency. We have summarized the characteristics of all the facilitators in the table 5.1.

5.4.6 Missed Opportunities

In our design, the group activity was structured such that the groups were supposed to use the content material and interact in a pre-defined sequence. There was no other form of scaffolding to validate the understanding of the content or help to resolve ASHAs' queries. We observed that in the absence of instructors, in some cases, the groups developed inconsistent knowledge of the facts. The two statements from two different groups, given below, differed in the recommended duration of handwashing before touching a newborn.

Facilitator - *“how should we clean a baby, how should we wash hands? how should we explain these things to the mothers?”* **Sarita** - *“Hands should be cleaned for 20 minutes; every step should be done for 20 minutes.”*— I_1G_2

Facilitator - *“for how long should we wash hands?”* **Saroj** - *“ Wash for a good 5 minutes, then dry hands well”*— I_1G_3

In the cases of new and complex topics, the need for experts was apparent. For example, on the topic of mother's depression, the discussions mostly centered around ASHAs'

general perceptions of depression. ASHAs conditions of mother not taking care of herself and child, sadness due to causes relating to family issues, health problems, child gender, and child adoption. A major portion of their discussion focused on the gender of the baby. They did not discuss other causes of depression. As also found by other studies, ASHA knowledge on depression lack in terms of understanding its psycho-social nature, its impact, and signs and symptoms. [171, 172, 173]. Also, we did not see any reference to prior knowledge on depression. Some ASHAs even acknowledged that they had limited or no knowledge of depression.

5.5 Discussion

This chapter builds on the previous chapter by providing a positive direction of reinforcing peer-to-peer learning opportunities for ASHAs. The chapter demonstrated ASHAs' potential to use the mobile-learning tool and direct their group learning by engaging with the learning material and leading group discussion. We now discuss the design implications for the technology-supported peer-learning paradigm for ASHAs.

We now summarize the implications for designing technology-based peer learning solutions for ASHAs useful for policy-making and HCI/CSCW research.

5.5.1 Peer Learning and Scaffolding Scope

Our analysis of the group sessions found elements of peer learning in the form of peer tutoring [174], verbalization [153], and co-construction of knowledge [151]. ASHAs questioned content topics, exchanged explanations, and shared experiences. While doing so, they built upon each other's ideas, particularly the presence of active members, positively influenced other shy peers. Further, the role of group facilitators was found to play a key role in the effectiveness of discussion. Some of them emerged as leaders and made significant efforts in their facilitation strategies. Despite any training or prior experience of using a discussion forum, as a start, these thinking practices were highly positive, suggesting a

good scope of designing peer learning solutions.

To further enhance the skills of facilitators, the app can be improved to allow the addition of meta-content, which facilitators can use on-the-fly during group sessions. Feature to support in-session exercises should be explored in order to structure the group learning activity further. To mitigate learners developing a partial understanding of the facts, techniques like problem-based learning [175, 176] can be applied. For factual information, strategies should be used to emphasize the information. More emphasis can be placed on the information by repeating or employing exercises to validate understanding. Likewise, group discussion can be structured through techniques e.g. scripted roles and stances[153], jigsaw [177], external collaboration scripts [178], problem-based learning [175]

Further, utilizing group composition is another factor that can contribute towards making the peer learning approach effective. Research has confirmed the benefits of heterogeneous group composition having students with mixed performance - low, mid, and high [179, 180]. For ASHAs, the group composition can be experimented both at the intra-center and inter-center levels. While the intra-center group composition can help shy ASHAs to open up, the inter-center group composition can help in gaining new experiences from the ASHAs of other centers and have more opportunities of healthy competition. System-wise, statistics about individual and group performance can be maintained by automatically collecting group performance and then automatically generating group compositions.

5.5.2 Forum to Practice Discourses and Exchange Perspectives

Informally ASHAs are a community who invariably leverage each others' knowledge in performing their duties [58]. They share common understandings of the culture and the various challenges their communities face in healthcare access. These include women's position in society, familial contexts, financial constraints, societal norms, and awareness on healthcare. When ASHAs discussed such aspects, they not only discussed challenges

but also how to address them by bringing forward their situated knowledge. This highlights an important opportunity for bridging the disconnects between ASHAs and the health officials at higher positions to providing greater visibility into the ground realities [181, 123]. Further, having an online community would help ASHAs develop their confidence. Studies evaluating ASHA performance have highlighted lack of confidence as one of the important factors in skill-building. A discussion forum creates a healthy and structured environment to practice discourses that would potentially help in improving the confidence of ASHAs to deal with their cases, e.g., client counseling.

5.5.3 Control Experiments with ASHAs

Randomized Controlled Trial (RCT) has long been the gold standard approach to determine the effect of interventions. However, in real-life settings, it requires careful consideration of several logistic challenges for its feasibility and may not always be a practical option [182]. For example, in our case, Frontline health workers like ASHAs in rural areas are not always the easiest groups to conduct rigorous evaluations with. ASHAs sit at the lowest ladder in a strictly hierarchical healthcare system and are controlled by supervisors who have little control over the directions coming from higher authorities. Also, ASHAs are simultaneously engaged in many different programs, controlling which is difficult and sometimes impossible for researchers outside of the system. In our study, we observed that one of the health centers in the control group was exposed to a parallel mobile training which we couldn't control.

Sometimes randomization process itself is difficult to perform. In both of our studies (chapter 4 and Chapter 5), we did not have full control in the sampling process of ASHAs and were allotted already selected ASHA samples from the field partners. We learn that researchers should make sure to involve all the relevant authorities and discuss future activities of ASHAs well in advance and have alternative plans to complement RCT.

5.6 Summary

Through our field experiment, we found that the collaborative learning approach to train ASHAs is a promising strategy to overcome the shortage of instructors and to support their learning needs. We designed a peer-led educational intervention in which ASHAs organized their group learning sessions independently. By using already developed content and providing minimal guidance for group discussions, we could see that ASHAs were able to show significant knowledge gains and, most importantly, feel empowered by sharing their thoughts with peers. They were able to acknowledge their knowledge gaps and have discussions on the areas of improvement. By analyzing ASHAs' group learning sessions, we arrived at design guidelines for developing collaborative learning platforms for ASHAs. Overall, we believe that the model of collaborative learning should be investigated further with different pedagogical strategies and tried at a larger scale of deployment.

Chapter 6

Understanding Training Needs through a Large-scale Study

Our first two studies provided promising preliminary results in the efficacy of the proposed tool for supporting expert-based training and peer-to-peer learning opportunities for ASHAs. In this study, we aimed to guide ourselves for the future designs of such mobile platforms by understanding the information and training needs of ASHAs more closely. In particular, we aimed to understand the prominent gaps in the knowledge of ASHAs to tailor future training interventions.

We adopted a large-scale study design to collect information-seeking patterns of ASHAs using our platform⁴. We complement the prior work which have substantially reported performance gaps by measuring knowledge levels or assessing performance. By collecting and analyzing the queries of ASHAs, we try to understand the common and unmet training needs that, in turn, also serve as a groundwork for planning to implement any mobile training intervention on scale. We focused on these research questions:

- **RQ1** What kind of information ASHAs seek from experts?
- **RQ1** What kind of knowledge or skill gaps the information seeking represent?
- **RQ1** To what extent the existing reference material of ASHAs can address the information seeking of ASHAs?

In a period of five months and one week, 500 CHWs were trained on six topics of Home-Based Post Natal Care in 20 batches. Through 144 training sessions, composed of delivering audio lectures on the training topics and facilitating interaction between an

⁴Deepika Yadav, Prerna Malik, Kirti Dabas, and Pushpendra Singh. 2021. Illustrating the Gaps and Needs in the Training Support of Community Health Workers in India. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI, 1-16.

expert and CHWs, we collected 1178 questions. We examined the questions both qualitatively and quantitatively to find the topics and the nature of information seeking. We also mapped the coverage of these questions with the reference material of CHWs and collected CHWs' experiences by interviewing 48 of them.

We observed that when CHWs received the opportunity of interacting with an expert, they sought knowledge on field cases to improve problem-solving skills. The three key broad themes for improvement were routine patient care, knowledge on identifying danger signs, and skills to support breastfeeding. The findings highlighted the need to improve the on-the-job support system. We looked at the need to adopt holistic approaches such as improving the coverage and presentation of reference material, enhancing the training structure for problem-solving, and providing forums for interaction with experts.

The contributions of our study are primarily two. First, we present the first large-scale study in the HCI4D literature that goes deep into examining the knowledge gaps of CHWs by studying information seeking of 500 workers over a period of five months. We complement prior studies in this domain by collecting day-to-day field queries of CHWs and understanding what kind of knowledge CHWs seek to address them. Second, we contribute to the HCI4D community, which has been increasingly growing around CHWs, maternal and child health contexts in disadvantaged groups by outlining key takeaways for designing holistic learning solutions targeted towards the health education of CHWs.

6.1 Methodology

We conducted this study with the same NGO partner - SWACH.

6.1.1 Participants

We selected ASHAs using convenience sampling. SWACH staff first connected with their points of contact at the community health center levels (CHCs, a health facility at tier-3). The in-charge officials at CHCs helped in reaching out to ASHAs by introducing the

proposed training intervention and recruiting ASHAs. Based on ASHAs’ interest and availability, the ASHAs were included till we crossed our sample size of 500. We finally selected 500 ASHAs who provided their written consent to receive the training. These ASHAs remained till the end of the intervention. The participants’ demographics are given in the table 6.1. Our selection process resulted in the coverage of 10/10 CHCs with an average number of 45 ASHAs per CHC (minimum was six from two CHCs, the maximum was 110 from one CHC) as reported in the table 6.1. All participants spoke Hindi with accents of Haryana and Punjab regions. Participants were remunerated for their time by cash incentive; each ASHA received an amount of 1000 INR.

Table 6.1: Participants Demographics

Age	Count(%)	Education (grade)	Count(%)	Experience (years)	Count(%)	CHC	ASHA Count
<30	20 (4%)	5 th -8 th	12 (2%)	0-5	21 (4%)	Brara	86
30-40	242 (48%)	8 th -10 th	79 (16%)	5-10	201 (40%)	Bilaspur	55
40-50	188 (38%)	10 th -12 th	357 (72%)	10-15	222 (45%)	Chaurmastpur	110
>50	28 (6%)	Graduation & above	30 (6%)	>15	34 (7%)	Khizrabad	67
no information	22 (4%)	no information	22 (4%)	no information	22 (4%)	Mullana	6
						Mustafabad	30
						Naharpur	39
						Radaur	51
						Sadhaura	6
						Shahzadpur	49
						No information	1
Total ASHAs		500					

6.1.2 Intervention Execution

The planning and preparation phase of the intervention started six months before the actual implementation. Several face-to-face meetings were organized to understand the resource availability, budget, and methodology. Two of the authors made back and forth visits to SWACH to conduct training workshops and facilitate running mock training sessions. With ten team members involved (7 from the SWACH staff), 12 days were devoted to the testing period, and 18 mock training sessions were conducted. Initially, few sessions were dedicated to test the functions of the android app and the web portal, which took approximately 8-10 minutes per session, followed by conducting full-length sessions of 20-30 minutes. Various kinds of issues with the system connectivity and functionality surfaced,

e.g., network delays affecting the app when using mobile data, and were addressed.

For the final deployment, a team of eight team members - three authors from our side and five from SWACH. The SWACH head assumed the lead trainer's role, two staff members played the role of training moderators, and the rest acted as assistants to these moderators. We handled the responsibility of providing technical assistance to the SWACH staff and overseeing the overall execution that included monitoring system logs, taking prompt action to rectify errors during live sessions, and maintaining data records.

For the training topic, we decided to continue with the same topic of Home-Based Postnatal Care (HBPNC) that aligns with the official training curriculum of ASHAs and has been identified as one of the most critical areas for improving the skills of ASHAs [183]. Under HBPNC, this time, we reduced topics to six, namely breastfeeding, danger signs in mother, danger signs in newborn, newborn temperature control, play and communication with newborns, health, and mothers' happiness. Total seven sessions were planned for a batch - six topic sessions and one feedback session. Based on the findings of our prior studies, we decided the size of a training batch to be around 25. Using the sequential sampling method, we formed 20 groups consisting of about 25 ASHAs in each group. The session timing was fixed according to the ASHAs' availability. The majority of the ASHAs preferred time between 10:30 a.m and 1.00 p.m.

To manage the expert's availability, we modified our training design in the following manner. The training sessions were dedicated to delivering training content, conducting group discussions, and taking ASHAs questions, leaving out the live interaction with the doctor. Instead, the doctor's responses were collected offline. After finishing the training sessions of a day, the moderators would meet the doctor to record his responses. The moderator would then share these responses with the participants in the subsequent sessions. This hybrid approach allowed us to use the expert's time efficiently. The lack of experts is an identified problem for training CHWs.

We started our intervention in April 2019, completed it by August 2019. Throughout the

deployment, we faced technical challenges that were navigated with technical intervention from our side. Some got resolved smoothly with modifications in the system code; for others, workarounds were developed by our team. However, many times, mainly due to slow internet speed, sessions faced frequent interruptions. We planned to conduct training sessions for two groups each working day. However, at times, we had to suspend the training sessions for a few days in some weeks. Also, due to availability issues of ASHAs, the batch size varied from 19 to 27. Even with prior notice of the training, some of the ASHAs had to go for other meetings and visits. In total, 144 sessions were conducted for the 20 groups, seven sessions per group. Three sessions were repeated for group 15 due to low attendance, and one was repeated for group 14. Overall, the average attendance of ASHAs was 76%.

6.1.3 Data Collection and Analysis

Data collection was performed at various stages. The system server recorded every training session (audio recordings) and logged session event logs, e.g., call drops.

The training moderators and research staff made extensive field notes recording daily issues, observations, etc.

Q&A Analysis

The ASHAs' questions and answers were extracted from the daily evening meetings' audio recordings between the moderators and the doctor. These were transcribed daily by one of the moderators. Two authors later transcribed the answers to the questions.

Both the authors were fluent in Hindi (the language of conversations) and English. The recordings were first transcribed into Hindi language and then translated into English. Since the native language of all the authors and the ASHAs was the same, we decided to perform the analysis on the Hindi transcriptions to understand the local terms and associated nuances better.

Three authors started the inductive thematic analysis of the questions individually by reading each question with two aspects in mind - the topics of the questions and the type of information seeking. After analyzing 112 questions, the authors discussed their codes and analysis rationale to develop an initial code dictionary.

Following this, two authors continued the analysis of the rest of the questions. After completing the annotation of every subsequent 200 questions, the authors discussed, refined, and added new emerged codes into the dictionary. While the codes for the type of information seeking saturated after the second iteration (eventually resulted in five themes), the codes for the topics and sub-topics increased until the last iteration. Finally, the final iteration reduced 30 codes of the main category to 15 and 321 sub-categories to 131.

Content Analysis

A separate analysis activity was performed on the subset of the questions to understand the extent to which the reference material provided to ASHAs addresses them. We obtained e-material from the National Health Mission website, the apex government body managing the community health workers [41]. The material is divided into seven modules and serves both as the training and learning material. The modules are specifically organized in the form of books provided to ASHAs when they get appointed and join the training program. We used these seven books along with an induction training module, which is a consolidated version of the first five modules for our analysis.

The two authors first understood the learning material by individually going through it and identified the relevant sections of the books to search content in. After this, the authors individually analyzed a few sample questions of two different topics to arrive at a consistent search and tagging method. For example, in addition to straightaway looking into the relevant chapters' sections, keyword searching at the individual file level and folder level was also used. While searching for a particular question topic, the authors also looked into related chapters that could potentially cover the topic indirectly, e.g., a question related to

consumption of iron supplement post-delivery was also checked in pregnancy care sections as both the stages are advised for iron consumption. Finally, all the questions of the selected topics (Home Based Postnatal Care, details in the finding section) were mapped to the extent of the coverage in terms of whether answers to the questions were present or not and if present then fully or partially.

Interviews

The last main activity of the study was interviewing the ASHAs. The aim was to collect ASHAs' training experiences, usability issues, feedback for future improvement, and general information on existing training mechanisms. The selection process of the participant followed a systematic sampling approach. We first shortlisted 100 ASHAs from the initial pool of 500. From the 500 ASHAs already divided into 20 groups, we selected every 5th member. Going serially, we obtained consent from 60 ASHAs and could successfully conduct interviews with 50. Two interviews were discarded from these due to a very low attendance rate (less than two sessions).

The demographics are given in the Table 6.2. The education, age and experience characteristics were similar to that of the parent sample of 500 ASHAs. The distribution was across 9 CHCs with maximum share from three CHCs.

The interviews were conducted telephonically by three authors in the Hindi language. On average, an interview took 30 minutes to complete. Interviews were recorded after obtaining the consent of the ASHAs, which were later transcribed. Descriptive statistics were computed for the closed-ended questions, and an inductive thematic analysis was adopted for the open-ended questions [184]

6.2 Findings

In this section, we report 1.) the analysis of the questions asked by the ASHAs by discovering the topics and the kinds of gaps they indicate in the knowledge and skills, 2.) analysis

Table 6.2: Interview Participants Demographics

Age	Count(%)	Education (grade)	Count(%)	Experience (years)	Count(%)	CHC	ASHA Count
<30	3 (7%)	5 th -8 th	1 (2%)	0-5	2 (4%)	Brara	11
30-40	25 (54%)	8 th -10 th	4 (8%)	5-10	17 (35%)	Bilaspur	3
40-50	16 (35%)	10 th -12 th	36 (75%)	10-15	28 (58%)	Chaurmastpur	12
>50	2 (4%)	Graduates	7 (15%)	>=15	1 (2%)	Khizrabad	12
no information	2(4%)					Mullana	0
						Mustafabad	1
						Naharpur	1
						Radaur	3
						Sadhaura	1
						Shahzadpur	4
Total ASHAs		48					

of the reference material given to ASHAs and its mapping backward with the questions to understand the coverage, and 3.) analysis of the ASHAs perceptions and experiences on our training intervention and existing face to face training methods.

6.2.1 ASHAs Engagement

Before we delve into the analysis, we would like to present the participation of the ASHAs in the training session in terms of their attendance and contribution in the questions. Our sessions starting from the first week of April and continued till mid-August. ASHAs were trained in 20 groups, having a size of 25 members on average. The sessions for the ASHAs were conducted sequentially, taking two groups at a time, whereby these two groups would complete their training in 7-8 days in a row typically. We measured the attendance of the ASHAs session-wise. We found no temporal trend that could indicate attrition over the intervention duration. The individual attendance rates of the groups varied between 61% and 89%, and the average attendance for all the groups was 76%, see table 6.3.

In this deployment, we recorded a total of 1178 questions of the ASHAs. From these, we could map the ASHAs distribution for 1141, an activity that was performed later. Due to the loss of recordings of two sessions, we couldn't tag ASHAs names to the already transcribed questions for these sessions. There were 341 ASHAs out of 500 (68%) who asked questions. Among these 341, the number of questions asked per ASHAs ranged from 1 to 25. The table 6.4 and the histogram in the figure 6.1 shows the distribution of

Table 6.3: ASHA Engagement

Group ID	Group Size	Attendance (%)	No. of ASHAs who Asked Questions
group1	25	17 (69%)	21
group2	25	20 (81%)	18
group3	24	19 (79%)	20
group4	24	16 (68%)	11
group5	25	22 (86%)	17
group6	25	18 (74%)	15
group7	25	18 (70%)	16
group8	25	22 (89%)	13
group9	25	22 (89%)	16
group10	25	19 (76%)	19
group11	25	18 (72%)	15
group12	25	18 (71%)	19
group13	26	21 (80%)	17
group14	25	20 (81%)	15
group15	19	15 (81%)	18
group16	27	17 (64%)	15
group17	27	17 (61%)	17
group18	27	20 (75%)	23
group19	26	20 (76%)	14
group20	25	20 (81%)	22
Average	25	19 (76%)	17
Total	500		341

the ASHAs across different question intervals.

Looking from the point of activeness in questioning, we can say that overall from 500 ASHAs, 32% (158) participated only passively by listening to the training content and others conversation, 44% (222) participated less actively by asking a maximum up to 3 questions, 29% were moderately active asking 4 to 7 questions, 3% were quite active asking 8 to 11 questions and 1% were exceptionally active asking more than 11 questions.

Further, we also computed the participation area-wise, shown in the table 6.5. Excluding the two CHCs with few f ASHAs (6), the attendance rate varied from 71% to 87%, and the questioning rate varied from 50% to 85%. In this study, we did not further investigate the variation in participation across the CHCs; however, there might be factors relating to infrastructure, organization, or population load that could have affected the participation

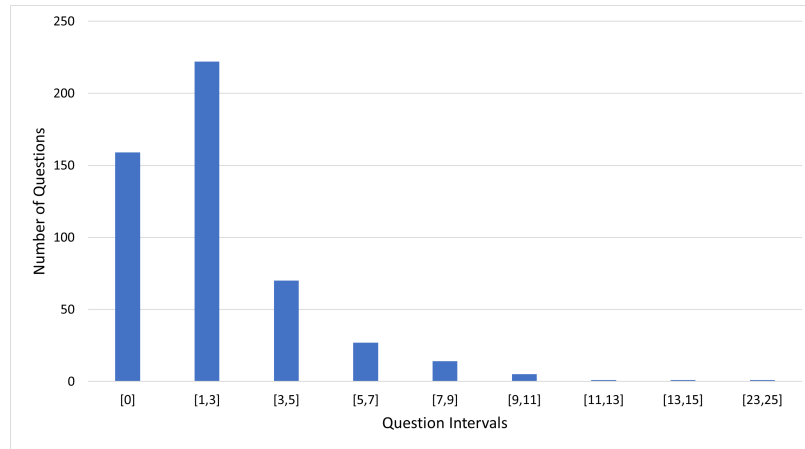


Figure 6.1: Histogram of the questions asked by the ASHAs

of the ASHAs. Considering the high engagement of ASHAs in multiple programs, this is important to study what we would like to do in the future.

Table 6.4: Distribution of ASHAs' Question Asking Behavior

Question Intervals	No. of ASHAs (%)	No. of Questions
[0]	159 (32%)	0
[1,3]	222 (44%)	439
[3,5]	70 (14%)	298
[5,7]	27 (15%)	182
[7,9]	14 (3%)	117
[9,11]	5 (1%)	53
[11,13]	1 (0%)	12
[13,15]	1 (0%)	15
[23,25]	1 (0%)	25

6.2.2 Question Analysis

We analyzed a total of 1178 questions of ASHAs. Each question was analyzed to find the topic and sub-topic it contained and the type of knowledge-seeking. Table 6.6 shows the 16 topics, topic frequencies on which ASHAs asked their questions and distribution of ASHAs across the topics. Taking together, these 16 topics cut across the spectrum of reproductive, maternal, newborn, child, and adolescent health, with four major clusters centered on antenatal care, health and happiness of mother (post-delivery), breastfeeding,

Table 6.5: ASHA Engagement Across Community Health Centers(CHCs)

CHC	ASHA Distribution	Attendance Rate(%)	No. of ASHAs(%) who Asked Questions
Barara	86	81%	71(83%)
Bilaspur	55	87%	40(73%)
Chaurmastpur	110	79%	70(64%)
Khizrabad	67	83%	44(66%)
Mullana	6	97%	4(67%)
Mustafabad	30	73%	15(50%)
Naharpur	39	82%	33(85%)
Radaur	51	81%	31(61%)
Sadhaura	6	71%	3(50%)
Shahzadpur	49	71%	30(61%)
No information	1		

and newborn care. We selected the first eight topics covering the six training topics (first six) and the top four topics with the highest frequency.

ASHAs' questions are concerned largely with field cases. Through these, ASHAs sought information and advice on the various kinds of health problems their clients faced. Our first measure of analysis identified the topics and sub-topics of the problems to develop a sense of the prevalent areas on which ASHAs need knowledge support. The second measure of analysis identified the level of knowledge and skill gaps ASHAs showed while discussing these field cases. To do this, we referred to the official training material of ASHAs that defines an ASHA's role in dealing with health problems based on three levels. For mild health problems, an ASHA should be able to provide guidance to families, including giving basic treatments. For moderate problems, which are currently non-severe but need attention, an ASHA should be able to guide families by watching for early signs of danger and making referrals if necessary. Moreover, for severe problems, an ASHA should facilitate early detection and making referrals.

6.2.3 Knowledge Seeking Type

Given a question, we gauged the severity of the problem mentioned in it by understanding its response given by the doctor and validating that from the reference material. Doing this for all questions, we observed three forms of knowledge-seeking as follows:

Table 6.6: Question Topics and Frequency

Topic	Number of (%) Questions	Number of ASHAs who asked questions (per topic)
Breastfeeding*	239 (20.29%)	177
Danger Signs in Mother*	29 (2.46%)	24
Danger signs in Newborn*	78 (6.62%)	61
Health and Happiness in Mother*	123 (10.44%)	87
Newborn Temperature Control*	36 (3.06%)	33
Play and Communication with Newborn*	13 (1.10%)	11
Antenatal Care*	214 (18.17%)	140
Newborn Care*	265 (22.50%)	163
Gynaecological Issues	93 (7.89%)	69
General Health	12 (1%)	10
Adolescent	10 (0.85%)	9
Older child (> years)	19 (1.16%)	16
Older child (1-6 months)	13 (1.10%)	10
Older child (6 months-2 years)	25 (2.12%)	21
Top feed	7 (0.17%)	4
Miscellaneous	2(0.17%)	2
Total Questions	1178	
Total unique ASHAs who asked questions		341

* topics selected for the analysis

- *Basic Knowledge Improvement*: represented information seeking that showed gaps in the essential knowledge and skills to execute the defined roles of ASHAs across all the three levels of problems - mild, moderate, and serious. For instance, in mild problems, ASHAs lacked understanding of the problems, causes, and the simple solutions to be provided to the families; in moderate problems, ASHAs lacked understanding of symptoms and the scope of help they can provide to families; and in severe problems, ASHAs showed lack of knowledge in referring families to the right facility and in providing guidance till families receive care or after receiving the care (see table 6.7 for examples). The questions were mainly of ‘what’ and ‘how’ forms, seeking factual and procedural knowledge for problem-solving [191]. In our data, we found 892 questions (75%) showing information seeking basic knowledge improvement. From the total 342 ASHAs who asked questions, 323 asked on basic knowledge improvement.
- *Knowledge Enhancement* - In this form of information seeking, ASHAs showed interest in knowing more than factual knowledge by focusing more on the reasoning,

Table 6.7: Question Categorization by Severity Level and Type of Information Seeking

Question Classification	Rationale
MILD	
“Post-delivery mothers usually develop constipation, what advice should we give?” (<i>Basic Knowledge</i>)	- Constipation is a common problem most mothers face after delivery. It usually takes few days for normal bowel movements to occur [185]. - An ASHA can help mothers by providing advice on water consumption, food intake, and physical exercises
“Many newborns develop jaundice on birth, what is the reason for that?” (<i>Knowledge Enhancement</i>)	- Newborn jaundice is a common usually harmless condition, particularly in babies born before 38 weeks’ gestation (preterm babies) and some breastfed babies. Mostly mild, it starts 2-3 days after birth and without treatment tend to get better after 2 weeks [186, 187]. - ASHAs should know how to check yellowish discoloration of skin and eyes correctly and advise mothers to continue breastfeeding.
MODERATE	
“During HBPNC visits, if we observe small pimples on the body of newborn then what should we do?” (<i>Basic Knowledge</i>)	-Skin conditions in a newborn can range from mild diaper rash to milia to a more severe pustules and blisters [186]. - ASHAs should be able to identify the severity as more than 10 pustules are dangerous and need referral.
“If a pregnant lady in her third-month experiences bleeding, but ultrasound report comes fine, will everything be all right later on?” (<i>Knowledge Enhancement</i>)	-Vaginal bleeding is a common first-trimester complication, often considered to be a sign of a problem in pregnancy. Bleeding multiple times do have more risk of preterm labour [188]. - ASHAs needs to be more vigilant with these mothers and refer immediately if the mother reports spotting or bleeding at any point in pregnancy.
SEVERE	
“What should we recommend in the case of reduced amniotic fluid in six-month pregnancy stage?” (<i>Advanced Case</i>)	- Oligohydramnios occurs in about 1–5% of pregnancies at term. It is associated with a high rate of pregnancy complications and increased perinatal morbidity and mortality [189, 190] - Such cases need expert advice
“Each time the child breathes in, the chest pulls in, the skin on the neck pulls in, the child is also not breastfeeding. In such as case, what advice should we give and where should we refer?” (<i>Basic Knowledge</i>)	- Chest indrawing in a child with cough or difficult breathing indicates that the child has pneumonia, should be referred to the hospital [186]. - Aiding in the management of acute respiratory infection is defined as one of the key tasks under the skills for recognizing danger signs of children. ASHAs are supposed to have good knowledge on recognizing and classifying breathing patterns

causes, and concepts. The problems ranged from mild to moderate (see examples in table 6.7). Typically the questions under this category had “*why*” form of seeking, e.g. “*why do healthy infants get milk in ears*”, “*why do newborns catch jaundice on the third day after birth*”, “*what is the reason of menstruation not getting stopped during pregnancy for some women*”. Out of 342, 94 ASHAs showed interest in knowledge enhancement and asked 147 questions (13%).

- *Advanced Cases* - The questions under this category represented health conditions which were stated advanced for ASHAs such that either the health problems, as already diagnosed, are complex or in severe condition. ASHAs sought general knowledge on the problems. For such cases, the doctor recommended ASHAs to not focus on understanding the problem but on providing support to the families (see examples in the table 6.7). The training materials of the ASHAs also did not cover such cases. The total number of questions under this category was 139 (12%).

We will now illustrate the gaps in the essential basic knowledge and skills in the next

Table 6.8: Questions Distribution According to Severity

Topic	Mild	Moderate	Severe
Danger Signs in Mother	0	8	21
Danger signs in Newborn	0	25	53
Health and Happiness in Mother	92	24	0
Newborn Temperature Control	26	10	0
Play and Communication with Newborn	12	1	0
Antenatal	87	71	56
Newborn Care	231	33	1
Total	448 (60%)	172 (23%)	131 (17%)

section, which is our major finding. As mentioned previously, we discuss these through the eight selected topics, namely breastfeeding, danger signs in mother, danger signs in newborn, health and happiness in mothers, play and communication with newborn, newborn temperature control, antenatal care, and newborn care which composed of 997 questions.

6.2.4 Illustration of Knowledge Gaps

Routine Patient Care

By making home visits, ASHAs get first-hand accounts of their fellow community members' routine health experiences. This reflection held a major theme in our results. 60% of the questions represented day to daycare concerns and common health problems (see table 6.8 and figure 6.2). The maximum number of queries on antenatal care (87 of 214) were on common problems and discomfort due to pregnancy changes, e.g., cramps, heartburn, varicose veins, etc. The recommended remedies to these concerns are related to self-care and lifestyle changes. In addition to developing adequate factual knowledge on guiding these, as observed from the doctor's answers, the key aspect was to tailor the information according to individual needs and address the prevalent perceived lack of willingness towards health adherence in an effective manner. For instance, even though Anemia is one of the biggest threat to maternal health in rural India and given the focus on increasing adherence to the consumption of iron and folic acid supplements in the antenatal care in the training material, ASHAs lacked basic knowledge about the intake and side effects of

the supplements “*Should iron tablets be taken during day time or after dinner?*”, “*Can iron tablet cause itching?*”.

The common questions post-delivery constituted of problems related to delivery discomforts and body changes (42 questions, see the graph - health and happiness of mother in the figure 6.2), e.g., bleeding, discharge, stitches pain, etc. The second most sought topic in this phase was contraception (23), mainly concerning the Copper-T method (13). Few questions sought further knowledge on the safety extent of breastfeeding as a natural contraceptive.

Questions on the diet highlighted the prevalence of deep-rooted traditional practices (18). Corroborating with the various kinds of dietary restrictions during pregnancy and post-childbirth as reported by the prior studies [192]. ASHAs sought both reassurance and clarification of these practices. In only one question, an ASHA acknowledged the practices to be harmful and sought counseling tips. The rest questions showed how ASHAs carried on the misbeliefs and lacked scientific knowledge, for example, “*How many days after delivery should a mother take a bath?*”, “*Do infants frequently pass stools because mothers consume ghee (clarified butter)? Should less ghee be given to such a mother or not given altogether?*”, “*After the delivery if a mother is not given enough food and is given hot water so that her belly does not protrude out. Is this okay?*”

Queries on newborn care sought knowledge on the daily care of newborns (102), common health problems (43), and weight tracking (36). Examples of sub-topics under the routine care topic were umbilical stump care, massaging technique, bathing frequency, eye care, sleep routine, etc. Some of these, such as stump care, bathing frequency, and eye care, showed the need to address the communities’ prevalent malpractices. Monitoring the growth of newborns means tracking newborn weight gain week by week for the first 42 days. This is one of the critical knowledge components concerning newborn survival. However, the ASHAs showed significant gaps. In 32 out of 36 questions, ASHAs showed a complete lack of knowledge on the appropriate weight gain ranges, e.g. “*How much*

weight a newborn should gain in a week?". Also, ASHAs did not seem to have a good understanding of the factors associated with newborn growth, as shown below:

ASHA13, Group11: *"If a newborn's weight does not increase even if he/she is breastfed well, then what advice should we give?"*

Doctor: *"If this is happening, then the mother is not feeding the baby properly. You or the mother might feel that the baby is being fed properly when he/she is not. Proper feeding means that any worry does not bind the mother. It means that she is feeding the baby multiple times, both in the day and night. It means that she feeds only from one side at a time. The baby should not just suck on the nipple but put pressure on the areola; the baby's chin must be touching the mother's chest"*.

The topic of newborn temperature control, which requires more hands-on skills, reflected a poor understanding of the topic by ASHAs. 22 out of 36 questions were on body temperature. ASHAs showed confusion on measuring temperature, interpreting temperature readings, and taking corrective action, e.g., *"What should be the newborn body temperature in summers and winters?"*, *"If on touching a child feels warm but otherwise his/her temperature is normal then what we should do?"* The topic of play and communication had very few questions (13) covering basic questions on newborn development, five senses, and mother-child play and bond, all of the mild severity.

Recognition of Danger signs

The second most important information seeking represented problems of moderate to severe nature, holding 40% of queries (see table 6.8 and figure 6.3, 6.4). These were mainly about illnesses and diseases where ASHAs sought to improve their knowledge on distinguishing between danger and normal signs and necessary actions to take (a majority of the questions under danger signs represented severe conditions - shown in figure 6.4). The questions showed gaps in basic knowledge, for example, post-partum hemorrhage is one

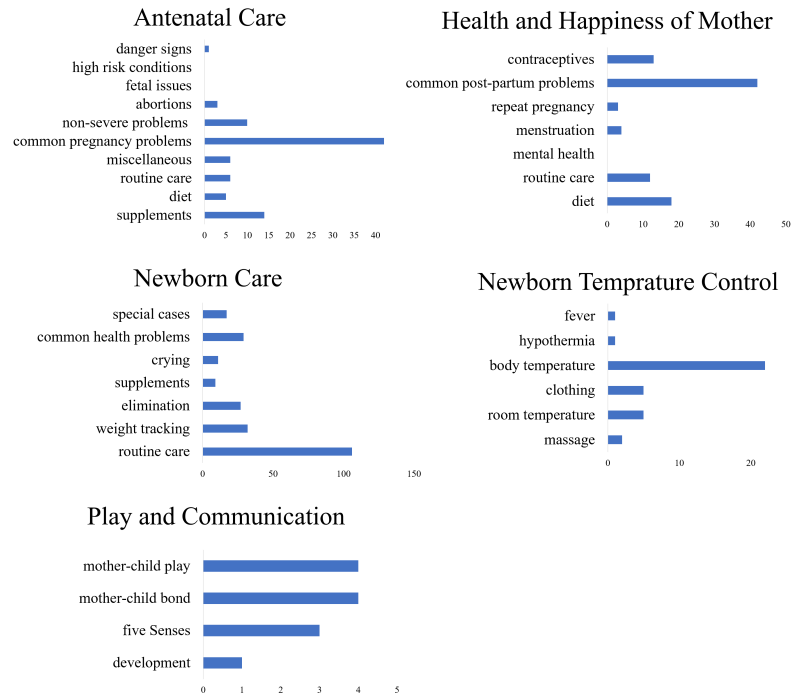


Figure 6.2: Topics and sub-topics of questions containing problems of mild severity
The figure describes the mild questions that were asked by ASHAs under different topics and sub-topics.

of the most common life-threatening danger sign, had maximum questions in danger signs in the mother category (11 questions, see figure 6.4), that is also covered in the training curriculum. However, ASHAs did not show clear understanding on recognizing the severity of bleeding such as “*If after the delivery a mother changes her pad 8-10 times in a day, then is it a danger sign?*”, “*After the delivery if the mother experiences heavy bleeding then what should be done?*” Likewise, 33 of 78 questions under danger signs in newborns reflected gaps in basic knowledge and skills (25 moderate and 53 severe). The prominent areas of questions were newborn diseases and congenital disabilities, followed by growth, breathing complications, and skin problems.

Breastfeeding Support

Breastfeeding, as a topic, emerged as an independent theme. Since breastfeeding is not a health problem but a natural phenomenon that requires skilled support, the questions were

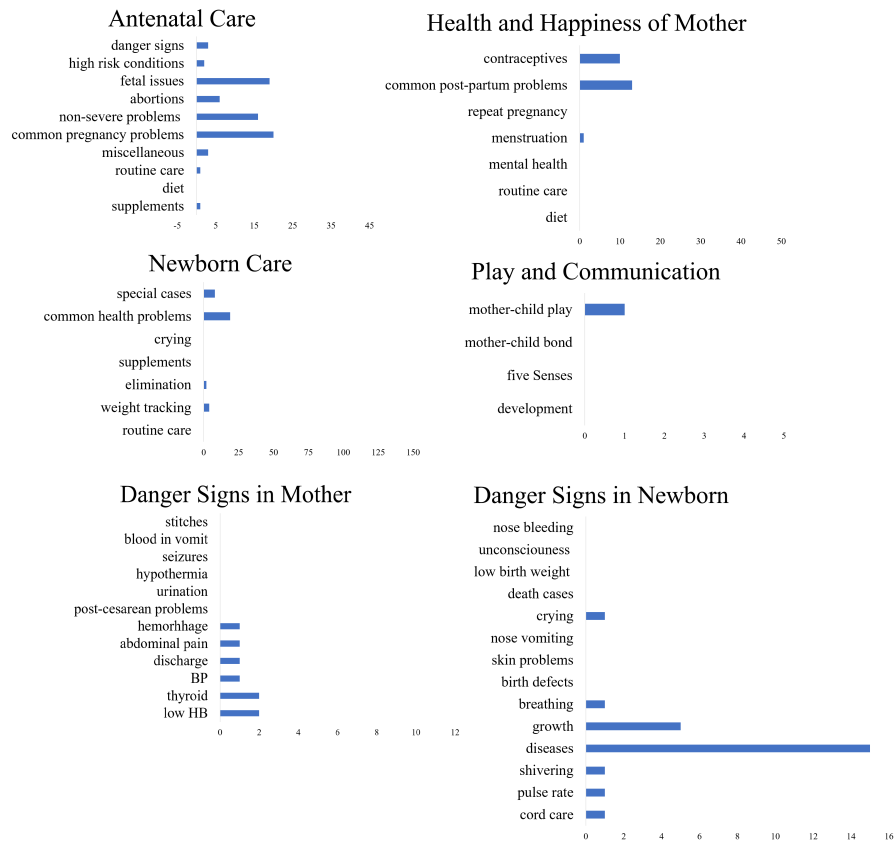


Figure 6.3: Topics and sub-topics of questions containing problems of moderate severity
 The figure describes the moderate questions that were asked by ASHAs under different topics and sub-topics.

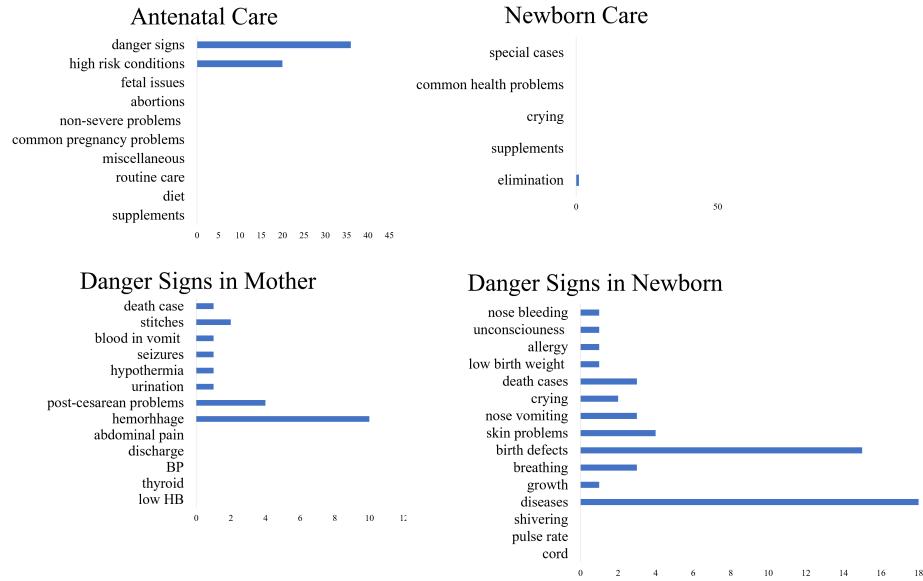


Figure 6.4: Topics and sub-topics of questions containing problems of severe severity. The figure describes the severe questions that were asked by ASHAs under different topics and sub-topics.

not judged as mild, moderate, or serious. Providing breastfeeding support is a core skill for ASHA and forms a part of fundamental knowledge improvement. We categorized the questions further into six sub-topics, as shown in the table 6.9.

Queries on the early initiation of breastfeeding (37) covered seeking tips on encouraging new mothers, providing counseling on initial concerns of milk supply, and teaching breastfeeding techniques. A key concern raised here was about how to ensure initiation of breastfeeding within one hour of delivery in case of cesarean sections, “*When a child is delivered via cesarean, then mother remains unconscious for hours, in such a situation, how can we facilitate the initiation of breastfeeding with the help of doctors?*” Cesarean section delivery adversely impact breastfeeding initiation is a growing public health concern [193]. It has been reported that many birth facilities do not follow the recommended best practices, e.g., keeping mothers and newborns together, facilitating skin-to-skin contact. Here, ASHAs also sought to understand how they could better support breastfeeding in existing hospital environments.

The core gap in the knowledge of ASHAs emerged about breastfeeding physiology

Table 6.9: Breastfeeding Queries Typology and Definition

Category (count)	Sub-Category (count)	Category (count)	Sub-Category (count)
Early Initiation of Breastfeeding (37)	cesarean deliveries milk production & newborn suckling concerns	Perception-based (73) problems	insufficient milk supply (36) child refusing breastmilk (13) breastmilk is harmful (14) mother not willing (4)
Breastfeeding Technique (39)	Positioning (4) attachment (3) frequency (4) one sided nursing (4) twins (6) triplets (1) low birth weight babies (11) inactive babies (1)	Breastfeeding discontinuation (38)	mother is sick (31) child is sick (2) mother is pregnant (5)
Breast Problems (43)	engorgement (3) cracked nipple (14) lump in breast (10) nipple shape (14) breast size (2)	Miscellaneous (9)	myth (1) introduction of water (2) diet (1) newborn death (2) dos and don'ts (2)

and technique. The questions and explanations covered under the topics - breastfeeding technique (39 questions), breast problems (43 questions), and insufficient milk supply (36), and child refusing breastmilk (13) in perception-based problems, majorly showed this. The root cause highlighted by the doctor for all these associated with ineffective breastfeeding technique - poor positioning, inadequate latching, and inadequate feeding frequency. A sample conversation is given below:

ASHA5, Group4: *“If the mother is breastfeeding the baby yet a lump forms in the breast, what should she do about it?”*

Doctor: *“Lump formation even after breastfeeding is a sign that the mother’s breast is not getting emptied. That is why she must not let her/him suckle the nipple when the mother feeds the baby. The baby should suckle on the areola, and then milk will come in nicely. if a lump has formed and is not dissolving, then you should not take any risk and refer the mother.”*

Maternal perceptions of breastmilk insufficiency is a common barrier to exclusive breastfeeding [194]. However, ASHAs’ mentions of the associated problems seemed to be no different from mothers. ASHAs even carried the prevalent community misbeliefs, for ex-

ample, considering breastmilk as being harmful to children. The understanding of exclusive breastfeeding was also observed as limited. ASHAs showed confusion and presented a variety of situations to understand whether to continue breastfeeding or not. For example, “*If a newborn has red rash/bumps at birth, can mother breastfeed the baby?*”, “*A mother has a six-month-old baby and now she is again pregnant, can she breastfeed her six-month-old baby?*”.

To know the current training duration on breastfeeding, we investigated two training officials of the region selected in our study. The breastfeeding topic is covered in less than half a day as part of the Home-Based Post-Natal Care training module. Besides this, there is no other specific training.

6.2.5 Mapping of Questions to Reference Material

The reading reference material of ASHAs is spread across seven modules, corresponds to their training modules. The official training of ASHAs covers these modules in two phases. The first phase covers module 1 to module 5, also called the induction training program, and the second phase covers module 6 and module 7 to impart skills on Home Based Post Natal Care, which we chose as our training topic. Overall, the seven modules cover 19 themes, which are covered in 23 days of training. These themes are further organized into lessons such that each lesson is 2-3 pages long and can be completed in half an hour, as mentioned in the books. Every lesson covers both knowledge and some skills aspects presented in simple language with fair use of illustrations and highlights. The information is presented in the form of a bulleted list that can be read and skimmed. However, the books do not provide information in the format of frequently asked questions, and one needs to search for information topic-wise.

Questions Coverage Proportion

We could classify the coverage of ASHA questions into three categories. First, the questions for which answers could be directly found in the content of the associated topic. Second, questions for which answers could be derived only partially because the present information is not complete enough to understand the concept fully or find a solution to a problem (a sample depicted in the table 6.10). Third, the questions whose answers could not be found either because the associated topic is not covered or the underlying problem is too specific. Of 997 questions, only 22% were covered, 15% were partially covered, and 63% were not covered.


Table 6.10: Sample of a partially covered question

Question: “if a mother experiences bleeding for 2 months post-delivery then what should we do”?
Material Content:

Complications during the post-partum period

Some women can develop complications after the childbirth. The symptoms of these major complications are:

1. **Excessive bleeding:** Ask the mother if the bleeding is heavy. Often this is quite obvious, but sometimes it may be difficult to judge. If the woman is using more than five pads a day or more than one thick cloth in a day, she is having heavy bleeding. You should immediately refer her to an institution which manages complications. You should also ask the mother to begin breastfeeding immediately, that should help reduce the bleeding. Referral is most urgent. Even the delay of a few minutes can make a difference.



Looking more into what is not covered, we now present our findings across the three themes discussed in the previous section - routine patient care, recognition of danger signs, and breastfeeding. Mapping a coarse analysis for the topics - antenatal, health and happiness of mother, newborn care, newborn temperature control, and play and communication with more than 70% of the problems as mild, 69% were found to be not covered in the reference material.

Table 6.11: Topic Wise Coverage

Topic	Covered	Not Covered	Partially Covered	Total
Breastfeeding	85	99	55	239
Danger sign in mother	8	12	9	29
Danger Signs in Newborn	10	64	4	78
Newborn Care	48	188	29	265
Newborn Temperature Control	11	11	14	36
Play and Communication	12	1	13	
Health and Happiness in Mother	10	104	9	123
Antenatal	45	136	33	214
Total	217 (22%)	626 (63%)	154 (15%)	997

Coverage Analysis

In the antenatal care topic with 61 questions under common pregnancy discomforts, only 12 were covered (see table 6.11). Forty-four were not covered, and five were partially covered. From all the common problems, only discharge and swelling in the body were covered as part of content under danger signs. Rest of the problem types which most mothers face, however, were missing in the reference material. The overall content on antenatal care (covered into two chapters over 20 pages) mainly talks about educating women on making antenatal contacts, watching for early signs of dangers, caring for anemia, educating on the importance of nutritious diet and iron supplements, helping women receive food-related services from nearest centers, and developing plans for birth preparedness [195, 196]. However, it does not provide any pointers on common discomforts, dos and don'ts, and general care information.

Likewise, from the 55 questions on common post-partum problems in the health and happiness of mother topic, only four were covered. Three of these, two on fever and one on bleeding, were covered under the section on complications during the post-partum period [197]. The fourth question about iron tablets' side effects was covered indirectly in the diet section under antenatal care. All other types of problems, such as pains, bleeding, vaginal discharge, stitches' discomforts, skin problems, hemorrhoids, and bowel movements, were not covered. The diet-related questions sought clarifications of prevalent misconceptions

(18/18), doubts and concerns related to body image and routine care (10/12), counseling support (6/7), menstruation (5/5), repeated pregnancy (3/3) were not covered. 10 out of 23 questions on contraception had missed topics on breastfeeding as a contraceptive, and oral and injectable hormonal contraception [198].

In newborn temperature control (36 questions), 11 were covered, 14 were partially covered. The remaining 11 that were not covered questions were about room temperature and methods of measuring temperature. The play and communication were not covered in the material at all.

On danger signs, 12 of 29 danger signs in mother (41%) and 64 of 78 questions on danger signs in the newborn (82%) were not covered (see table 6.11). On danger signs in mother, post-cesarean problems, thyroid problems were not covered [197]. From the 11 questions on excessive bleeding, six were directly covered. The remaining 5 represented case-specific problems, e.g. *“There is a case in which the bleeding of the mother stopped after 15 days of delivery; however, started again after some days then what to do?”*. Of these, four were partially covered, and one was not covered.

For Danger signs in newborns, the not covered topics majorly came from newborn diseases (30), skin problems (4), and congenital disabilities (15). A common disease that most newborns develop immediately after birth is jaundice, which mostly remains mild to moderate but becomes serious and needs referral and is listed as a common danger sign. There were 11 questions on jaundice, all of which were not covered. We found only one line of information on jaundice covered as part of the section - Neonatal Sepsis: Diagnosis and Management, written as *“When to refer baby - becomes yellow (jaundice) on the first day or jaundice persists after 14 days”* [198]. Congenital disabilities, which have been reported to high in rural India, constituted of 15 questions and were included in our training intervention were also not found to be covered.

Finally, in the 239 questions of breastfeeding, 85 (36%) were covered, 99 (41%) were not covered and 55 (23%) were partially covered (see table 6.11). The prominent areas

in which the questions were not covered included breastfeeding technique (15), discontinuation of breastfeeding due to sickness of a mother or newborn (38), and attitudinal and perception-based problems (27).

The 15 questions not covered under breastfeeding technique included specific problems, cases of twins (6), triples(1), low birth weight cases (4), and one-sided nursing (3). The content concerning the continuation of breastfeeding during the mother's or child's sickness was inadequately covered. The section on "Engorged and painful breasts (very full breasts)", in Book 6, contained one statement as "She should continue to breastfeed (from both sides) even if she is taking antibiotics". Under the category attitudinal and perception-based problems, there were 73 questions that constituted four types of questions - not enough milk, a child refusing breastmilk, perception of breastmilk being harmful, and mother not willing to breastfeed (see table 6.9). From these, 32 were covered, 29 on not enough milk and 3 on child refusing to breastfeed, the rest two categories as mother's perception of breastmilk being harmful (11), which is a myth and mothers' unwillingness to feed were not addressed (3). The counseling component, which is a crucial skill for addressing perception-based problems, was not explicitly explained. There were only general tips for communicating with mothers and mentions of causes. For instance, the section on "not enough milk" only list causes such as, e.g., mother's anxiety, exhaustion, insecurity, and inadequate family support without elaboration.

6.2.6 Training Experience

In this section, we present the interview findings of the training experiences of ASHAs and their feedback for the future.

Perceived Benefits

While most of the ASHAs liked all the three features of the systems - content listening, Q&A with the doctor, and peer to peer group discussion - the interaction with the doctor

was most strongly preferred. 29 ASHAs liked all the three features, 5 liked two - interaction with the doctor and peer-to-peer interaction, 3 liked peer-to-peer and 3 did not answer. To the question “Would the system without the feature of interaction with doctor be good?”, 32 said no and emphasized on the necessity of the presence of doctor in training. The potential pitfalls with ASHA-only system pointed were the authenticity of information, inability to arrive at correct conclusion in group interaction, and less benefit in gaining knowledge from peers than experts.

With dedicated time allocated to questioning and answering with a field expert every day, the ASHAs mentioned they could effectively discuss their field problems. This was reported as important because of the lack of regular forums for problem-solving.

Moreover, ASHAs acknowledged the respect they received as health workers. Prior studies have reported issues with recognition of ASHAs as health workers, which was reflected in the views, for example, “*One benefit that I felt was that there is someone who understands us and would listen to us. Because sometimes our doctors and nurses are not able to understand our point. But they (trainers) listened to us very patiently and carefully.*” (ASHA1, Group11)

By receiving expert guidance, ASHAs felt more confident in facing their clients, expressed as follows.

“If we are unable to give them [clients] correct guidance, we feel like a failure, but when we are able to guide them effectively, then we feel successful and that we have executed our responsibility correctly. So that is what I asked the doctor about and he explained very nicely that things are like this, do this, do that, if they still do not understand, counsel them like this. Moreover, the rest of the things we learn by practice”. (ASHA2, Group16)

On the extent of interaction with trainers in existing face-to-face training methods, ASHAs commented that while they interact with trainers in the sessions, that is more limited to clarifications of doubts on the training topics. The training schedule remains

typically tight with limited scope for discussion on day to day field queries.

In addition to getting help in problem-solving, the training intervention served the purpose of refresher training. ASHAs said that they receive training as and when new programs are launched; however, they do not get opportunities to refresh older topics. The use of reference material did not seem to be effectively used. While mentioning the benefit of direct interaction with experts, ASHAs said that they do not get time to read the material and prefer verbal communication.

Usability

As reported in our prior studies, this deployment also found sub-optimal cellular connectivity as a key challenge. Due to lower signal strength, call drops were frequent. According to the logs captured by our systems, 86% of ASHAs (428/500) experienced at least one call drop in every session, and 30 ASHAs experienced more than three call drops in a session (max was 7). Further, troubleshooting activities due to poor internet connectivity at the trainers' end and issues on the server-side added to the inconvenience. When we asked the ASHAs about their experience of attending the sessions, 20 (out of 48) mentioned the connection problems and mainly complained about the voice quality issues. As a result, one ASHA even preferred a traditional brick and mortar training mode over this mobile-based.

Another challenge observed by some of the ASHAs related to making adjustments with the training timings. The morning hours did not suit them as they had to be in the fields for usual ASHA work. Even after prior notice, they had to skip some sessions, sometimes because of meetings with supervisors and other times to serve urgent duties. These were on top of domestic responsibilities, which are typically quite demanding, expressed as “*By the way, it is also important that housework is also necessary, work had to be done at that time. I used to get the phone call while cooking, and you know, family members would then speak.*”

Feedback

Feature-wise, ASHAs suggested making the audios available to them for offline use over WhatsApp or in other form. Some ASHAs also wished for videos so that they can show them to their clients during home visits. Interaction feature-wise, ASHAs suggested to keep all the three and did not show an inclination towards using the system with only peer-to-peer interaction feature. An expert's presence was deemed important to have authority and authenticity in the information. For timing concerns, a suggestion was to keep their departments well informed and not just immediate supervisors. For the frequency of mobile-based training, 31% desired for once in three months, 40% desired for once in six months, and 29% once in a year.

Topic-wise, ASHAs found breastfeeding and danger signs as the two most impactful areas to learn on. ASHAs said that as they frequently face complex health situations such as recurrent abortions, pre-term deliveries, newborn deaths, they need more training to develop a good understanding of recognizing dangers early on.

6.3 Discussion

As we observed, most of the questions pertained to day to day care concerns and common health problems (more than 60%). This is the area that requires the most improvement. ASHAs showed significant gaps in their basic knowledge to address their clients' needs. We now discuss three potential areas to focus on.

6.3.1 Improvement in Reference Material

We observed two concerns with the use of existing reference material. First, the material is not used by ASHAs, and second, the material does not sufficiently cover common queries.

Regarding the non-use of material, though we did a coarse level of inquiry, we noted that ASHAs prefer discussion-based learning over reading text. ASHAs find reading text

to be time-consuming and want something that can directly answer their questions. This is one of the reasons why ASHAs favored interaction with the doctor as the most useful feature of our system. While the requirement of enhancing the content design in the form of FAQs and problem-solving exercises is clear, it is essential to investigate the usability further. Understanding how ASHAs comprehend the material will help recognize better the cognition challenges ASHAs might have due to considerable variation in their education and literacy levels [199].

Likewise, the investigation should also extend to other forms, such as those designed specifically for use in the fields. Prior studies have reported less use of pictorial flip charts by ASHAs in their home visits.

Project - Mobile Kunji - provides a successful example of using flashcards in this case [131]. The project combines flashcards with an IVR application to assist ASHAs in their dialogue with women in-home visits. Flashcards are an effective way of reinforcing spaced learning. Flashcards are a handy resource that has been found useful for every stage of class [200]. Flashcards are also more appealing to visual learners like ASHAs who generally have low exposure to formal schooling. Further usage of Flashcards or alternate interventions may be explored to support ASHAs in the field.

The second aspect is to improve the coverage of the existing reference material. Overall, we found 63% of the questions to be not covered - 69% in routine patient care, 70% in danger signs, and 41% in breastfeeding were not covered. By developing a typology of the questions, we provide the coverage information further in detail and create a resource for future work. This calls for enhancing the existing material and thinking of other solutions to cater to the information needs of ASHAs. Further, we also suggest to improve the content analysis by going deeper into understanding the nature of questions - fact-based or case-based etc.

6.3.2 Design Guidelines for Mobile-Based Training Solutions

Our findings showed the importance of providing a forum for interaction with experts to ASHAs. In addition to knowledge improvement, two key benefits highlighted were improved communication with clients and problem-solving skills. ASHAs tried to learn by discussing their field cases with the expert. This helped them understand the systematic ways of making conversations with their clients and arrive at appropriate decision-making. The majority of the ASHAs desired such mobile-based training at a frequency of twice a year. This is encouraging to find. However, given that there are acute shortages of experts in the developing settings [201], it is crucial to employ better training designs. So that technology use and human effort can be balanced. This suggests shifting the effort of answering repeated and fact-based queries to the machine and use experts' resources for improving decision-making skills. This also implies incorporating automation in the training process with a focus on the use of pedagogical techniques to encourage self- and peer-learning [202, 203, 204, 205]. Prior work has shown promising results of employing spaced education and offline learning formats [206]. Designing coursewares for CHWs that can be delivered through inexpensive feature phones is a potential research direction.

Further, given that the smartphone penetration is rapidly increasing in poor regions and increasing news of equipping ASHAs with smartphones [207, 208], it is worth to design richer applications. Our study observed that though the IVR-based platform provided an advantage of reachability, it was limited in user experience, e.g., dependency on voice-based communication. Smartphone applications will help in supporting visual learning and delivering learning resources for offline use.

Another factor to consider in providing mobile-based training interventions is the workload of ASHAs, which is not limited to just the official duties but domestic responsibilities [209]. Corroborating with the prior studies [14, 204], we observed time challenges with ASHAs. Due to high engagement in the fields, urgent community needs, and family responsibilities, it became difficult for some of the ASHAs to attend all the sessions. This

calls for attention at multiple levels - human-centered design in HCI, program management, and policymaking. Designs taking care of the intersections CHWs are positioned at have the potential to further the aspirations of CHWs in becoming a credible health workforce [209]. Kumar et al., through their reflexive analysis of three mHealth project deployments draws attention to the impact on the stability of an organization on the introduction of new technologies [210]. Any form of technology introduction in the work lives of ASHAs leads to reconfiguration at different levels such as communication with coworkers, power relations, and community relationships. Factoring in these at the right stage of design is important in order to aim a fruitful, scale deployment.

6.3.3 Directed Attention on Breastfeeding

Breastfeeding has an important role in child survival and child health. The Lancet series on child survival identified breastfeeding interventions to have the potential to prevent 13% of all under-5 deaths in developing areas of the world, ranking it as the most important preventive measure [211]. Hence, the promotion of breastfeeding is an integral part of all maternal and child healthcare-related programs in India and, therefore, a core responsibility of the ASHA [46].

Also, as an activity post-delivery, breastfeeding immediately becomes central in which both the mother and the healthcare worker are required to be effectively engaged in. Right from the initiation to the first few weeks of postpartum, breastfeeding entails challenges that need skilled support [212, 213]. As evident from our study, ASHAs had the maximum number of queries on breastfeeding, asked by a maximum of them (177 ASHAs). However, these queries showed a clear lack of knowledge on fundamental concepts and skills to support mothers. The key gap highlighted is that ASHAs lack knowledge to address the breastfeeding barriers. Outside influences such as advice given by female relatives and friends have been reported to be a major interference to breastfeeding practice which impact perceptions of the mother on milk supply and her confidence to continue exclusive

breastfeeding. Exercise of traditional practices such as adding pre-lacteal food and mixing breastfeeding with animal milk is common in India, (also reported by us in Chapter 8) [214]. The questions of the ASHAs showed that they too believed in such practices.

The reason behind the lack of knowledge is evident from the fact that training on breastfeeding is inadequate on the ground. As per our investigation, ASHAs receive only 2-4 hours of training on breastfeeding as a part of their HBPNC training module. This is substantially low as compared to the international guidelines. According to WHO/UNICEF Breastfeeding Hospital Initiative (BFHI), all health care staff who have any form of contact with mothers, infants and/or children must receive at least 18 hours (five days) of training on breastfeeding and lactation management [215]. Further, the training is not aligned with the expectation documented in the training curriculum where ASHAs are seen as a vehicle for promoting exclusive breastfeeding through counselling support [197].

Overall, we find that there are two primary needs. The first is to improve the training on the ground with a focus on improving fundamental concepts and counselling skills. The second is to tailor the training content according to the community needs to enable ASHAs to address the prevalent socio-cultural barriers of breastfeeding.

Chapter 7

Semi-Automating the Curation of Training Material

One of the requirements highlighted by the ASHAs in all of our field studies was to have access to training audio recordings for offline use. Particularly, for on-demand access to topic-wise content during client visits. Such access would help ASHAs to augment their dialogue with clients and develop knowledge organically by discussing the topic information at the point of its real application. This meant providing an easy-to-use digital audio library that contains recordings of the training topics and frequently asked questions. To achieve this, the basic task is to organize, tag, and categorize the audio recordings; however, this is time-consuming because it has to be performed manually. Due to the non-availability of automatic methods for local languages, in our case, it was Hindi with a mixture of its variations, the process of curation becomes challenging when data volume increases. In fact, content curation and moderation have been a bottleneck problem in the sustainability of voice-based forums.

Existing large-scale forums such as CGNetSwara [18] and Gram Vaani [65] employ dedicated teams of full-time moderators for the curation tasks. Example of moderation tasks includes screening the quality and legitimacy of voice messages, ranking messages in the IVR menus, selecting good messages for publishing at other media forums. Human-based curation, while has merits on judgment and quality aspects, impedes scalability. Prior work, SangeetSwara [21], and Gurgaon Idol [216], have investigated community moderation mechanisms for voice forum content management. Here users could upvote and downvote audio recordings to influence the playback order and categorize the content based on voice quality. Another work by Vashistha et al. proposed a crowd-sourced system that enables people who speak and understand these languages, particularly the low literates, to transcribe in an easy manner [217]. It works by assigning short utterances of audio to multi-

ple users, collecting clearer re-spoken versions, and estimating the best transcript. However still, these are human-dependent approaches, and the main problem in applying any automatic language processing technique has the non-availability of good-quality transcriptions of audio recordings. Manual transcription is extremely time-intensive and costly.

This chapter addresses the challenge of automatic curation by exploring a semi-automated approach for categorizing and labelling audio recordings. We used low-accuracy transcripts generated by Google Speech Recognition APIs and applied basic natural language processing algorithms such as topic modeling and extractive summarization to cluster and summarize audio recordings. We based our research around these questions: given the audio transcripts of low accuracy, how can the standard techniques of natural language processing and information retrieval be leveraged to automate or semi-automate the basic curation tasks of clustering, tagging, and summarizing, and will that type of curation be found relevant by the end-users? The specific research questions were:

- **RQ1:** Are topic models useful for clustering the voice forum dataset?
- **RQ2:** Is the relevance perception of the automatic annotation similar to manual annotation?
- **RQ3:** Is the relevance perception similar across summary types (summary as a sentence, summary as a group of keywords)?
- **RQ4:** Does the preference of the users for the type of summary change based on the annotation source (human versus machine) and annotation type (summary sentence versus group of keywords)?

We attempted to address the above research questions through a field trial with 48 ASHAs⁵. Our evaluation showed that the users found topic annotation relevant with the

⁵Deepika Yadav, Mayank Gupta, Malolan Chetlur, and Pushpendra Singh. 2018. Automatic annotation of voice forum content for rural users and evaluation of relevance. In *Proceedings of the 1st ACM SIGCAS Conference on Computing and Sustainable Societies, COMPASS*, 1–11.

audio clusters. In the case of annotating audios with the summary, the relevance perception varied between manual and automatic annotation, but automatically generated summaries were still found to be useful to access the voice forum audios.

Our primary contributions in this chapter are: (i) developing automatic annotation of voice forum data for rural users, (ii) developing a Hindi corpus of training material of community health workers and (iii) understanding user's perception (relevance, preference) of automatic annotation in comparison with manual annotation through a field trial in northern India.

7.1 Dataset

In this study, we used the audio dataset of our first field study - *Sangoshthi* - which was in the Hindi language with its variations due to a mixture of dialects and different accents. The data comprised audio recording of the training content prepared by the experts (10 audios, 150 minutes) and the Q&A recordings between the doctor and the ASHAs (175 audios, 350 minutes). A Q&A audio was composed of a question asked by a health worker and its answer given by a doctor and had a duration of 2 minutes, on average. We used the Google Speech Recognition engine for transcribing the audios considering its availability, ease of use, and coverage of languages [218]. The APIs offer both real-time and offline transcription services along with a feature to get timestamps of the transcribed words that we later used in constructing the audio summaries. The produced transcripts had an average word length as 129 (min 20, max 401) and average confidence score (estimation of the correctness of recognition) normalized by word count as 0.91 (min = 0.73, max = 0.93). The word error rate (WER) was computed as 67% on a subset of audios (41) that were selected randomly for manual transcription. The high noise in the transcripts was mainly due to the factors of type of communication channel (telephony), use of regional accents, and the nature of speech which was spontaneous.

Further, we also created our domain-specific corpus covering the training material of

ASHAs of India because corpora for the Hindi language, particularly of the health domain, are limited. The content was collected from various resources available at different websites of National Health Mission, the government organization managing the Community Health Workers program [41]. The text was cleaned and tokenized to form a corpus containing 12,513 sentences and 166201 tokens. We have made our corpus publicly available¹.

7.1.1 Pre-Processing

Before applying any text-processing techniques, the raw transcripts were pre-processed to filter out the noise. This involved stop-words removal, parts-of-speech (POS) tagging, stemming, and removal of words that were typical of the telephonic conversation (hello, welcome, etc.). Post these steps; we selected nouns and adjectives for further processing. For tagging parts-of-speech we used the tagger for the Hindi language developed by [219].

7.2 Methodology

In this section, we describe the semi-automated approach of developing an IVR-based library consisting of audio recordings of the Q&As generated by the *Sangoshthi* voice forum. For simplicity of use, the structure of the IVR application consisted of only two levels. The first level was composed of the broad topics of the library and the second level that of the corresponding audio recordings. Figure 7.1 illustrates the steps followed; the overview of the two key steps of the curation process are:

- i Theme classification - This step pertained to the task of finding themes in the dataset comprising Q&A audio recordings using topic modeling technique. This step mapped to the creation of the main menu of the IVR. Once the audio clusters were created, human intervention was used to construct labels for these themes.
- ii Audio Summary Creation - This step pertained to the task of constructing audio summaries of the audio recordings accessible on the second level of the IVR.

¹https://github.com/deepikay/ASHA_Corpus

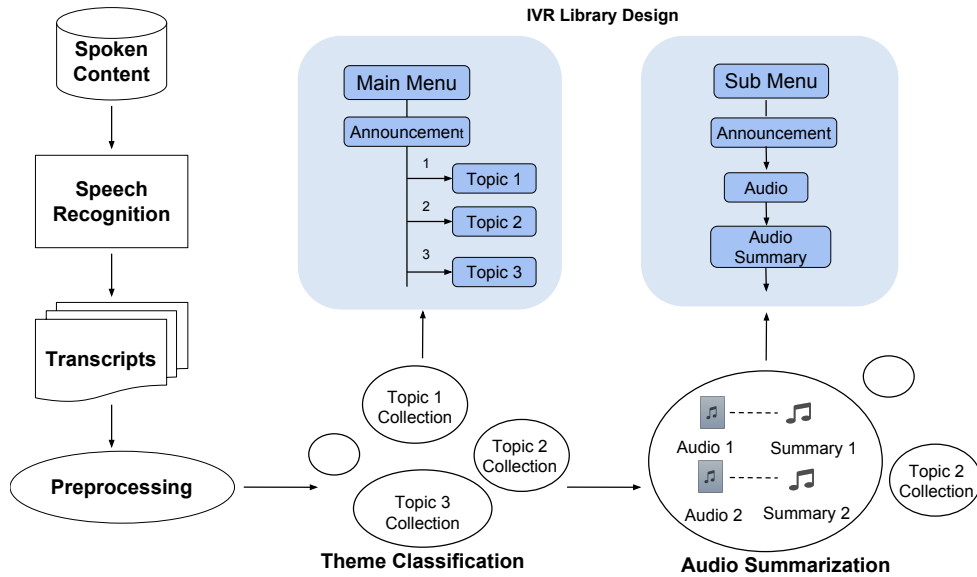


Figure 7.1: Curation Methodology

7.2.1 Theme Classification

Topic modeling is a widely used technique to discover themes in a collection of text documents. It is an unsupervised data-driven approach that takes a bag of words as input and generates output in the form of document-topic and topic-word distributions. Topics are represented as sets of top- n words ordered by their marginal probabilities, e.g., Topic 1: {newborn, breastfeed, milk, mother}, Topic 2: {hospital, medicine, doctor, vaccination}. Topic modeling has been successfully applied in the retrieval, presentation, and summarization of course material. For example, Podcastle [220] [221] for the searching of podcasts in Chinese and Japanese languages, MIT lecture browser [222] for topic-wise navigation of the course material, and NTU virtual instructor [223] for supporting on-demand learning by organizing the course lectures semantically. However, these cases had standard languages with fair quality of speech transcripts.

While deciding which topic modeling algorithm to apply on our dataset, considering its short transcripts, we had two choices: Latent Dirichlet Allocation (LDA) and Bi-Term Topic Modeling (BTM). LDA [224] is one of the most standard algorithm; however, gets affected by data sparsity found in short text documents such as messages, tweets etc.

Whereas, BTM [225], which is an improvement over LDA, is able to handle the sparsity problem by modeling word co-occurrences explicitly at corpus level instead of document level as done in conventional topic models. Before adopting BTM, we verified empirically by applying both of the algorithms on our dataset. The analysis was performed using two popular metrics, namely coherence score [226] and PMI-score [227]. These metrics measure the quality of generated topics in terms of coherence between the constituent words, based on the underlying assumption that words describing a single concept tend to co-occur. Given a topic t and V^t as the list of K most probable words, the coherence score is calculated as:

$$C(t, V^t) = \sum_{k=2}^K \sum_{l=1}^{k-1} \log \frac{D(v_m^t, v_l^t) + 1}{D(v_l^t)} \quad (7.1)$$

where $D(v)$ is the number of documents in which the word v appears and $D(v, v')$ is the number of documents in which the words v and v' appear together. While the coherence score looks for word co-occurrences in the corpus on which the topic modeling is applied, which in our case were the Q&A transcripts of the *Sangoshthi* dataset, the PMI-score refers to external data sources, e.g., Wikipedia. For PMI-score calculation, we used two data sources, covering the training material of the health workers(ASHAs), one was the corpus created by us and the other available in the *Sangoshthi* dataset. The formula of PMI-Score calculation for all unique word pairs is as follows:

$$\text{PMI-Score}(t) = \frac{1}{K(K-1)} \sum_{1 \leq i < j \leq K} \text{PMI}(w_i, w_j) \quad (7.2)$$

where $\text{PMI}(w_i, w_j) = \log \frac{p(w_i, w_j)}{p(w_i)p(w_j)}$, $p(w_i, w_j)$ and $p(w_i)$ are the probabilities of co-occurrence of the word pair and the word, computed using a sliding window of word size 10 [227].

In this experiment, we compared the performance of LDA and BTM by varying topic sizes from 10 to 50. Since on every run of the algorithms, the output distributions change slightly, we considered the output of 10 runs in each topic size category. Hence, the overall

score for a topic size was averaged over the runs. For the number of words in a topic, we followed the convention of representing a topic via its top-10 words as usually ten words are able to convey sufficient information about a topic [226, 227]. The computed coherence scores and PMI-scores for the LDA and BTM are shown in the table 7.1. Higher scores represent better coherency in the topics. Clearly, BTM performed better than LDA. Further, to finalize the number of topics for the library, topic size 10 was selected due to its high score. Also, ten topics seemed appropriate according to our prior knowledge that the Q&As were around the fixed ten topics on which the training was given in the *Sangoshthi* deployment [58]. Typically, selecting the number of topics is a heuristic-based approach where expert knowledge is used and developing an automatic metric is still an open problem [224].

Table 7.1: Topic Coherence Based Comparison of LDA and BTM

Topic Size	Coherence Score		PMI-Score	
	LDA	BTM	LDA	BTM
10	-89.4 ± 1.6	-72.9 ± 1.3	0.09 ± 0.03	0.08 ± 0.03
20	-85.8 ± 2.9	-77.3 ± 1.5	0.08 ± 0.05	0.08 ± 0.04
30	-84.2 ± 2.1	-78.6 ± 1.0	0.06 ± 0.04	0.08 ± 0.03
40	-81.7 ± 2.1	-78.5 ± 0.7	0.05 ± 0.02	0.07 ± 0.04
50	-79.1 ± 2.6	-79.0 ± 1.2	0.08 ± 0.04	0.05 ± 0.04
Mean Score	-84.10	-77.30	0.07	0.08

Topics Labeling

Automating the creation of intuitive labels for the topics i.e. textual phrases, to make them easier to understand is a challenging problem. For the current study, we considered using a manual approach to produce more natural constructs, where, given a set of words for the topics, our goal was to use them in constructing general sentences with the caution of adding no specific meaning. This activity was performed by one of the authors who had familiarity with the domain and the data. Table 7.2 presents the English translation of some of the selected topics with their labels. While constructing these sentence-style representations, not all the words in a topic were used, as few of them did not contain any

useful meaning. For example, in constructing the phrase for the topic 2 - “baby, matter, mother, weight, nice, day, light, card, normal, quite so” as “this topic discusses the weight and growth-related matter of the newborn,” the words “quite so”, “nice” were not used as they did not hold any useful meaning for the context. Also, here the domain knowledge of the coder plays an important role. Since the coder knew that the word “card” represented the MCP card (Mother Child Protection Card) which is used for monitoring the growth of a baby, she then constructed the phrase accordingly.

7.2.2 Audio Summarization

In a document collection, after the generation of themes and their labeling, document summarization is an important task to help users access the content in an efficient way. This is particularly important for audio-only interfaces where information is rendered sequentially. We generated two types of machine-created summaries, namely keyword-based summary, and sentence-based summary. While the keywords-based summary annotates audio with a group of words, the sentence-based summary annotates with a representative extract from the audio itself. The subsections below describe the methodology of constructing the two types of summaries.

Sentence-Based Summary

Creating audio summaries from transcripts requires text summarization techniques which are of two types; extractive and abstractive [228]. Extractive summarization generates a summary by concatenating the important segments of the text, and abstractive summarization applies linguistic methods to create condensed and syntactically correct formats. Extractive summaries are easier to create and are widely used. Both supervised and unsupervised approaches have been explored [229, 230, 231]. In comparison to well-structured forms such as broadcast news, summarization of spontaneous conversations is challenging due to the high rate of disfluencies, redundancies, and recognition errors [232]. Neverthe-

less, extractive summaries have been found to be effective in document retrieval [233].

In the speech corpus, we applied extractive summarization by first identifying useful sentences in a transcript and then fetching the audio segment corresponding to the most representative sentence. Although generally extractive summaries are composed of multiple sentences per document, we selected only one sentence per transcript because the Q&A audios in our dataset were of short duration (2 minutes). The three-step process is as follows:

1. Selection of Candidate Keywords - Since the significance of a sentence is characterized by the significance of its constituent words, the selection of candidate sentences was preceded by the identification of keywords. Typically, candidate keywords are selected following heuristic rules, which generally include stopwords removal, POS-tagging, and selection of n-grams based on some criteria. We performed these steps in the pre-processing stage that gave us a collection of words belonging to two parts of speech as nouns and adjectives. Further, to extract important words among these, we used the tf-idf (Term Frequency-Inverse Document Frequency) statistic. The top 10% of the words ranked by tf-idf weight were selected as the candidate keywords for a transcript. The tf-idf technique is an effective technique, however, in case of noisy transcripts, it can lead to weighing of misrecognized words as high. Nevertheless, this gets compensated when the corresponding audio segments are fetched.
2. Selection of Representative Sentence - Now that we had a set of candidate keywords for a transcript, the selection of the most representative text segment was achieved by analyzing the neighborhood of the keywords. For each keyword location in its transcript, a window of 10 words with the keyword in the middle was checked for the presence of rest of the keywords and scored on the basis of total keywords present. The score was computed as the sum of tf-idf weights of all the keywords that appeared in the window. Here, the sum score was normalized by the count of keywords to avoid giving preference to the text segments having multiple keywords with low

tf-idf ranks as opposed to the ones having one or few high rank keywords. Finally, the window with the highest score was selected as the most representative text segment of a transcript.

3. Selection of Audio Segment - The audio summaries were generated by extracting the relevant audio portions for the selected text segments. For this, we used the timestamp information given in the transcripts. Since the text segments were not grammatically correct sentences due to missing speech recognition, we did not directly extract the audio segments from the start and end timestamps of the first and last words of the text segments. Instead, we fetched the audio segments between two natural pauses occurring before and after the first and last timestamps respectively. While extracting the audio segments, each was checked for its duration against the limits set as a minimum of 4 seconds and maximum of 12 seconds. The duration thresholds were found out by conducting lab testing. An audio segment not fulfilling the duration criteria was discarded, and the step would get repeated for the next preferred text segment.

Keywords-Based Summary

We explored another more abstract way of summary creation that represented the high level idea of an audio through a set of keywords. After selecting the required number of keywords for a transcript using the steps described in the previous subsection, an important question in constructing the audio form was whether to use machine synthesized speech or extract their utterances from the audios. To address this, we conducted lab testing. Given a set of keywords for an audio, when their utterances were concatenated to form a single audio summary, it brought uneven transitions between consecutive words due to variation in pitch and background noise, leading to lack of clarity. On using Google text to speech conversion engine, we found better quality. However, the main concern in regard to text to speech conversion engine was because of the presence of the mis-recognized words which

are directly used for speech production. To overcome this, we regenerated the keywords by incorporating an additional step of removing irrelevant words after the pre-processing step and before the tf-idf scoring. The pre-processed words (nouns and adjectives) per transcript were checked for their presence in the two corpora (ASHA training material) and the list of most frequent words of the collection (taken as the top 10%). Although this step ensured that no out-of-domain words were selected, it led to the loss of some useful words. We chose the number of keywords per audio to be seven following the guidelines by [234].

To evaluate the automatically generated summaries, we prepared a baseline of manually created summaries for an audio set that was later used in the field trial. This coding activity involved three participants - two authors and one master's student and was performed in two stages. In the first stage, all the coders individually generated their summary versions, and in the second stage, one of the coders, who had better domain knowledge, selected the final version of the summaries. In the case of keywords-based summaries, the number of keywords per audio was consistent with the automatic method (seven). Once all the coders had tagged every audio with a set of seven keywords, the main coder selected the final set of keywords by following a procedure in which she first hand-picked the common keywords with at least two coders followed by the addition of the remaining keywords by selecting from her set of keywords. The average number of common keywords found per audio was five. Note that the keywords were selected from the audios and not constructed by the coders. In the case of sentence-based summary, the coders were asked to summarize every audio in one sentence, which was similar to title creation. To generate the best summaries, the main coder, based on her judgment, either chose the best among the three summaries for an audio or constructed a new one by combining their idea.

7.3 Experiment Design

In this section, we describe the details of a within-subjects experiment design that we conducted to evaluate our approach of curation. The dependent variable is the user ratings and

independent variable is the type of audio annotation and clustering.

7.3.1 User Judgments

To evaluate the usefulness of automation in real-world scenarios, we conducted a user study with the 48 community health workers (ASHAs) in India and collected their judgments on the components of the library which were curated automatically. These judgments were of two types as follows:

- **Relevance Judgments** - Users' judgments of relevance were collected on two components of the library. One was on the quality of audio clustering that was associated with the audios and their allocated themes, and the other was on the quality of audio summaries. The judgments were collected on a three-point Likert scale, namely, 1—not relevant, 2—moderately relevant and 3—relevant.
- **Preference judgments** - Since users were made to listen to two types of audio summaries (sentence and keywords), their preferences were collected on a four-point Likert scale as 1—sentence-based summary, 2—keywords-based summary, 3—both, 4—none.

7.3.2 Testbed

In order to do an effective evaluation, we designed our testbed in such a way that users were exposed to different testing conditions. Every user was supposed to listen to two versions of the library having audio summary types as sentence-based and keywords-based, which could be human created or machine created. Overall, we had four combinations of modalities as shown in the Table 7.3. Therefore, we divided 48 users into four groups, assigning each to one of the testing conditions randomly.

We used Freeswitch, an opensource telephony platform, to develop the IVR application of the library. Users were provided a phone number on which they could call and listen

Table 7.2: Topics and Labels

Topic	Words Distribution	Label
1	baby, matter, milk, mother, night, nice, month, know, day, hospital	this topic discusses on the cases related to newborn going to hospital, care of newborn in the first month and feeding problems
2	baby, matter, mother, weight, nice, day, light, card, normal, quite so	this topic discusses about the weight and growth related topics of the newborn
4	baby, matter, delivery, milk, mother, day, stomach, quite so, problem, water	this topic discusses about issues related to delivery, problems related to mother or baby and newborn feeding
8	baby, matter, milk, mother, family, nice, important, quite so, water, problem	the topic discusses about important aspects related to the families of newborn, newborn feeding, and problems related to mother and newborn
9	baby, milk, matter, mother, day, month, harm, reason, important, problem	this topic discusses about newborn care in the first month, newborn feeding, and problems related to mother and baby
10	baby, matter, milk, day, harm, beautiful, nice, reason, mother, eyes	this topic discusses about the five senses of newborn, newborn feeding, and problems related to mother and baby

to the contents of the library. To make the calling activity free of cost for the users, the system was designed to work on the model of the missed call. A user wishing to listen to the library, would have to drop a missed call to the given phone number and connect to the IVR application on immediate callback.

The users' judgments were collected in two phases corresponding to the evaluation of the two versions of the audio library. A single phase could be completed in one or more calls depending on the convenience of the users. The relevance judgments were collected while listening to the library content, and the preference judgments and overall feedback were collected at the end of the second phase.

Table 7.3: Testing Conditions

Condition	Type 1	Type 2
1	human keywords	human sentence
2	human keywords	machine sentence
3	machine keywords	human sentence
4	machine keywords	machine sentence

7.3.3 Library Content Selection

Considering the userbase of community health workers, who have limited literacy and technological exposure, we tried to keep the design of the IVR application simple with a small number of items. The first level of the IVR consisted of only three topics and the second level consisted of two audios under each topic. We selected the topics and the audios for the user study using the criteria of maximizing the coverage of audios in the dataset and

keeping the minimum required number of users (four) for the evaluation of every item. Therefore, two sets of topics for the two versions of the library (sentence and keywords) were used in the study. These six topics were selected randomly from the set of ten topics generated by the topic modeling algorithm. In each of the four testing conditions (Table 7.3), 12 users were allocated, so, instead of using the same audios for all the users, we divided the 12 users into 3 sub-groups and created three different audio sets to avoid the possible bias originating from the type of audio. The allocation of the audios to these three sets in a modality was done as follows. The first audio set consisted of the first and the second most probable audios of every topic, the second audio set consisted of the third and the fourth most probable audios and the third audio set consisted of the fifth and the sixth most probable audios. Hence, a total of 36 audios, divided into two groups, each consisting of three sub-sets of the audios were used across the testing conditions in our study. Finally, to avoid the sequence effect, we adopted the full counterbalancing strategy by altering the order of the modalities to be exposed to the users in the two phases of the assessments.

From the usability aspect, all the instructions in the IVR application were presented in a clear voice using colloquial Hindi language - the mother tongue of the participants. Instructions were repeated multiple times and had prompts to handle invalid inputs from the users while collecting judgments. The mapping of the keys to be pressed for giving the judgment ratings was made consistent everywhere in the application. Prior to the release of the application, a small pilot was conducted with two health workers and the suggested modifications were incorporated.

7.3.4 User Interaction Flow

We now describe the interaction of a user with the developed IVR-based library through a workflow diagram as shown in the Figure 7.2. On a successful call connection, the user is presented with the introduction of the library followed by an announcement of the topic list and the corresponding keys to be pressed for their selection. After the user has selected

a topic, the first associated audio is played followed by its summary. At this point in time, user feedback on the summary quality is collected over three parameters as sound clarity, understandability, and relevance. Upon successful collection of ratings, the next audio and its summary are played if the content of the current topic is not finished, otherwise judgments on the association of the played audios and the assigned topic is collected. Every time on completion of a second level, the first level is brought back to present the topics list again. When all the topics are complete, the user is prompted to give an optional feedback by recording her voice. Finally, if the current call is the last call of the assessment, then preference judgment on the two modalities (keywords or sentence) of the summary is collected before exiting. To handle the cases of bad sound quality due to issues in the telephony network, user feedback on the sound quality is collected after the playback of every audio and if it is bad, the call is terminated by leaving a message to try again later. Based on our lab and pilot testing, a single call without any network or sound issue could be completed in 15-20 minutes.

7.4 Participants

With the help of SWACH, we recruited 60 ASHAs for the study. Out of the 60 ASHAs, only 32 could successfully complete the assigned tasks. The rest had to be dropped from the study due to reasons as follows: 8 ASHAs lacked the understanding of IVR systems, 10 ASHAs had call connectivity issues in their areas, and the other 10 had availability issues. Later, we enrolled 24 ANMs (Auxiliary Nurse Midwife), a higher cadre of CHWs and reporting supervisors of ASHAs, out of which 16 could complete both of their assessment phases. In total, we had 48 participants in our study. Among the ASHAs group, the average age was 38 (min = 25, max = 47), with the distribution of educational backgrounds as 10%—8th standard, 47%—10th standard, 23%—12th standard and 20%— Bachelor's degree. Their experience ranged from 3 to 15 years (average = 9 years), with the exception of one having only 3 months. In the ANM group, the average age was 36 (min = 26, max

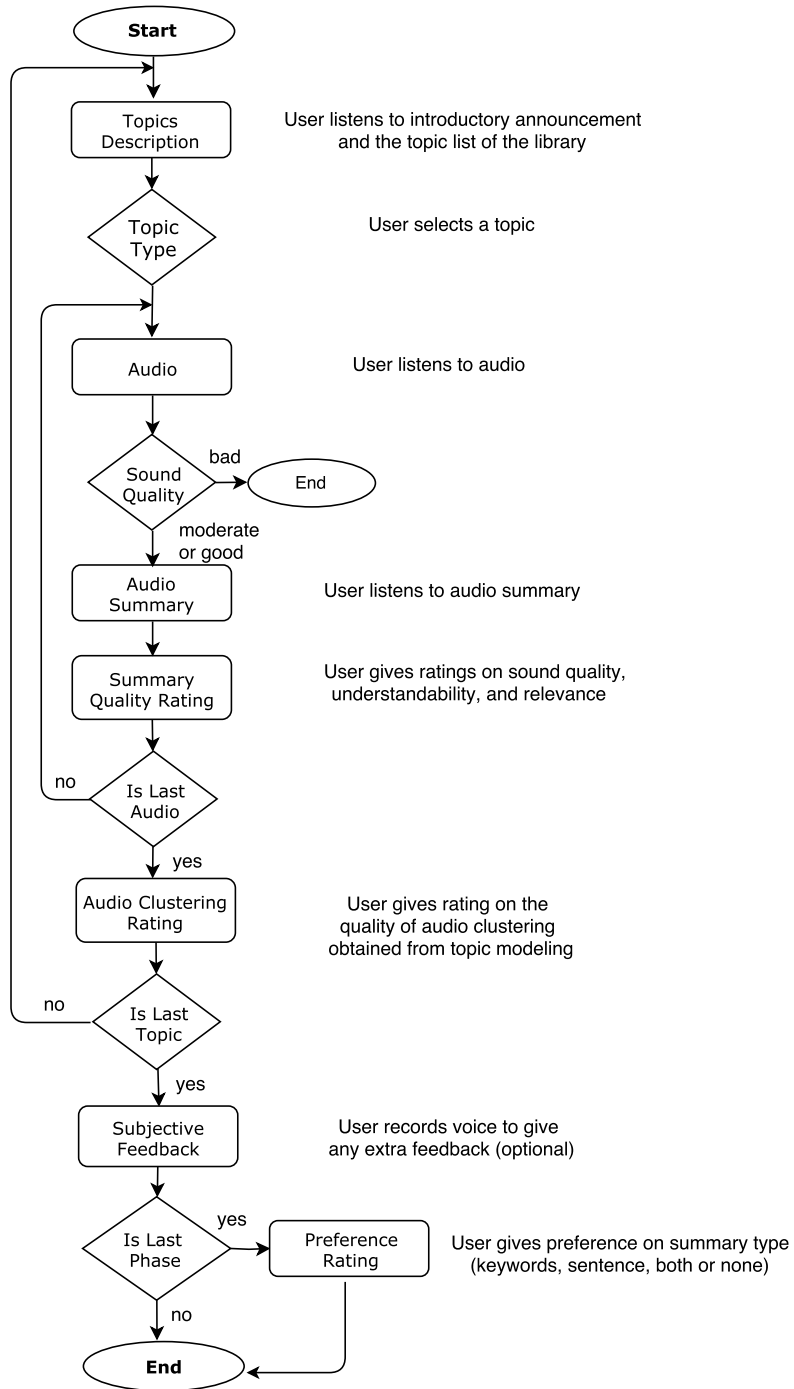


Figure 7.2: User Interaction Flow

= 56), with educational background as 25%—10 standard, 50%—12th standard, 12.5%—Bachelor's degree and 12.5%—Master's degree. The experience ranged from 1 to 31 years with the exception of one having only 6 months. Every participant was compensated for their time with a monetary incentive of 100 INR.

7.5 IVR Application

We developed our IVR application using the Freeswitch platform, an open-source Software Defined Telecom Stack. We used Python language to code our programs and MongoDB database to store logs. To pass calls from the software into the cellular network, we used our own VOIP-GSM gateway placed along with the server in our institute. To avoid users bear the call cost, the system use was made incoming call-based such that to be in a call; a user was required to just drop a missed call. Whenever a user is ready to evaluate the system, they have a phone number to place a call on. On receiving a call from a registered user, our gateway would disconnect the call and callback the user. Our VOIP-GSM gateway had 16 SIM slots that allowed to support 16 parallel calls.

To record user evaluation ratings, DTMF inputs at specified points were captured and automatically saved into the database. The database recorded the details such as call timestamps, user group IDs, call status - first phase or second phase/complete or not complete, DTMF input, level of DTMF input - main menu/sub-menu, item category - human keywords/human sentence/machine keywords/machine sentence, etc. All the MongoDB records were extracted into .csv formats for further statistical analysis.

7.6 Results

In this section, we apply multiple statistical tests to the data. The data on which the results are presented contains both ASHAs and ANMs evaluation ratings. While it would be interesting to study the presence of difference in the judgements of ASHAs and ANMs (who have higher educational levels and formal medical degree), in this study we do not study

that. We use the collapsed data to retain statistical power.

7.6.1 Users Perceptions of Summary Relevance

To effectively automate the process of creating audio summaries, it is necessary that users find them relevant enough so that the dependency on human moderators can be removed. Given the users' relevance judgments, we statistically analyzed the relationship between the relevance perceptions of the users for different types of summaries used in the study. Since the data were the subjective judgments collected on a 3-point Likert scale, we applied the Fisher Exact test of independence between two categorical variables: relevance and summary-type, for different combinations of the testing conditions. Here, the contingency table for the two variables contains the distribution of frequencies for the three categories of the relevance measure, as “not relevant”, “moderately relevant” and “relevant”. The null hypothesis states that *the relevance perceptions of the users for a summary do not depend upon its type i.e. there exists no relationship.*

When we try to compare proportions of a categorical outcome according to different independent groups, we can consider several statistical tests such as chi-squared test, Fisher's exact test, or z-test. The chi-squared test and Fisher's exact test can assess for independence between two variables when the comparing groups are independent and not correlated. For our data, Fisher's exact test was relevant because it was small-sized. Since we make multiple comparisons to test our hypothesis, we adjust the p value with Bonferonni correction. For the following six comparisons on user relevance ratings, the adjusted p value is 0.008 (0.05/6).

In the first test, we considered the testing combinations as {human keywords, machine keywords} (Table 7.4) and {human sentence, machine sentence} (Table 7.5) to evaluate the effectiveness of the automated approach with respect to the baseline of human-based approach. Here it can be noticed that these testing combinations were not directly assigned to the users; in all of the four testing conditions used in our study (Table 7.3), it was necessary

that every user listened to both sentence and keywords type of summary. Therefore, we explicitly took out the frequency distributions from different groups for this test. For both the combinations, statistically significant results were found ($p < 0.001$, two-sided fisher-exact test and $p < 0.001$, two-sided fisher-exact test respectively). Thus, we reject the null hypothesis and accept the alternative hypothesis that relevance judgments get affected by the type of summary where in this case, one was generated by human and the other by machine. Changing the source of summary creator, change users judgments of relevance. The users found the human-generated keywords to be more relevant than machine-generated. This suggests the scope of improvement in the automated approach. In the current study, we applied basic techniques for summary creation (extractive summarization), in future work, we would like to investigate the effectiveness of other advanced techniques.

Table 7.4: Relevance Judgments on Human Keywords vs Machine Keywords

	human keywords	machine keywords
not relevant	2	6
moderately relevant	15	39
relevant	127	99

* $p < 0.001$, relevance judgments are dependent on the type of summary

Table 7.5: Relevance Judgments on Human Sentence vs Machine Sentence

	human sentence	machine sentence
not relevant	2	3
moderately relevant	10	42
relevant	132	99

* $p < 0.001$, relevance judgments are dependent on the type of summary

The second test had the testing combinations as {human keywords, human sentence} (Table 7.6), and {machine keywords, machine sentence} (Table 7.7). Here, the summary type changes in its modality (keywords-based or sentence-based) but the source of creation either machine or human, remains the same within each combination. No significant results were found ($p = 1$, two-sided fisher-exact test and $p = 0.179$, two-sided fisher-exact test respectively). Thus, we fail to reject the null hypothesis and conclude that we cannot infer

any relationship between the users' relevance ratings and type of summary in the case when summary modality changes (keywords-based or sentence-based), but the source (human or machine) remains same.

Table 7.6: Relevance Judgments on Human Keywords vs Human Sentence

	human keywords	human sentence
not relevant	1	0
moderately relevant	3	4
relevant	68	68

*p=1, relevance judgments are independent of the type of summary

Table 7.7: Relevance Judgments on Machine Keywords vs Machine Sentence

	machine keywords	machine sentence
not relevant	5	1
moderately relevant	23	20
relevant	44	51

*p=0.179, relevance judgments are independent of the type of summary

Finally, the third test had the testing combinations as {human keywords, machine sentence} (Table 7.8) and {machine keywords, human sentence} (Table 7.9), where the summary type changes both in its modality and source of creation. No significant results were found on the relationship of summary type and the relevance judgments (p-value = 0.080, two-sided fisher-exact test and p = 0.052, two-sided fisher-exact test, respectively). Thus, we fail to reject the null hypothesis that there is no relationship between user relevance ratings and summary type when the summary changes in both the source and modality. However, here we would like to emphasize for further investigation or repetition of the evaluation as these cases represent contrasting difference. In the case of {machine keywords, human sentence}, the quality of keywords-based summary which is machine-created and machine-spoken seems obviously low to the sentence-based summary which is human-created and human-spoken. Also to that end, the p value was 0.052, close to the original significance level of .05 (without Bonferroni correction), thus indicating towards the actual difference.

Table 7.8: Relevance Judgments on Human Keywords vs Machine Sentence

	human keywords	machine sentence
not relevant	1	2
moderately relevant	12	22
relevant	59	48

*p=0.080, relevance judgments are independent of the type of summary

Table 7.9: Relevance Judgments on Machine Keywords vs Human Sentence

	machine keywords	human sentence
not relevant	1	2
moderately relevant	16	6
relevant	55	64

*p=0.052, relevance judgments are independent of the type of summary

7.6.2 Users Preferences for Summary Type

At the end of the second phase of the assessment, when the users had been exposed to both of the assigned modalities (keywords-based and sentence-based), preference judgments were collected on a 4-point scale as 1-“sentence”, 2-“keywords”, 3-“both” and 4-“none”. The overall distribution for all four testing conditions is shown in the Table 7.10. To test whether the observed distributions were different from the expected distributions of having an equal chance of choosing each judgment category, a multinomial goodness-of-fit test was applied. For the testing conditions as {human keywords, human sentence}, {human keywords, machine sentence}, {machine keywords, machine sentence}, non-significant results ($p = 0.080$, $p = 0.169$, and $p = 0.407$) were found which indicated the occurrence of the preference distributions by chance. For the testing condition of {machine keywords, human sentence}, though the result was significant ($p = 0.03$) supporting the occurrence of the sum distribution not by chance, the post-hoc tests (Exact Binomial Test with Holm method of adjustment) for the categories (sentence, keywords, both, none) individually gave non-significant results with p-values as 0.050, 1.000, 1.000, 0.130. Thus, we cannot infer the preferences of the users statistically.

Therefore, to get some insight, we qualitatively analyzed the preference views of the

16 users who were interviewed (selected randomly). Out of these 16 users (ASHAs), 11 users mentioned their preference for sentence type of summaries, 3 users for keywords type and 2 for both. The users who preferred sentence-based summary commonly said that sentence modality is clearer in understanding because it gives complete information. One of the users of this group highlighted a negative aspect for the keywords-based summary by saying that *“keywords-based summary is not good because the constituent words do not match with the audio”*. Whereas the other user group who favored keywords-based summary considered the spacing between the consecutive words as a positive point towards a better understanding. A supporting quote is as follows *“I found the keywords-based summary to be better as they are presented cleanly in the form of separate words as compared to the sentence-based summary which can start and end abruptly”*. One of the users who favored both said *“for me, both types of the summary are good enough; however, for other ASHAs, sentence summary is better as many of them have low literacy and comprehension skills”*. Overall, the tendency of the users was towards the sentence-based summary.

Table 7.10: Preference Judgments

	human keywords, human sentence	human keywords, machine sentence	machine keywords, human sentence	machine keywords, machine sentence
sentence	5	5	7	4
keywords	2	4	3	5
both	5	3	2	2
none	0	0	0	1

7.6.3 Effectiveness of Theme Classification

In our design of the library, the first level in the IVR structure presented three broad topics using abstract descriptions around the words generated by the topic modeling algorithm. User feedback on the association of the topics and the audios was collected at the end of the second level when all the audios and their corresponding summaries had been played. The measuring Likert scale was 3-point as 1—“not relevant”, 2—“moderately relevant”, 3—“relevant”.

The observed distribution of the relevance judgments is given in the Table 7.11 below. A multinomial goodness-of-fit test gave statistically significant result, thus, rejecting the possibility of occurrence by chance ($p < 0.001$, significance level = 0.05), followed by similar results of the post hoc tests for all the three categories individually (not relevant, $p = 0.0$; moderately relevant, $p = 0.0$; relevant, $p = 0.0$). Overall, the clustering of the audios to the topics was found to be relevant by a majority of the users.

Table 7.11: Relevance Judgments for Theme Classification

not relevant	moderately relevant	relevant
7	50	221

7.7 Discussion

Our experiment towards automating the automatic annotation of the voice forum data to reduce the manual effort raised some interesting future directions that we discuss as follows:

7.7.1 Use of Topic Models for Voice Forums

We used topic modeling in finding out themes in the audio collection and presenting the catalog of the library by labeling them. There are multiple facets of topic modeling that pose both challenges and opportunities for research as the scale of voice forum increases. The first is the task of deciding the number of clusters/topics. When the scope of a voice forum is narrow then heuristic-based estimation of the number of topics seem feasible. For instance, in our study, given the dataset of Q&A of the *Sangoshthi* forum, we had the prior knowledge of the number of topics on which these Q&As were based that we used in finalizing the topic size. However, in forums like CGNetSwara [18] and MobileVaani [65], which pertain to a spectrum of topics, dynamic update of the clustering process with the right parameters is a challenging task. The second is the task of creating interpretable representations of topic words. In the current implementation, we manually created topic representations by constructing abstract sentences for the topic words. However, we would

like to further explore other better ways. While for the natural language processing and machine learning research, there are opportunities to come up with techniques to automatically generate better representations, the design research can explore the usability aspects for the user groups of context similar to rural communities of developing countries.

7.7.2 Human-in-the-loop

In this study, as we see that human intervention is required to fill the gaps that machines cannot do effectively. We need to think of better frameworks for involving human effort. One potential way in our application context could be crowd-sourcing of the tasks that can improve the performance of the automated techniques. For example, providing representative phrases for the topics, tagging audio contents with keywords, etc. While designing such crowd-sourcing applications, it is necessary to address the challenges of it as well as design mechanisms that incur minimum overhead to the system. For instance, instead of developing a crowd-sourcing application for curation tasks in the silo, engaging users during their application use is also a relevant approach. For example, SangeetSwara collected upvotes and downvotes from the forum users while presenting the contents to them.

7.8 Summary

In this chapter explored the automatic annotation of the voice forum data towards building an IVR library. Voice forums and its applications are actively studied for developing countries. However, automatic annotation of voice forum content is still an unsolved task. This chapter evaluated the effectiveness of techniques of natural language processing and information retrieval fields to address this challenging problem of

We applied standard techniques to voice forum data, and specifically topic modeling for generating themes, and extractive summarization for constructing summaries. The transcript extraction had a high noise (WER = 67%), and we employed additional pre-processing steps to extract relevant keywords. Our results are promising in terms of users

relevance for audio clustering and summary annotation. The evaluation results are encouraging for using automatic annotation in voice-based applications for rural users.

Chapter 8

Understanding Opportunities for Conversational Agents in Breastfeeding Education

To address the limited availability of instructors, conversational agents (chatbots) offer a promising alternative. Chatbots are increasingly being integrated into different educational contexts. Chatbots-based education is relevant in our context as trainers are acutely short. Chatbots can be an effective alternative to better engage ASHAs with their learning material and address their frequent basic queries. Considering increasing ownership of smartphones by women in India and the low-learning curve for chatbot-based applications, we were motivated to explore its potential in our context. In addition to the education of ASHAs, this chapter focuses more broadly on the potential of chatbots for breastfeeding education in the Indian context by also involving mothers⁶.

8.1 Introduction

In recent years, chatbots have received great attention. Chatbots integration has dramatically increased in different digital applications since 2016, when major tech companies released open APIs for building chatbots. The growing trend of shifting from web-based browsing to messaging apps and personal assistants makes chatbots a promising future technology. Currently, more than 300,000 bots exist on Facebook messenger [235] cutting across a variety of use-cases—online shopping [236], casual chatting [237], travel arrangements [238], etc. Commercially chatbots are an effective alternative to save customer service costs by replacing human assistants and increasing customer satisfaction by speeding up response times. However, chatbots are still in their beginning stages of expansion, and there are several purposes and domains un-explored.

⁶Deepika Yadav, Prerna Malik, Kirti Dabas, and Pushpendra Singh. 2019. Feedpal: understanding opportunities for chatbots in breastfeeding education of women in India. In *Proceedings of the ACM on Human-Computer Interaction*, 3, CSCW, 1–30.

The Special Interest Group at CHI'18 discusses how chatbots may be used for social good and underscores two important factors to their democratizing potential: first, chatbots can be made immediately available to billions of users through messaging platforms and second, chatbots offers a low threshold for uptake across users groups due to their conversational character in natural language. The use of chatbots for competence was identified as one of three potential areas for social impact. Given the fact that smartphones are rapidly increasing in low-income countries, chatbots are a promising technology to bridge digital divides [239].

The use of chatbots in education is increasing. In particular, in online education, where the sheer number of students overwhelms the instructors and makes quality teaching extremely difficult, chatbots offer an effective solution. Chatbots reinforce self-directed learning by reacting to individual intents. However, the existing studies are centric to settings where learners have a significant amount of background in the use of computer and digital applications. We introduce the education research of chatbots to a new user group.

Our users, ASHAs, and mothers residing in rural or under-developed (slums) regions of India have limited or no access to technological advancements in chatbot research because of poor economic conditions and limited literacy. While some of them now possess smart-phone, it is often a low-end smart-phone ($< \$100$) [62]. Moreover, the socio-economical conditions dictate that the phone may be shared within the family, often with the husband or other male members of the family [240]. This makes our users the first-time users of chatbots. So far, the research around chatbots has been majorly technology-driven with a limited investigation on user perceptions and contexts of use [241].

In this study, we explore the feasibility of using chatbots for breastfeeding education of community health workers and mothers in urban slum areas of India and understand how they react and perceive chatbot-based intervention. We aim to contribute to the HCI and CSCW community by informing design recommendations for chatbot implementation for causes like breastfeeding education in under-developed areas, with users who are newcom-

ers to personal device use. We guide our exploration with the following research questions:

- **RQ1:** What is the perception of users towards chatbot-based breastfeeding education?
- **RQ2:** What kind of information users — ASHAs and Mothers — seek from a chatbot?

We study users' interaction with the chatbot through a Wizard-of-Oz experiment with 22 participants (12 ASHAs and 10 mothers). We prototyped our chatbot as an interactive question-answering application and analyzed users' interaction patterns, perceptions, and contexts of use. Our findings highlight the role of the familial unit in breastfeeding practices. We found that the majority of questions sought by users are answerable by a chatbot and the value of chatbots for mothers as the first point of contact. This gives us the confidence that breastfeeding education is a potential application for chatbot intervention. We also discuss implications for the design for future bots and the characteristics they should embody to address users' concerns in constrained settings.

8.2 Methodology

Since ours is the first study that explores the use of chatbot for breastfeeding education in the Indian context, with no prior knowledge base available, we adopted Wizard of Oz (WoZ) technique to collect users' reactions and interactions for the first time. WoZ is a standard prototyping methodology in HCI that enables designers to collect design requirements and evaluate features without actually developing the full system [242]. It also helps in uncovering different scenarios of use which might be expensive to study later on [243].

Through a customized chat application, a human wizard emulated the functionalities of a chatbot, making users believe as if they were chatting with a real chatbot application. The wizard is a doctor in a remote site looking up answers from an official reference book,

receiving the messages directly from the app over the internet. We will discuss the details in the following subsections.

8.2.1 Participants

The study was conducted in the East-Delhi region across two government dispensaries, separated by 3km. We chose the study area by using the convenience sampling method since it was a field practice allocated to our institute from the Delhi State Health Mission [166]. Each dispensary had 30 ASHA workers [244]. The inclusion criteria for the participants was familiarity with smartphone use. Based on prior WoZ studies [245, 246], we pre-estimated the sample size of around 20 for our experiment, 10 mothers and 10 ASHAs, and began our recruitment process. We first started recruiting ASHAs at one center, where we selected 8 ASHAs; the rest either did not use smartphones or were not available (on leave) during the experiment period. Using snowball sampling [247], these ASHAs further helped recruit mothers in their areas. Mothers who were breastfeeding their child (preferred child age—0-1 year) and had been using smartphones in some way (either their own or shared phone of the family) were selected. At this center, 8 mothers from the areas of 3 ASHAs were selected, thereby making a total of 16 participants. In a similar fashion, we selected 3 ASHAs and 3 mothers at the other center. Finally, when we reached 22 participants, we stopped further selection. The demographics details of the ASHAs and the mothers is summarized in the table 8.1 and table 8.2.

8.2.2 WoZ Architecture

Building a conversational agent that acts like a human is one of the most challenging areas of artificial intelligence and natural language processing fields. The architecture of a chatbot is decided on the type of purpose, whether the chatbot is intended to help users complete specific tasks (task-based chatbots) [248], or engage users in conversations on open domain topics (non-task based chatbot) [249]. Considering the non-task based chatbots, there can

Table 8.1: Mothers Demographics

ID	Age	Education	Age of breastfeeding child	Parity
1	28	tenth	2 days	Primiparous
2	27	graduate	1 month	Multiparous
3	25	graduate	1 month	Primiparous
4	28	graduate	1.5 months	Primiparous
5	32	post-graduate	2.5 months	Multiparous
6	24	eight	3 months	Primiparous
7	28	twelfth	5 months	Multiparous
8	34	tenth	6 months	Multiparous
9	24	graduate	8 months	Primiparous
10	23	graduate	9 months	Multiparous

Table 8.2: ASHAs Demographics

ID	Age	Education	Job Experience
11	32	twelfth	3 years
12	38	tenth	10 years
13	40	tenth	10 years
14	36	graduate	4 years
15	29	graduate	4 years
16	34	twelfth	4 years
17	37	eighth	7 years
18	49	tenth	9 years
19	35	twelfth	8 years
20	35	graduate	1 year
21	30	twelfth	3 years
22	28	graduate	5 years

be two models as generative and retrieval-based. While the retrieval-based bot parses user input to find out message intent (keywords based) and returns the best matching response from a predefined set of messages, the generative-based models generate a response from scratch using complex natural language processing and machine learning algorithms.

In this experiment, the wizard imitates the retrieval-based model of chatbot in a single turn scenario, which only considers the last input message. Further, in wizarding such a bot, we make assumptions about the richness of the knowledge base, accuracy level in finding the responses, and parsing the messages.

To answer users' questions, we prepared a knowledge base from the training material of the ASHAs and a book of 100 most commonly asked mothers questions on breastfeeding

[250]. This book was written by the SWACH head. Originally the book was in the English language, which was then translated into Hindi and cross-checked by a medical expert for correctness. Apart from this, for any new query, we referred to WHO content material.

We modeled our chatbot as an interactive question-answering application that features three functionalities broadly: it can answer user queries on breastfeeding, counter-question users, and present interesting facts and information. We defined the properties of the bot as follows. The users can input their message in both voice or text form like used in general messaging apps. For the text form, both the Devanagari (Hindi script) and transliterated form (Hindi form written using the English alphabet) are allowed. However, the bot responds in text form only, using the Devanagari script. Further, the bot's understanding of the language is limited. It does not understand the implicit utterances or informal feedback cues such as *c ya*, *alright*, etc, which are generally used in human conversations. It also does not entertain casual talks. Finally, our bot is not intelligent to overcome any ordering effects. For example, if the bot is in the process of finding an answer to a query and the user feeds more queries in between, the bot does not automatically process them. The history of conversations is not taken into account.

8.2.3 Wizard Workflow

To give the users a feeling of conversing with a real chatbot, we limited the wizard's ability to answer every question. Given a user query in a conversation, the wizard imitates a chatbot using four types of messages as follows: 1.) *resend prompt* - wizard prompts the user to resend the message to show parsing errors. The wizard decides this prompt by judging the quality of messages. The voice message is prompted for resending if it is noisy, too long, difficult to interpret, and text message if it contains misspelled words, garbage characters, or incorrect sentences. For the case in which the user messages do not contain any error, the wizard still deliberately prompts to resend at least once in an interaction. 2.) *out of scope* - users is denied to receive any answer if the question is out of the breastfeeding

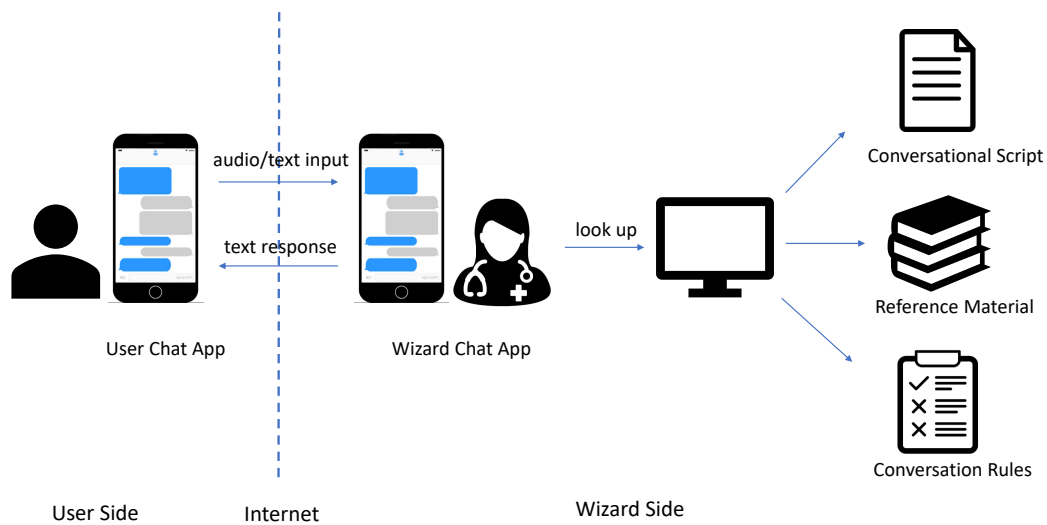


Figure 8.1: Wizard-of-Oz Experiment Setup

domain, 3.) *near-relevant responses* – The wizard responds with near relevant answers to the questions which are complex or advanced, e.g., health conditions described with a variety of details including symptoms, diagnosis, history, etc. Based on the keywords, best-matching information is returned. This helps in showing limited intelligence level of a chatbot. Here, the wizard leaves those queries which require human expertise, e.g. breastfeeding when a mother is suffering from cancer, etc. 4.) *not found responses* - when the answer to a question is not found in our knowledge base, the wizard replies with this message. The flowchart representing the conversation flow and the decision-making is shown in the figure. 8.2.

To help the wizard respond consistently and quickly to the users, conversational scripts were used. For example, conversation starter sentences included phrases such as “Hello”, ”How may I help you”, message acknowledgments included ”Please wait while I search the information” etc. After the initial few sessions, a document of frequently asked questions was also used. The figure depicts the overall WoZ setup 8.1

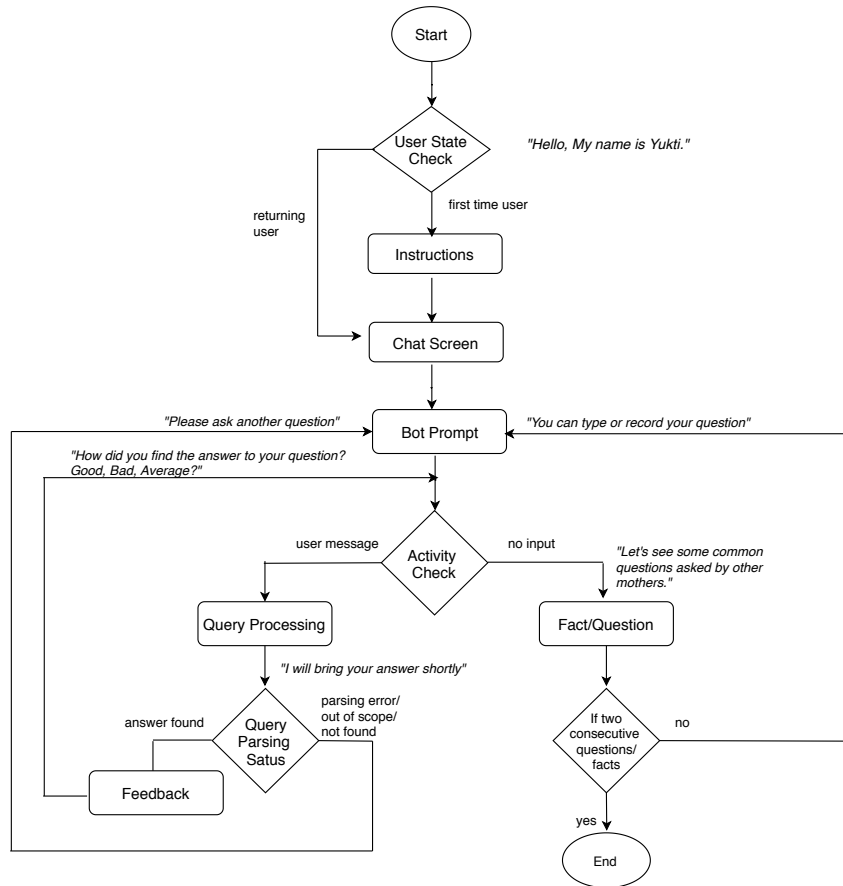


Figure 8.2: User-Wizard Chat Flow

8.2.4 Chatbot Design

We developed our chat application for the Android platform using Google Firebase. Using authentication and real-time database services, messages were passed between two endpoints. The interface of the chat screen was made simple, having a chat view, a text box, a voice recording button, and a file attachment icon. We designed the bot persona as a lady in her 30s wearing the traditional Indian dress of salwar-kameez and named her as “Yukti” which means tactic to solve a problem. We attempted to give the personality that resembles ASHA, a helping sister. Considering the cultural sensitivity about talking openly to a male in Indian society [251, 252], we preferred the female gender for the bot. To make the chatbot self-explanatory, we added animated introductory tutorials in the beginning screens. The app starts with Yukti introducing herself, followed by a feature explanation and sce-

nario of use. Figure 8.4 shows the app snapshots of the user and the wizard's version. We portrayed four features for Yukti as one source of information (user can find all breastfeeding information through Yukti), authentic information (medically validated content), 24 * 7 availability, and Ease of Use (voice messages).

We also incorporated functionality to take users' feedback on bot responses. Through a button, the wizard could push feedback rating tabs onto the user's app. The scale of the rating was 3-point: good, bad, and average. Other useful functionalities that were under-development and not used in this study, including indication when a user is online, push notifications, and read receipts, were managed manually with the help of research staff. A sample conversation (name of the user is changed to protect privacy) is shown in the figure. 8.3.

Finally, we conducted a pre-pilot study with seven lady security guards in our institute campus. All these ladies were mothers and smartphone users. Their mean age was 31 years (26-38), and education levels ranged from tenth to graduation (three with 10th, three with 12thand one with Bachelors). The chat sessions conducted with them helped us develop the time estimate to curate responses to users' messages, get an idea of the type of user queries, and serve as practice sessions for the wizard. The feedback shared by the ladies improved the interface of the app.

8.2.5 WoZ Setup, Session Details and Ethics

In our WoZ experiment, the users and wizard were separated physically, and communication happened through the app over the Internet. While working with mothers of newborns, we had to be sensitive to their convenience and comfort. Traveling for the mothers was not feasible; therefore, we made house visits to conduct the sessions. Further, the house visits allowed us to capture users' interactions in their natural environments, informing us on contextual aspects. ASHAs' sessions were conducted at the health dispensaries, which they regularly visit as part of their duties (see figure 8.5). Our team was composed of three

Yukti: Hello, What can I call you?
Mother: Aarti
Yukti: It's nice to meet you Aarti.
Yukti: If you have any questions, you can type or record it.
Mother: What should be given to children after 6 months?
Yukti: This question seems to be out of the topic of breastfeeding. I am not capable of answering it right now. Please ask another question related to breastfeeding.
Mother: How long should a child be breastfed so his/her stomach gets full.
Yukti: Thank you. Getting your answer from my material.
Yukti: Some babies suckle fast and some are slow. As a child grows, their feed duration can change. Duration of feed can also depend on when the milk comes in after the child starts suckling. Usually, a baby spends 5-10 minutes on a breast, but we recommend that you let the baby decide the duration of the feed.
Yukti: How did you find the answer to your question, give your rating by pressing one button:
 Good/Bad/Average.
Yukti: #GET USER GET_FEEDBACK#
Mother: Good
Yukti: Let's see what questions other breastfeeding mothers like you ask?
Mother: After 6 months, should I exclusively breastfeed or give top feed as well?
Yukti: Question: How will I find that my child is full so I can stop breastfeeding?
 Answer:
 • Your child will fall asleep while feeding.
 • Your child will not actively suckle or will completely stop suckling.
 • Child can open his/her fist, arch his/her back or smile or shout.
 • You will feel that your breasts have gone soft.
Yukti: How did you find this fact. give your rating by pressing one button: Good, Bad, Average.
Yukti: #GET USER GET_FEEDBACK#
Mother: Good
Yukti: If you have any questions, you can type or record it.
Yukti: Let me ask you a question.
Yukti: If mother or child has vomiting, diarrhoea or other illness, so mother should stop breastfeeding for some time. Choose one from below given options:
 A. True
 B. False
Mother: B
Yukti: Absolutely Correct Answer. :)
Yukti: A sick mother or child is not a reason to stop breastfeeding. Breast milk given during sickness helps in maintaining the nutrition status of the baby. Continuous breastfeeding also helps in recovering from illness. It also stops illness and malnutrition due to low diet. And breast milk is especially beneficial if the child has diarrhoea.

Figure 8.3: A Sample of Question-Answer Session

members: two research staff and one medical expert (MBBS, MPH doctor, acted as the wizard). The wizard setup was located at our Institute's lab.

We conducted the experiment with participants after obtaining approval from the review board of our institute. Before the sessions, participants were briefed about the purpose of the study, data to be collected, and potential risks. Participants were assured that all of their interactions would remain confidential and used only for the analysis through proper de-identification. Participants were informed that they were free to leave the study at any point in time.

We planned three sessions with every participant and conducted them after obtaining the consent. We introduced *Yukti* to the participants as a chatbot that is under-development, thus not fully ready, and that we wish to collect their experiences and inputs for research purposes that would help the development of future systems.

In the debriefing sessions, we explained the phenomena of the chatbot through various analogies like robots, automated machines etc. They were told that they would chat with a machine that curates answers from an authentic knowledge base. Since the experiment was a WoZ, participants were deceived on the part that a human instead would be responding. About the 24*7 availability feature, participants were informed that it will be applicable only when the actual chatbot app will be released.

The three sessions of a participant were conducted on three separate days. Adjusting to the routine schedule of ASHAs that included coming to the health centers for immunizations, antenatal checkups, etc., we conducted the sessions based on their availability. The sessions with the mothers were conducted at their houses. On the first day, the associated ASHAs accompanied the research staff to show the houses and introduce them to families. On subsequent days, the research staff went on their own except for two houses that were found difficult to reach. During the sessions, both the ASHAs and the research staff did not interrupt the mother except for clarifying questions regarding the app use. However, the presence of the staff might have affected mothers' interaction or behavior as the study was

not in-the-wild and has the same limitation as that of general WoZ conducted in a lab.

To conduct sessions, we used our mobile handset that was given to the participants only for the session duration (a single session ranged between 10 to 30 minutes). We preferred to use our handset to maintain consistency in use and avoid users attempting to use the app outside of the session timings when the wizard would not be available. We used a Motorola C plus handset that costs \$84, lying in the average price range of smartphones in India [62]. Thus, the phone was equivalent to the type of handsets generally used by the participants.

Due to the use of Firebase to support the chat functionality, the application required a Gmail account to log in. Many of the participants were unaware of the email application and had their phones configured with husbands' or children's email accounts. For these participants, we created new dummy Gmail accounts without using any personal information. We did login ourselves without sharing the credentials. All of these temporary email accounts were later deleted. To maintain the privacy of the users, we de-identified participants' details before starting our analysis.

Considering the use of the conversational agent for breastfeeding education, we anticipated certain ethical concerns in our experiment, which we attempted to address as follows. Prior studies on intelligent agents have found that despite knowing the true form of a bot, users tend to develop strong emotional attachments towards bots [253] and thereby develop high expectations. To minimize the risk, we clearly explained the functionality and scope of the bot at the outset. We also ensured that wizard uses language that reflects its machine nature and its limitations, e.g. "please wait while I search for information in my material".

Another perceived risk lay in the way users interpret the bot responses. Users sometimes might not understand the meaning of the received answers and need further explanation. As observed, sometimes, when the mothers were not convinced by the bot responses, or they were confused about the interpretation of the responses, they expressed it to the research staff. We ensured that the research staff note these points during the session but responsibly explain them at the end to mitigate the risk of incorrect interpretation.

Since the breastfeeding phase of mothers, in reality, entails a lot of issues that need counseling support, we noted the encountered problems and conveyed them to an NGO working in this field and the ASHA workers. However, we did not specifically arrange the counseling support directly.

8.2.6 Data Collection

We took detailed notes of the participants' reactions, comments, and ambient activities during the sessions. Further, whenever needed, the research staff also made contextual inquiries, for example, the number of family members. At the end of each session, the overall feedback rating was collected on a five-point scale represented in the form of Emojis.

In the end, we conducted semi-structured interviews with the participants. There were two parts to the questionnaire. The first part was common to the ASHAs and the mothers, designed to collect their feedback on *Yukti* use. The questionnaire, as adapted from [254], covered aspects of usability, satisfaction, and perception on the usefulness of *Yukti* and consisted of questions like “*Did Yukti supply all the information you wanted?*”(yes/almost/no), “*Do you think Yukti understood everything that you asked?*”(no/almost/yes-all), “*How difficult it was for you to use Yukti app?*”(difficult/easy/moderate), “*Did you find the information provided by Yukti to be useful?*”(yes/almost/no), “*what kind of improvement do you want to see in Yukti?*”, “*Would you like to use the app in future?*”(yes/almost/no). The second part of the questionnaire had different questions for the ASHAs and mothers. For mothers, questions were specific to sources of information on breastfeeding, the role of husband, and ASHAs, e.g. “*Where did you stay after the delivery?*”, “*How did your husband participate in the care? describe*”, “*How helpful do you find the support of ASHAs in breastfeeding problems?*”. An example of questions asked from the ASHAs is “*do you think six post-natal visits are enough for addressing breastfeeding issues?*”. We remunerated the participants with a cash incentive of 100 INR per session.

Apart from the field notes, session recordings, and interview data, we also used chat

logs in our data analysis. Together with these, the three members of our team worked on finding the emergent themes. The thematic analysis was inductive [184] in nature, where codes were shared, discussed, and refined in multiple iterations.

8.3 Findings

This section describes the recurring themes that emerged from the analysis of the field observations, user interactions with the bot (both the ASHAs and mothers), contextual inquiries, and the final interviews conducted. Throughout the chapter, we refer to mothers by their pseudonyms to maintain their privacy.

8.3.1 Information Sources and Influence

In this theme, we describe the socio-cultural settings in which women are placed, available sources of information, and the influence of these sources on women's breastfeeding choices and practice. This includes factors pertaining to the family institution, a woman's position in exercising power, and gaps in existing communication channels.

Role of Female Relatives

In all our house visits to the mothers, we observed the household dynamics of Indian family culture. Mothers were primarily concerned with household tasks and childbearing, one of the primary manifestations of gender inequality in Indian society [255]. Mostly they were homebound and depended upon others for any outdoor tasks. Whether mothers lived in a nuclear or joint family, the mindsets and practice of age-old traditions came into play, including childbirth and care. Generally, post-delivery in India, women are given care by their relatives where the primary caretaker is either mother-in-law or the mother, and the husband's role is limited. In our interactions with the mothers, we consistently found that their mothers and mothers-in-law significantly influence breastfeeding practices.

In one of the cases, Kamini (a new mother of 4 days old baby girl) was being taken care

of by two, a mother-in-law and a grandmother-in-law. Till fourth day the breastfeeding practice had not started, and the family was very concerned. According to them, despite making numerous efforts, the child was not able to suckle. The mother's nipples were tight and sore. They said that the child does not take the mother's nipples into her mouth and cry a lot. The mothers-in-law also concluded the child had developed an aversion for the mother's nipple. To compensate, they were feeding the child on external milk (toned, packaged milk of cow). According to breastfeeding guidelines, in any case, if infants are being fed on external milk, it should be formula milk and not animal milk. We sensed the familial atmosphere to be quite uneasy for the woman (mother) as her mother-in-law complained to us that she wakes up late in the morning.

The sessions with another mother, Meena, who lives in a big joint family of 16+ members, again highlighted the role of the mother-in-law. Meena was breastfeeding her two months old child; however, she was also supplementing cow milk. She gave the reason as follows *“my mother-in-law advises me not to feed the child after taking a head bath as this can give cold. To avoid letting the child hungry for long, we give cow milk at such time intervals”*.

Most women followed the suggestions received from their mothers and considered it to be a reliable source of information. Evidently, in a case in which mother support was absent, the woman expressed her feeling of missing it: *“I am anxious, this is my first child, there is no one to talk to at home. I feel helpless and alone as my mother-in-law is not here. I am not able to have adequate knowledge and information. Outsiders tell ten different things; no one knows what is right. Now we can ask everything from Yukti”*.

Role of Husband

Like prior studies [256], we found low husband participation in childcare and breastfeeding practice, especially during the initial phase post-delivery. During day time, they would go to the workplace and, at night, had restricted interaction with their partner and children.

Kamini, who was surrounded by her two mothers-in-law for the majority of the time, described her husband's participation as follows. *"He(husband) comes around 7-8 pm from his office, sits with me for a little while, and then goes to sleep in the room upstairs as he has to get up early for office. Gudiya(baby) cries at night, does not let him sleep, that is why he sleeps in another room."* Meena, who had two children, with a younger daughter of 2-3 months of age, shared her frustration about the limited participation of her husband. She complained about his husband's behavior towards children that he does not help her out in handling them and she has to manage everything on her own, *"He returns from his duty (work shift), and then sleeps off, says after working for the entire day I cannot handle baby"*.

Cases in which husbands were supportive also could not participate much due to job compliance and financial responsibilities. Sulekha, who did not have a mother-in-law, shared her experience as *"My husband and sister-in-law used to do all household work/chores when my baby was born. My husband is a car driver; he took leave to take care of me during those days, but then he had to go back to his job really soon as his leaves were canceled and even pay was cut. My husband told me that we both have to manage ourselves as no one else will come to help. Then just after 12 days, I started doing all the household work on my own"*.

Role of ASHAs

Maternal and child health care is the mainstay of ASHAs profile [257] and promoting exclusive breastfeeding during house visits is one of the priority tasks. However, their role as lactation counselors did not emerge in our study. Out of ten mothers, six gave negative statements for the ASHA support, two spoke in favor, one was neutral, and one found the support to be useful only in case of emergency or any specific inquiry. Among those who rejected ASHA support gave the common reason as poor communication with ASHA, *"ASHAs just come for vaccination we do not get any support on breastfeeding"*, another

said “*she does not visit, neither provides any information. She lives close-by but still does not come for the visits*”. Further, in one of our visits [Kamini’s House], we observed casual behavior from one of the ASHA. As the baby could not breastfeed since birth, the ASHA did not show any efforts to help. After assisting the mother only once in latching the baby, she soon gave up and remarked as “*this baby is naughty, does not take mother’s milk at all*”. She did not encourage or gave any positive reinforcement to the mother and the family. She did not even suggest the family see a doctor. Only when the family mentioned that they would like to go to a health dispensary and asked if she could accompany them, she agreed.

This observation is in line with the findings of the prior work assessing the performance of ASHAs as counselors. Factors like inadequate training on counseling, lack of compensation for counseling tasks, and low status in the community have been linked with ASHAs’ poor performance [124, 258].

Role of Mothers

In the light of limited mobility and resources, the mothers seemed eager to receive information from any source they could. For instance, Meena acknowledged the value of breastfeeding consultation received from a woman who used to come for her body massage as: “*15 days post-delivery a masseuse used to come, who would explain everything very nicely, and she was knowledgeable. She would take out dirty milk from my breast, massage them and advise me on breast issues, like if the breast is heavy. That is why, till now, I have not faced any problem.*” In another case, a mother quickly enrolled herself when she came to know about the Kilkari program, a government initiative to disseminate information on pregnancy, childbirth, and childcare through IVR service to new and expectant mothers. Since then, she has been listening to the audio content regularly and finds it very useful in her pregnancies. Additionally, she was among those women who searched for information over Google and Youtube.

Given the low exposure level and autonomy of women, the importance of ease of avail-

ability and accessibility of information became apparent.

8.3.2 Information seeking

We analyzed 296 questions received in 66 interactions on aspects of nature of the information sought, topics, and style of framing. The primary purpose of this analysis is to understand the type of queries users in our context seek from an educational breastfeeding chatbot. This gives a general idea of, to what extent a general knowledge base as used in our study is useful and what is required beyond that.

Query Types

We analyzed the information-seeking habits of the users on its nature and complexity level, which we represent through a four-quadrant matrix shown in the figure 8.6. We found the query type to fall in two categories broadly: i) fact-based, i.e., the questions which seek fact-based answers or which have standard text-book answers and may hold true for the majority, e.g. *“What is the benefit of mother’s first milk (Colostrum)”*, *“when should we start complementary food for a child”*, and ii) condition-based, i.e., the questions which seek personalized answers to a user’s health condition and may not be true for the majority, e.g. *“When I feed my baby I feel a lot of pain, what should I do?”*, *“my baby is three months old, I am not able to produce enough milk, what should I do?”*. We further divided these two categories into simple and complex queries depending on the nature of the questions. Out of the four categories, overall 88% questions were of simple nature, and we believe that they can be answered by a Chatbot using a knowledge base. The complex condition-based category (9%) included queries that are complex in the sense that they contain information like symptom details, treatment history, follow-up condition, etc. An example of a complex condition-based question is *“a mother who had TB for more than six months, she delivered a baby, now who is also showing symptoms of TB. Should the mother do breastfeeding”*; we believe that such questions require expert intervention and must be directed to a doctor.

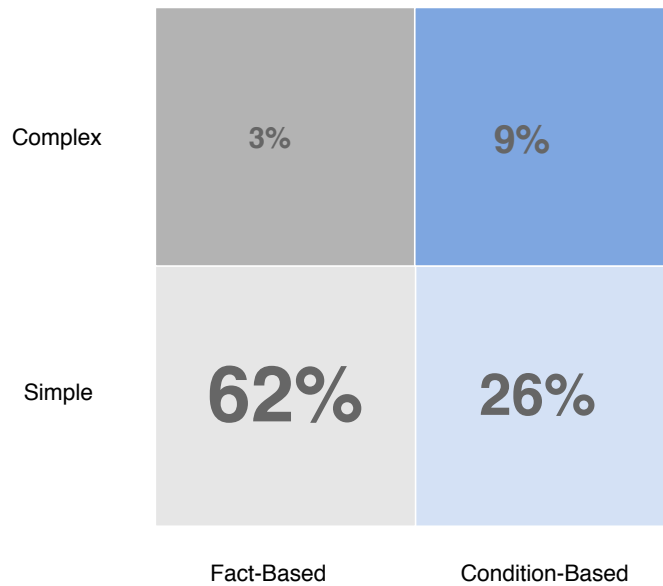


Figure 8.6: User Information Seeking

Lastly, the complex form of fact-based queries (3%) covered a more advanced form of fact seeking. The users are interested in knowing more about complex issues, e.g. “*if a mother has TB, can she breastfeed?*”.

Query Topics

Further, analyzing the topics in which users were interested, we found the categorization and prevalence as shown in the table 8.3. 26% of the queries were related to breastfeeding problems such as breast issues (soreness, mastitis, tightness, etc.), problems in latching, etc. 18% were related to conditions hindering exclusive breastfeeding. Mothers were already feeding external food to their babies and sought suggestions on their practices. Mostly, the external food in these cases was animal milk (packaged cow milk). Only a few asked about formula milk. Mothers also lacked general knowledge about exclusive breastfeeding as a good proportion of questions in this category expressed mothers’ confusion of continuing breastfeeding when the mother or child is sick. 15% were related to knowing the breastfeeding technique, including frequency, duration, and feeding position. On the feeding position questions, mothers were curious about the lying position. Their perception re-

flected hesitation in adopting it. A mother said, “is there any bad effect of feeding in lying position”. 11% were related to milk supply, where the mothers generally wanted to know how to determine that the child has taken enough breast milk, mothers’ milk is sufficient. Mostly, these reflected mothers’ perception of insufficiency of breast milk supply. 12% pertained to the miscellaneous category in which users majorly sought general information on various topics such as how to deal with milk leakage, how to store breastmilk. 10% were related to the diet of the mother and the child. The remaining 5% of the questions sought information on special topics such as AIDs, HIV, and TB during the breastfeeding phase. Of the total questions, 17% were out of the scope of breastfeeding and ranged over topics related to post-delivery and general childcare.

Many misconceptions and malpractices rooted within the Indian population [259] were seen in our sample. For example, the use of Janam Ghutti (an old Indian herbal concoction), water, and bottle milk, the commonly found barriers to exclusive breastfeeding were present in the queries [260].

Table 8.3: Questions Themes and Topics

Theme	Topics	Proportion(%)	Example Quotes
Breastfeeding Problems	breast issues, latching issues, infant crying, digestion	26.81%	<i>I have cracks in my nipples, can I feed the baby as blood comes out while breastfeeding</i>
Exclusive Breastfeeding	supplementing top feed - cow milk, introduction of water	18.12%	<i>I feed my son cow’s milk, besides this, if I give him powder milk, will it be alright?</i>
Breastfeeding Technique	feeding position, frequency duration	15.94%	<i>How long should a mother breastfeed each time, so that the child will be full?</i>
Milk Supply	how to boost milk supply how to determine child hunger, perception of low milk supply	11.23%	<i>Immediately after the delivery, mother says, that, milk is not coming from the breasts, now what should a mother do?</i>
Diet	mothers diet child diet after six months	9.78%	<i>What should a breastfeeding mother’s diet constitute of so she can successfully breastfeed her child?</i>
Miscellaneous	benefits of breastfeeding, cautions during breastfeeding, breast milk leakage, storage of breast milk	12.68%	<i>If we collect the milk expressed by mother, which metal utensil should we use and for how long can the milk be stored, that it is hygienic and good for the child</i>
Special Topics	AIDs, HIV, TB, cancer, and breastfeeding	5.43%	<i>If a pregnant woman finds out she has TB, should she breastfeed her child?</i>

Query Phrasing

User queries had different aspects of framing the question, the language used, and the content. The majority of the queries were short in length; however, they missed informative components, e.g. *“baby is crying, what to do.”* As compared to mothers, ASHAs phrased questions better, *“my child is three months old, can I give Janam Ghutti in addition to my breastmilk?”*. There were repeated expressions as generally found in natural conversations, *“I am not able to breastfeed my baby properly, how will she be able to feed? She is not having enough breastmilk!”*. The implicit information parts such as age of the infant and weight of the child were generally missed. Some of the users narrated their questions in the form of stories, e.g., *“If the mother has to go out due to any circumstance and can’t carry her baby along, the baby is very young, weather is bad, then what kind of milk should we give? can we give packaged cow milk available on Mother Dairy booths? can we give toned milk, is this type of milk good for baby, hygienic for the baby?”* They also merged multiple questions in one statement such as *“when we breastfeed our baby, we make sure to burp her but still, she vomits, what should we do? and my second question is when a baby is having a cold such that she cannot get cough but there is noise in breathing, how can we treat this?”*

The language of the participants was a mix of English, Hindi, and regional dialects. Delhi, being home to immigrants from various other states, does not primarily have a generic language but is a mix of Hindi and regional languages, dialects, and accents [261]. While, for the majority of the users, colloquial Hindi was the prime language, some mixed English words, e.g., *“mera bachcha six [English word] plus ka hai kya feed suitable rahegi?”* (my child is six plus of age, what feed would be suitable for him?). At times, when users preferred typing queries, they used Roman Hindi words (words written in Roman Script instead of Devanagari Script), e.g. *“hum dawaai khate hain to bache ko doodh pila skti hun”* (I am on medicines, can I breastfeed my baby?). Since there are no standard ways of spelling transliterated words, there were substantial spelling variations, highlighting the

problem space of code-mix, a well-identified challenge [262] in the Information Retrieval field.

8.3.3 User Perceptions

In this section, we will discuss what and how users perceived from the chatbot interaction.

Trusting and Available Partner is the Need of the Hour

The sense of receiving correct and verified medical information from the bot helped users develop trust in it. Only when the users developed confidence in the credibility of the bot, their likeness to use the app increased further. ASHAs tended to test the knowledge by asking about topics they have received training on. For example, an ASHA asked a question on how to care for breasts when they develop soreness. On finding the answer that soap should not be applied, she became satisfied and said: “*yes, the answer is correct, the same thing is told to us in our training*”. Users also compared Yukti with Google and were able to point out the benefits of receiving authentic information — “*Google brings any kind of information, we can’t trust that, but Yukti brings authentic and correct information*”.

Users appreciated the comfort of talking to the bot anytime, anywhere without the feeling of being judged. Some mothers mentioned their hesitation in reaching out to a doctor or anyone else and found the proxy of the bot to be useful. A mother[Pooja], who was shy and interacted with the bot using text messages in all her sessions, shared her feeling as “*I am shy when I visit the doctor, I am unable to ask anything. I could ask all my questions from Yukti*”. Hesitation in talking with males was highlighted in these experiences. In Indian society, sharing reproductive health with males is considered a taboo that makes women restrict themselves to female friends or relatives for any consultation. Meena (mother) - “*as a lady we share the same problems, if a male is standing in front of us, then we hesitate to talk about such matters*”. A mother confirmed from the research staff whether she could ask sex-related questions to the bot or not “*Can I ask a secret question? If a mother is*

breastfeeding her child, can she maintain physical relationships? People say this, but I went to my mother's place after delivery for seven months, but I had this question in mind, and I wanted to ask whether it is true or not?". After receiving the response, she appreciated the fact that she can ask anything from the bot, even personal questions. We noticed that she was waiting for the right time to ask this question and asked that in her last session, *"I was thinking since day 1 to ask this question"*. Mothers found the all-time availability of the app quite useful feature - *"there are times when we do not want to trouble anyone, for example, some problem arises at night then we can ask the bot"*. Many described Yukti as a friendly partner with whom they can share their concerns freely, *"Yukti gives answers like a friend, if I want to know anything, I can ask questions from the bot just like a friend"*.

Expectations of Stakeholders: ASHAs and Mothers

All of the participants expressed the need to broaden the scope of the chatbot beyond breastfeeding to other topics of mother and child care. While interacting with the bot some users attempted to ask questions other than breastfeeding and showed disappointment in not receiving the answers. The strong desire to talk to an expert and to get immediate solutions to their everyday problems and concerns was predominant among mothers. For example, Meena (mother) was curious to know suggestions on baby products from Yukti and asked a question as *"which product should I buy for my baby, Is the Patanjali brand good?"*. She also asked the research staff, *"can I ask questions on Thyroid, I had it before delivery, are there any chances of its continuation?"*. Another mother suggested *"you should also make Yukti type of application for girls to educate them on menstruation"*.

Compared to mothers, ASHAs were more restless about the limited scope of the bot. For instance, one of the ASHA said - *"why is the bot only about breastfeeding, there are only limited questions on breastfeeding, we can't ask more on this topic"*. Such feedback was particularly given by ASHAs, who mainly seemed to test the chatbot's knowledge. However, when the chatbot asked them questions back, out of 33 questions, the ASHAs,

on average, could correctly answer 19 (57%).

Comparing the perceived use-cases of a chatbot application for ASHAs and mothers, we majorly found two: ASHAs perceived the chatbot like a trainer to improve their knowledge and assist in handling their client cases. For Mothers, it was perceived to be more like a helper and first point of contact for addressing breastfeeding issues. Therefore, ASHAs and mothers did not represent a homogeneous group.

8.4 Discussion

Our exploratory study highlighted the promising potential of chatbots for educating community health workers and mothers on the subject of breastfeeding. Our study aims to understand how the actual beneficiaries (mothers and ASHAs in our case) perceive the AI intervention and identify the potential design opportunities and challenges. Within the realm of AI for social good, our study will expand the CSCW and HCI community's understanding of the potential of chatbots as an educational intervention in the under-served context of India. We believe that this understanding will be relevant and can be extended to similar cultural and resource-constrained contexts.

8.4.1 Interaction, Engagement, Trust, and Ecology

Our study with 22 users from resource-constrained settings of India highlights the value of providing timely breastfeeding advice to mothers. Given their restricted mobility and high dependency on others, the chatbot was seen as the first port of call by the mothers. Also, mothers found the chatbot a comfortable way of seeking information which they otherwise find difficult to discuss with others, especially with male doctors.

In terms of the effectiveness of answering the participants' questions, this simulated version of the chatbot could successfully respond to 88% of the queries with the curated reference material (ASHA training material). It was rare when the wizard had to take the help of external sources. These queries were mainly common breastfeeding problems. This

suggests that ASHAs' training material can be effectively used as a knowledge base for a chatbot. Further, we observed that while there were requirements for seeking expert consultation (26% and 9%), only 9% were complex enough queries that only a medical expert could answer. Given the low doctor-to-patient ratio in India, chatbots can be seen as a promising educational and training intervention to provide relief to already overburdened doctors. We would like to emphasize that chatbots should be seen as complementary support and not a replacement for a medical expert, as also emphasized by prior work on using technology for community education in developing regions [124, 58]

Our analysis of participants' information-seeking practices highlighted the need for sensitivity while answering within the user's context. We observed that the majority of the participants reflected deep-rooted beliefs on traditional practices. We observed that when the chatbot gave factual, technical answers, the mothers were not convinced; they sought more conversation on their ideas. Here, one approach could be expanding the capability of the chatbot, where it shares not just a fact but a rationale of why some practices started and why they should be discontinued. While presenting this kind of information, care must be given to local cultures, such as used in the studies of Sorcor et al. of delivering information on HIV, a taboo topic in India [263].

Further, our study highlighted the need to investigate appropriate methods for improving collaboration among family members in engaging with breastfeeding education. In almost all of the families, we noted limited involvement of husbands in breastfeeding-related concerns and activities, and predominance of female relatives such as mothers-in-law. Since both the husbands and female relatives have an important role in the mothers' lives in India, fostering their collective participation is necessary to stimulate the co-construction of knowledge. As suggested by Grimes et al., family settings also provide an idyllic environment to promote the use of health apps, creating opportunities for openness, care, and reflection [264]. In Indian societies where the involvement of male family members is limited, family informatics provides the opportunity to address gender-related social

norms [265, 266].

ASHAs perceived *Yukti* as a training tool and as a service to consult during field visits. This highlights the potential direction of investigating the role of chatbots in motivating ASHAs in their role of counselor. ASHAs have situated knowledge. Leveraging it in meaningful ways in the system design is important to address breastfeeding education in a more holistic way. Here, the use of Haraway's work on situated knowledge [267] can be explored in designing an ecology of actors (ASHAs, mothers, doctors) to make chatbots learn and inform more appropriately. For instance, by collecting data on mothers breastfeeding issues, a chatbot can maintain profiles of cases and proactively engage ASHAs at appropriate times.

Further, there can be other contextual scenarios hampering mothers' privacy. In the women population we studied, access to an internet enabled phone is a new possibility [209]. Many of them still do not have their personal smartphone, and share family member's phones. Further, even if they possess, they might not have complete control due to lack of operational knowledge and rely on family members for mediation. For example, we observed that ASHAs and mothers had their phones configured with the email-ids of their children or husband and did not know how to set up a new email account on their phones. This brings an interesting design challenge on two different aspects. First, How a woman can maintain her privacy on a shared phone, and second, how should the app behave in the given ecology. From a design perspective, one of the approaches could be to allow the app to have a private mode or password protection to protect its content from the non-intended user. To facilitate the phone sharing without causing embarrassment or discomfort to the sharers, one of the approaches could be to have configurable icons, notifications, reminders, etc., such that they are not embarrassing or disturbing to the other users of the phone, e.g., the husband.

8.4.2 Design Specific Ethical Considerations

Introducing conversational agents to vulnerable populations like those studied calls for careful attention to their conditions, culture, and contexts. A significant number of mothers in India do not have regular access to health care, have restricted mobility and power to make decisions [268]. In light of these challenges, we observed that chatbot availability while, on hand, gives the benefits of filling the gap of lack of information sources, on the other hand, poses a set of concerns that need significant ethical responsibility.

The first concern comes from the perception of the users towards chatbots designed for health education on topics like Breastfeeding. We observed that some of the mothers perceived the educational chatbot to be more like a healthcare delivery app. They asked a range of questions on their personal health condition to seek consultation. Given that they are using chatbots for the first time, a potential risk is that they might develop wrong notions about their health condition by just receiving generic information. This is particularly important given the sensitive topic of Breastfeeding in which the attitude and perception of the mother play a crucial role. For example, a mother perceiving low milk supply when asks a question might wrongly correlate some of the causing factors, thereby further exacerbating her condition. To mitigate these, it is essential that the chatbot design conveys its scope clearly and adopt strategies to help users arrive at correct interpretations. For example, a helpline service can be incorporated to connect mothers to a health expert at appropriate times.

In our study, the research staff had to clarify the doubts of the mothers on the chatbot responses on multiple occasions. Thus, we suggest designing support mechanisms to remove confusion right away. Further, discovering user intent behind the message automatically is a design implication for which the emerging body of work, analyzing social media posts to identify user intents can be leveraged [269]. Considering topics like Breastfeeding, which inherently have counseling aspects, the Chatbot design must take care of the language use. Techniques recommended for incorporating appropriate level of empathy should be utilized

[270, 271, 272, 273].

The second concern relates to the added risk of privacy and confidentiality. In our study, we observed that mothers found the chatbot to be a more comfortable option for seeking advice on private questions as compared to physicians or others. This raises the concern of how to preserve their privacy. If the chatbot design includes taking other health workers into the loop, there is a need to provide choices to the users whether they want to share the data of particular conversations or not. In particular, when users like ours who have low literacy and exposure to the digital world must be safeguarded appropriately on their data utilization. This also highlights the need for policy-level recommendations to be thought of for balancing the potential benefits and risk of introducing conversational agents in healthcare, an ongoing discussion in the artificial intelligence community [274, 275, 276, 277]. We emphasize before designing the actual chatbot, more experiments and consultations should be performed to develop a realistic sense of ethical pitfalls.

8.5 Summary

The increasing penetration of smartphones in developing regions has opened new opportunities for delivering targeted, low-cost interventions of public health education. Chatbots, with their ease of use, offer opportunities to reach out to populations who have limited digital experience. Towards this, we attempted to understand the potential of chatbots in educating mothers and community health workers in slum areas of India in the context of breastfeeding education. Our study unraveled several unexplored facets of chatbot applications for public health in low-resource communities. We found out that the chatbots have the potential to fill the gap of the lack of the first point of contact for seeking information. Further, we uncovered various contextual aspects that a chatbot design must take care in order to provide information in an effective manner, e.g., addressing age-old practices, the role of family members, etc., and other associated ethical and societal challenges.

Chapter 9

Discussion & Conclusion

The Alma Ata Declaration in 1978, signed by 134 national government members of WHO, was a milestone in shifting the discourse of public health from curative care to preventive care [278]. The Alma-Ata Declaration defined health as a state of complete physical, mental and social well-being and not mere absence of diseases. By recognizing health as a human right and calling out “health for all” as a flagship global health policy agenda, the declaration emphasized taking multi-sectoral measures and proposed primary health care as a core strategy to achieve the agenda. This led to the emergence of community health worker programs across the world at various scales [279]. However, the increased privatization and liberalization during the 1990s brought a downfall to the vision [279]. Many governments declined the cornerstone approach of community participation.

After observing stalled progress in Millennium Development Goals and growing health inequities, primary health care and community health workers once again came into prominence [280, 279]. Since 2007, there is a renewed focus to revitalize CHW programs to address the shortage of health professionals and the growing burden of diseases, especially in developing countries. Moreover, CHWs are considered bridges between the health sector and communities who can address the challenges associated with health service coverage and low community engagement in the health system and expected to enhance or embody health system accountability. The fulcrum of CHWs’ functioning is their social and geographic position that gives them an edge over professionals to understand healthcare barriers and thereby become key players in achieving global and national efforts to accomplish universal health coverage.

Community health workers play a primary role in providing maternal and child health services. CHWs are responsible for many interventions, including utilization of antenatal,

perinatal, and post-partum services, health promotion and disease prevention, breastfeeding promotion, family planning, and newborn care. These services have aided in reducing levels of maternal and child mortality. However, despite this, the overall progress has been slow. There are numerous practical obstacles in fulfilling the potential of CHWs relating to existing inefficiencies of the health systems, lack of clarity in the roles of CHWs, recognition issues by other workers in the hierarchies, and practical challenges in the program implementation. These have resulted in the shortfall of critical elements such as supportive supervision, continuous education and skill development, logistical support, remuneration, and the community's sense of ownership of the CHW program.

By focusing on the training aspect of CHWs in India, this dissertation develops an understanding of the basic knowledge and skill development needs of ASHAs and the scope for technology-based mediums. The table presented in the appendix 9.1 summarizes the associated studies. Through field-based studies, we came across the life and work settings of ASHAs in which the training interventions are provided and learned that the way forward is to focus on training as a process to help ASHAs continuously and systematically fill their knowledge gaps. Given the educational backgrounds of ASHAs, their position in the health system and nature of work, one-time or fixed training can not adequately address the deficiencies. We observed that even after having received pre-service and periodic training, ASHAs struggled with basic facts and sought assistance in handling their field cases. While ASHAs have sound knowledge of the communities' culture and contexts, they are not equipped with the appropriate training to leverage that knowledge in addressing the barriers to healthcare. The questions asked by the ASHAs reflected this need prominently. As emphasized by the expert in our experiments, the simple aspects of routine care have profound value in bringing behavior change and care-seeking. To make ASHAs skillful in these, there is a need to foster dialogue between ASHAs and the experts on a frequent basis. Technology-based mediums offer this opportunity at a low cost.

Another important aspect we observed through our research is regarding the ways to as-

sess knowledge of ASHAs. The gold standard methods of pre- and post-intervention tests, while give a good sense of the knowledge gaps and the gains, do not inform much about the nuances of the knowledge application. We need to dig deeper into how ASHAs construct knowledge in after-training environments. This is a potential future work. Mechanisms that can help ASHAs and the community members reflect together are needed.

Our large-scale study with 500 ASHAs (chapter 6) enabled collecting ASHAs questions and discerned topics and patterns in the information-seeking of ASHAs. Technology-mediated learning platforms offer this capability to complement existing face-to-face training methods, which often have limited time to discuss ASHAs queries and experiences. Such forums in turn, help in knowing the unmet needs of the communities and creating synergies between health systems and communities.

I will now discuss three prominent directions that emerged in the dissertation.

Feasibility, Opportunities, and Limitations of IVR Systems in Low-Resource Settings

One of the most significant advantages of IVR-based applications for resource-constrained settings is reachability. It enables providing services for those who are often left behind - low-literate, disconnected, and poor. On this premise, the HCI4D research around IVR has grown and demonstrated potential, covering a variety of application areas such as information access, community-led social networks, promotion of health, helpline services, crowd-sourcing applications [18, 17, 18, 281, 65]. We extend this direction by using IVR for the training and learning purposes of frontline health workers.

The affordance of voice communication makes IVR a usable technology, so long as the interface design is not complex. In our system, we attempted to keep minimum use of touchtone inputs for users. Unlike regular IVR systems, e.g., customer service that requires users to navigate through menus and options to interact with information, our system used standard voice call interaction. The ASHAs were required to interact with only one touchtone input (press '1' to raise hand). Without training, the ASHAs could

easily use the application and participate in the training session, where a single session could extend up to one hour. This saves significant training costs and time. Deployment of such systems thus provides feasibility benefits, although we acknowledge there is scope for improvement in the system design, and there are challenges with cellular connectivity.

For future designs, IVR represents a trade-off. On the one hand, while it provides the necessary reachability, on the other hand, it remains limited in user experience. Also, poor cellular connectivity that we observed persistently in our field studies needs careful attention when designing real-time interaction. Going forward, considering the increasing penetration of smartphones and the internet, it is relevant to explore rich interfaces. Still, IVR cannot be completely ruled out and should be incorporated at different levels to seam digital divides.

Here, we would like to highlight the usefulness of IVR integration in broad systems and hybrid system designs for creating contextual solutions. IVR offers capabilities to extend the reach of technology and includes users in remote areas where computing systems typically go absent. For instance, while the mobile subscriptions in India have reached 1176 million users, it still leaves behind 184 million people [282]. In our system, we adopted a hybrid architecture of combining a telephony application with a smartphone app to extend the reach of the Internet and facilitate online training in low-resource settings. By efficiently leveraging the user capabilities - some having access to smartphones and others having access to feature phones, we could offer an engaging interface over IVR. Likewise, the addition of asynchronous IVR services to the platform will facilitate learning anytime and anywhere. Users can access information on-demand in the fields without the dependency on mobile data, which is also a need raised by the ASHAs. We see good scope for IVR integration in various other applications, e.g., chatbots, data collection and workflow apps, etc. Since users with low digital literacy are still in the initial phase of learning and adopting computing systems, providing familiar fallback mechanisms for support is necessary.

The importance of investing in universal technologies becomes apparent in the current time of the COVID-19 pandemic. While the rest of the world is managing to move forward by adopting new tools for online working modes, users with low digital literacy and resource constraints face a dearth of tools. And as we know that the pandemic will continue to the following year (2022) or probably more, it is kind of urgent that we come up with inexpensive and easy-to-adopt remote mechanisms for low-literate and poor populations to avoid their relegation further. Our platform provides a strong case in favor of this need. Our tool has its applicability not limited to the context of CHWs training but more generally wherever group communications are needed, for example, remote education in rural schools, communication between employees, etc.

Mobile-Learning: a Promising Solution for Ongoing Training Support of CHWs

Traxler defines m-learning as the personalized, connected, and interactive use of handheld computers in classrooms, in collaborative learning during fieldwork, and in counseling and guidance [283]. It supports learning that is more situated, experiential, and contextualized within specific domains and affords the creation and use of up-to-date and authentic content [284].

Considering the setting in which ASHAs work, there are multiple factors for the suitability of mobile learning. First, the cost of infrastructure, transport, and logistics can be saved substantially. For instance, our intervention incurred a cost of 110.85 INR (1.63 USD) per ASHA for one-hour training session, which is much less than a face-to-face mechanism. Second, mobile platforms can respond to the social and practical challenges ASHAs face by supporting anytime, anywhere model of learning. Given the reality that ASHAs bear the major domestic responsibilities and have limited agency to change their routines, mobile learning affords the needed convenience. Third and most important, mobile learning can help address the knowledge and skill gaps of ASHAs in a continuous manner. As observed in our studies, ASHAs seek to learn through field-case discussions.

With appropriate designs, relevant information resources and expert guidance can be provided at the point-of-care, which otherwise get missed in fixed training schedules. Lastly, mobile learning also has a role to play in supporting peer-to-peer learning, which is the main source of learning for ASHAs.

This dissertation informs on these factors and suggests a number of future directions. One of the interesting paradigms that emerged from our experiments is to design online learning management systems for CHWs. We explored this in our peer-to-peer learning experiment, where trainers could design learning courses for ASHAs from a central system. Working towards designing a comprehensive platform for the trainers and ASHAs considering the dynamics of responsibilities, constraints, and needs warrants future research.

Scope for Intelligent Techniques in maternal and child health education

In this dissertation work, we observed a substantial scope for widening this problem domain through intelligent techniques. In the study described in the chapter 5, we explored the use of semi-automated NLP-based techniques to curate voice forum content, and in the study presented in the chapter 8, we conducted a pseudo experiment (wizard-of-Oz) to explore the potential of conversational agents for breastfeeding education.

These techniques are required to address the challenges in these settings. For instance, given that there is a scarcity of trainers, intelligent alternatives such as chatbots offer a good replacement to traditional learning material-based learning. Through dialogue-based interaction, chatbots can actively CHWs in the learning process and improve interaction with the learning material. The specific characteristics and contexts of the users and the settings provide a good research ground for the chatbots for social good theme.

Another key challenge in this area for automated techniques is to process local languages. Due to the non-availability of speech recognition engines, it is extremely challenging to screen, tag, and organize data automatically. Even where the standard languages are used, the mix of other languages, dialects, and accents makes the transcription quality

to be low. This has been an open research area for NLP. Integration of machine learning algorithms at various levels should be investigated to learn user patterns. As we think to expand our learning platforms and support anytime, anywhere learning paradigm, there is good scope for artificial intelligence for personalization too. Personalized learning is relevant to address the considerable variation in the knowledge gaps of ASHAs. By deducing learning paths for ASHAs from their activities, relevant content can be delivered. ASHAs with similar learning needs can be grouped with an instructor to provide further support.

9.1 Concluding Remarks

This dissertation addressed a research lacuna of understanding and designing solutions for the training needs of community health workers in India. The focus of the researchers, practitioners, and non-profits around the world has been so far on improving the performance of CHWs without giving the required attention to their knowledge improvement needs. With increasing responsibilities of the ambitious CHWs programs and little support for competence development, CHWs face challenges in delivering quality services. Sometimes, as a result, even put into jeopardy; facing the loss of credibility from both the communities and the health systems.

Providing effective and regular opportunities for competence development is a foundational step towards CHWs empowerment. From this dissertation work, we learned that this should not only be dependent on traditional sources of training, which do not compensate well for the variations in the educational backgrounds of ASHAs. Providing access to learning tools to cover up deficiencies and frequent opportunities for interaction with experts are needed. This dissertation puts light on the information needs of AHSAs by analyzing ASHAs' queries and the fact that despite regular training exposure, ASHA seeks basic knowledge and assistance in handling field cases. We inform how alternative mobile tools can address these needs through better designs. The dissertation also provides promising results in the efficacy and fitment of the mobile learning paradigm in the work

and life settings of ASHAs. This dissertation enriches existing HCI4D research by adding focus to the training aspect of CHWs and potential of mobile learning in general for the competence building of para-professionals and other front-line workers.

Publications

Deepika Yadav, Prerna Malik, Kirti Dabas, and Pushpendra Singh. 2021. Illustrating the Gaps and Needs in the Training Support of Community Health Workers in India. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI, 1-16. [Chapter 6]

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Appendix

Table 9.1: Summary of Dissertation

Chapter	Study & Contribution	Research Questions	Study & Participants	Method
4	Proposing and Field Testing <i>Sangoshthi</i> Training Platform	Is the proposed system feasible for conducting training sessions in rural India? What is the effectiveness of the <i>Sangoshthi</i> training environment in terms of learning outcomes for ASHAs? Is the system usable and useful for ASHAs and trainers?	Field Experiment Randomized Control Trial 40 participants	Mixed method Pre-Post Intervention tests Interviews System Interaction analysis
5	Investigating Opportunities for Peer-to-Peer Learning Model	Can semi-structured, group-based learning exercises facilitated through <i>Sangoshthi</i> tool produce knowledge gains in ASHAs? What are the group learning characteristics of ASHAs?	Field Experiment Randomized Control Trial 120 participants	Mixed method Pre-Post intervention test Group Sessions Analysis Interviews
6	Understand Training Needs through a Large-scale Study	What kind of information ASHAs seek from experts? What kind of knowledge or skill gaps the information seeking represent? To what extent the existing reference material can address the information seeking of ASHAs?	Field Study 500 participants	Mixed method Query Analysis Reference Material Analysis Interviews System logs analysis
7	Semi-Automating the Curation of Training Material	Are topic models useful for clustering the voice forum dataset? Is the relevance perception of the automatic annotation similar to manual annotation? Is the relevance perception similar across summary types (summary as a sentence, summary as a group of keywords)? Does the user preference for the type of summary, change based on the annotation source (human versus machine) and annotation type (summary sentence versus group of keywords)?	Usability Study Within-subject Design 48 participants (32 ASHAs, 16 ANMs)	Mixed method Analysis of User ratings Interviews
8	Understanding Opportunities for Conversational Agents in Breastfeeding Education	What is the perception of users towards chatbot-based breastfeeding assistance? What kind of breastfeeding information users - ASHAs and mothers - seek from a chatbot?	Exploratory Study Wizard-of-Oz Experiment 22 participants (12 ASHAs, 10 mothers)	Qualitative Analysis Query Analysis (Chats) Context Analysis (Field Observations) Interviews

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