Low-Cost Mobile Learning Solutions for Community Health Workers

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ABSTRACT

Accredited Social Health Activists in India play a critical role in improving the access to healthcare services of rural populations. Despite their key contribution in Millennium Development Goals, they receive inadequate training and supervision. Traditional face to face training face challenges of infrastructure, management and cost. Existing research studies have highlighted the potential of alternative approaches e.g. mHealth for capacity building, however so far they mainly focus on providing job aids only.

In this thesis, we are exploring mobile technologies for building a distance learning platform for ASHAs; which is low cost, feasible and relevant to the local context. We propose our system that combines Internet and IVR technology in a novel way such that it allows the trainers to connect to ASHAs through a conference call and host structured real time interactions via a smartphone application. To evaluate the system we have conducted a field deployment of four weeks in the Haryana state, India. In collaboration with an NGO we provided a training intervention to 20 ASHAs on Home Based Newborn Care and found positive outcomes in terms of learning gains and acceptability by the stakeholders. We aim to build a comprehensive mobile learning solution that utilizes the available resources efficiently in order to produce larger impact.

Keywords

Peer learning; CHW; ASHA; IVR; mHealth; mLearning; training

1. PROBLEM

Many developing countries face acute shortage of well-qualified medical professionals especially in rural communities and compensate it by relying on Community Health Workers (CHWs) [18] [23]. CHW is an umbrella term used for individuals coming from the communities selected and trained to act at the interface between communities and the public health system. Their primary role is to promote access to health care services, and mobilize community towards adoption of healthy behaviors. CHWs have contributed significantly in achieving Millennium Development Goal 4 (reduce child mortality rates) and 5 (improve maternal health). For example, counseling of mother for health pregnancy and newborn care led to 54% reduction of newborn deaths in Uttar Pradesh, India [14]. CHWs are known by different titles across countries such as Accredited Health Social Activists, lay health aides, health promoters, volunteer health workers etc [22]

India enrolls female volunteers from villages to serve as a key cadre of CHWs known as Accredited Social Health Activists (ASHA). Main functions of an ASHA include providing health education in communities, promote awareness about health services, escort pregnant women for institutional deliveries, and make regular home visits for antenatal and postnatal care [16]. ASHAs have been contributing in improving the maternal and newborn health and are currently over 900000 across the country. However, India faces persistent challenge in providing requisite skills to ASHAs. Some of the prominent problems in traditional face to face training relates to lack of regular refresher training, delayed training schedules, limited availability of training aids, lack of skilled trainers and insufficient funds [21]. As a result, ASHA knowledge and skills remains sub-optimal [15, 4].

Distance learning is a low-cost alternative for improving the knowledge of health workers and keeping them abreast of new clinical practices. It offers opportunities of continued education and has been found as one of the core motivational factor in the retention of health workers working in rural or remote areas [19]. Delivery of distance learning has been transformed greatly by technology, moving from the use of basic forms of print media to advance interaction platforms such as Massive Open Online Courses (MOOCs) etc. While technology is increasingly being adopted for the training of health professionals such as doctors, nurses etc. CHWs have been overlooked. In recent years, few countries have started exploring e-learning methods for remote training of CHWs. For instance, Shere Lou Z et al. [26] compared web-based training with the traditional classroom training for Community Health Advisors in 15 African American churches in Maryland for a period of two years. Work by zurawski et al. [30] under the project ECHO (Extension for Community Healthcare Outcomes) used videoconferencing technology to augment in-person training for skill development in New Mexico. Further to provide wide accessibility and promote standardized training, few countries have also rolled out online courses [28] too. [3]. However, these e-learning methods

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cannot applied to rural areas of India where a significant portion of population do not have access to computers and lack digital literacy. Presently, rural Internet subscribers in India account for only 9% of the total population [20].

Under these constraints, a viable mean of reaching out to target users is mobile phone due to its high penetration even in the remote regions. Hence, there is a growing body of researchers exploring mobile based interventions for empowering marginalized communities of rural India [24, 29, 17]. For CHWs, use of mobile job aids have been showing encouraging prospects. But still, there is no platform for training and learning purpose as such. There is a clear need of sustainable mobile learning solutions that can fit into the existing ecosystem without incurring huge cost in terms of infrastructure.

1.1 State of the art

This section presents work using mobile job aids for CHWs. Since CHWs get enabled into field without going through a rigorous training period, job aids have been a preferred choice of improving their performance [9]. Elsenheimer [7] defines job aid as "an external device or cognitive artifact that provides just-in-time knowledge and information to help individuals with tasks by directing, guiding, and enhancing performance". Patient education and counseling is one of the core functions of CHWs. Studying aid of mobile videos during home visits has been an interesting line of research. For example, Ramachandran et al. [25] found positive outcomes in the motivation of ASHAs and strengthening of dialog with women by showing short instructional videos. Fiore-Silfvast et al. [8] on the other hand, focused on the perceived impact of the use of these mobile videos on CHWs' work flow, pedagogical aspect of video showing and issues of authority and patient trust. Dissemination of relevant information to CHWs is another important application of job aids. Caroline et al. [11] presented the perception of health workers for a text message based intervention for malaria case management. Treatman et al. [27] discussed the benefit of multimedia job aids as compared to conventional job aids through analysis of 10 deployments of Commcare [6], popular mobile based platform for data collection and assisting CHWs in their home visits in low and middle income countries.

Further to improve adherence of CHWs to clinical protocols while diagnosis and treatment, a number of research efforts have been made to use mobile in place of traditional paper based methods. D-tree international organization has been piloting several programs for developing clinical algorithms using mobile technology (Commcare application) to be used by nurses and other health workers at government health facilities in Tanzania [2]. Derenzi et al. [5], reported findings of their initial investigations into the task of automating IMCI (Integrated Management of Childhood Illnesses) through the proposed PDA based system at a dispensary in Mtwara, Tanzania. Preliminary investigation noted less amount of time required for training health workers, along with better adherence to the IMCI protocols and user flexibility.

2. PROPOSED APPROACH

2.1 Design Rationale

Considering the rural settings, we had three main considerations for designing the system: low-literacy, limited or no access to smartphones/Internet and poor network coverage in the villages. For information dissemination in such environments, researchers have found voice based systems to be particularly effective. Early work on Spoken Web by Kumar et al. [1, 13] extended the field of making web services available to the underprivileged through voice interaction over ordinary phone calls by proposing a framework for creation of voice sites and a telecomm web browser. Interactive Voice Response systems (IVRs) particularly gained much attention with its popular feature of voice forum allowing exchange of messages within a group sharing a common interest [24, 29, 17]. The use of these tools have been limited to provide information services and not yet for education purposes.

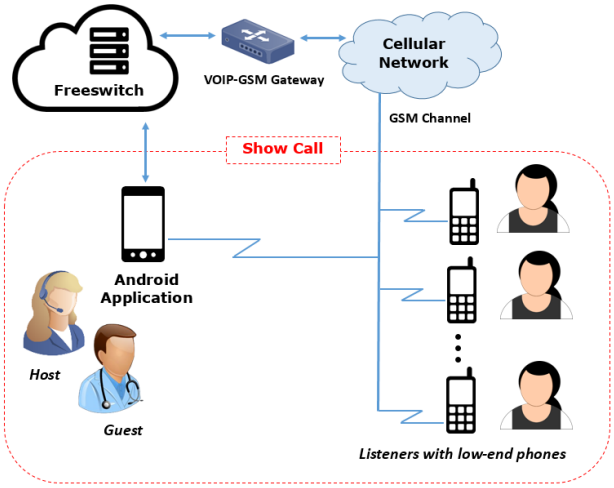

Figure 1: System Architecture

We aim for creating a platform using mobile phones that can offer the environment of a training session having both the trainers and the learners present together to discuss the content. To achieve this, we propose a system based on the architecture [12] that allows remotely present trainers to host real time training sessions with the distributed ASHAs via a smartphone application. While, the smartphone application that requires Internet connectivity is designed for trainers present in relatively resourceful settings, ASHAs can participate through basic phones only.

2.2 System Implementation

The interaction design of a training session is similar to a live talk show that has three kinds of participants - a host, an expert, and some listeners. The host with the help of the expert's knowledge and experience first delivers the topic content and then invites listeners to put forward their opinions or queries. Our system achieve this through a customized conference call amongst the participants over the cellular network. There are two main components: an android app as a client and a server built upon open source telephony platform known as Freeswitch [10]. While the Freeswitch handles all the telephony related functions, the android app controls the behaviour of the conference call. The communication between the app and the server happens over Internet either WiFi/mobile data. The app is designed to be used by the host or trainer which enables creation, preparation

and hosting of a show in the following sequence: 1.) create a show id, 2.) register phone numbers of the interested ASHAs, 3.) upload pre-recorded audio content, 3.) broadcast trailer calls to inform all the registered ASHAs about the upcoming show and 4 .) run and host the live show.

To run a show on the scheduled day of the show, the host via the app sends a start show request to the server, which in turn with the help of Freeswitch connects both the host and the registered ASHAs in a conference call. In this call, all the ASHAs join in mute mode and can only hear the host's voice. The host delivers the content of the topic by playing the pre-recorded audio file and then invites ASHAs to contribute their opinions and interact with the expert. ASHAs can signal their intent of speak by pressing "1" in their phones' keypad. This action is captured by the Freeswitch based server which in turn sends the list of ASHAs' caller ids (phone numbers) who have pressed "1" to the app. The app displays the last 3 digits of these ids using which the host can select ASHAs and send unmute request to the server on the basis of first come first serve, see Figure 1.

To be able to work in the low Internet bandwidth requirements, voice transfer was offloaded to the GSM based call instead of relying on VOIP (Voice over Internet Protocol) which consumes significant network bandwidth. Internet is required only for transferring control packets between the app and the server. This way any such interaction session can be hosted in environments with low-speed or intermittent connectivity of Internet which are often the cases in rural areas.

2.3 Mobile vs Non-Mobile Environment

On one hand, in rural areas where access to computers is so limited such that villagers often have to travel miles to the nearby cities, mobile phones on the other hand are widely available. Out of the total 449.17 million telephone rural subscribers in India, 444.84 million are of wireless subscriptions [20]. Hence, to reach out to the ASHA community anytime anywhere mobile phone is the only viable medium. The design choice of mobile has several advantages over the non-mobile. In the non-mobile version of our system ASHAs would be required to participate in the shows through registering their wireline telephone numbers. Not only wired connections are very few, this dependency would need ASHAs to be available near the phone location at the scheduled time of the shows. From the trainers' perspective, the non-mobile settings offers advantages such as reliable Internet connection and noise-free environment. But this will leave out the possibility where the trainer, a senior ASHA or nurse, host shows from the fields.

2.4 Features

Our system offers following features which are important from the standpoint of the constraints of a resource limited environment:

- No Additional Infrastructure: to train ASHAs with the current system, an organization needs to have a smartphone only. The only expense is the conference call charges which is around 36.96 INR (0.54 USD) per minute for 22 callers.
- No high speed Internet connection: Since voice transfer happens over the cellular network, Internet is required only for exchanging small data packets of control information between the server and the app.
- Language independent: the platform is voice based, it can be readily deployed in different states of India having numerous dialects.
- Real time interaction: The most important feature of the system is that it can host live interactions between the participants, which offers - training session environment, immediate query resolution, better audience engagement and sense of community building.

3. METHODOLOGY

We collaborated with a non-government organization located in Haryana state, India to get the ASHA userbase. The topic of the training was chosen to be Home Based Newborn care (HBNC), which is an important module in the training curriculum of ASHAs. HBNC programme was adopted by the government of India in 2011, to prevent newborn deaths through provision of basic care at home. Under HBNC, ASHAs are supposed to make home visits to the mothers post-delivery on specified days for the period of first 42 days. ASHAs need to guide mothers and families on nutrition, care, hygiene and family planning, identify illnesses of newborn and make referrals. To improve knowledge on these parameters, ten essential topics were selected. The content was prepared in written form based on the standard guidelines and molded according to the local context. Thereafter, to make the content ready for the training sessions, it was recorded in audio format in the form of dialogue between a host and a guest. Total six weeks were invested in content collation, script writing, rehearsing, and recording.

Participants included in the study were : 2 hosts, 1 doctor and 40 ASHAs. ASHAs were divided randomly into two groups: treatment and control. The treatment group received a training intervention for a period of 22 days consisting of 12 training sessions on the 10 topics. The time slot of the training session was decided on the basis of the preferences of majority of the ASHAs and were conducted at least twice in a week. The hosting location was the NGO office having both the doctor and the hosts physically present. In addition, a dummy listener was also recruited in every session to signal any kind of voice related issue.

3.1 Evaluation

To evaluate the system on its training aspects, we compared the knowledge gains of the ASHAs of the two groups through pre and post-intervention tests. The questionnaire for the tests had 20 open-ended questions covering the selected 10 topics. The open-ended format was chosen to get more insights for further qualitative analysis. An example of a question is "How do you recognize depression in a mother post delivery". Since all ASHAs were geographically distributed in an area of around 100 km, questionnaire was administered over phone calls. ASHAs test scores were computed by two evaluators (researchers involved in the study) using a common rubric designed by the doctor. In case of different scores for a response, final score was computed through the method of discussion between evaluators.

Incentive were given to ASHAs based on per interaction basis, 100 INR per interview and 800 INR for the 12 training sessions. Control group who were interviewed two times before and after the intervention, received 200 INR per ASHA

and the treatment group received 1000 INR. Our study was based on mixed method approach including both the qualitative and quantitative data analysis. Qualitative data included interview and training session transcripts. Total 103 interviews were conducted; 80 interviews of 40 ASHAs for pre and post test, 20 exit interviews of the treatment group and 3 in-person exit interviews of the doctor and the 2 hosts. Quantitative data used for the analysis included the system logs for call events such as session call answer/drop timestamps, mute/unmute timestamps, interaction counts etc.

4. RESULTS

The subsequent subsections are going to evaluate the system on four aspects: (1) Feasibility—Can *Sangoshthi* run training sessions successfully? (2) Efficacy—Do interactions via *Sangoshthi* enhance the knowledge levels of ASHA? (3) Usability—What are the attitudes and experiences of the hosts, experts and the ASHAs towards the *Sangoshthi* platform? and How do the stakeholders perceive the usefulness of *Sangoshthi*?

4.1 Feasibility

The primary concern in hosting of the shows is the poor infrastructure in the villages of ASHAs. A significant portion of ASHAs used to face frequent call drops during the on-going show calls. To combat with it, our system was designed to call back the callers on detecting their hung up events. Th upper limit of redial was set as four in case of no answer. Out of all the 12 shows, only two incidences of call drops having duration greater than 5 minutes were noted. On average, a show of duration greater then 60 minutes observed 19 call drops from 11 unique listeners and a listener experienced only one call drop per show. There was one listener who experienced maximum number of call drops (30) in 12 shows due to problems in connectivity in her area.

4.2 Efficacy

The pre-intervention test scores percentages of the two groups were non comparable 28% and 34% (Wilcoxon Sum Test, $p< 0.05$). Nevertheless, after the training intervention, the percentage of improvement in the treatment group was 16% (Wilcoxon Signed Rank Test, $p < 0.05$), as compared to control group 5% (Wilcoxon Signed Rank Test, $p < 0.05$). One of the possible reasons for statistically significant improvement in the control group could be the knowledge sharing activity between ASHAs of two groups, as many of them who lived nearby used to meet and share the training content as mentioned during exit interviews. The final post-treatment test scores percentages of the control group was 33% and treatment group was 50% with statistically significant difference (Wilcoxon Sum Test, $p < 0.05$).

Interaction Value

The emphasis of these training was learning by the act of sharing instead of didactic teachings. Hence, in a session having two segments: first for delivery of the content and second for interaction between the ASHAs and the expert, majority of the time was dedicated on the interaction segment. The interaction composed of multiple rounds that we called as Q&A. On an average in a show of 1 hour duration, 45 minutes were dedicated for Q & As.

Likewise, ASHAs also showed great enthusiasm toward participation in Q & As. According to the system logs for the interaction count of ASHAs, on an average a single session had 20 interactions, and every ASHAs spoke at least once per session. The benefits of active participation got directly reflected into ASHAs test performance also. Table 1 represents the correlation between the score improvement and interaction score. In fact, 3 ASHAs who had low initial scores reached amongst the top 5 scorers list.

Table 1: Impact of Interaction

Pre-Treatment Score	Interaction Score	Improvement Rate
low	low	17%
low	high	19%
high	low	9%
high	high	17%

Peer learning

The most important feature of the proposed training platform was its ability to foster peer learning. ASHAs effectively utilized the opportunity to put forward a wide range of queries. They mainly presented the cases in their areas and sought guidance on how to deal with them. ASHAs particularly appreciated the interaction session feature because it made them exposed to a variety of problems faced by other ASHAs which they were not aware of. Peer learning was also fostered within ASHA neighborhood through discussions and also through events of attending sessions in company of family members or friends.

4.3 Usability

The conversation protocol based on pressing the "1" key was appreciated by both the ASHAs and the trainers. The expert said that "*"The biggest advantage of this system was that we were able to converse systematically without any overlaps"*".ASHAs were able to easily remember their session identities as the last 3 digit of their phone numbers. In addition, over a period of time both the ASHAs and the host developed alternative ways to control participation in the shows. For example, some ASHAs used to press "1" before the invite in eagerness to come at the starting positions in the waiting queue. Likewise, the hosts managed the priorities of speaking based on their memory of ASHAs who had already spoken the maximum number of times in order to give turns to the new speakers. The system log showed that ASHAs in addition to the key "1" also pressed other keys. Total 9 shows had the functionality to capture these events and on average 22 such events were noted per show. On average per ASHA 6 such occurrences were attributed with an exception who did 62 times in 9 shows.

4.4 System Usefulness

In this section we would like to discuss the system aspects that support its potential to establish as a complementary solution towards existing training mechanisms.

- Economical Aspects: The main expense of our system are the call charges. With our current service provider Doorvaani, the cost of a single session of 60 minutes was 2217.60 INR (32.61 USD) and 110.85 INR (1.63 USD) per ASHA. Conversely for a single traditional face to face training session, the expense per ASHA estimates to be quite high due to travel and other logistics. Presently, the system use was free of cost for ASHAs because they were only required to

answer an incoming call. On asking for the reverse case, where ASHAs would be required to connect to a session through an outgoing call, most of the ASHAs agreed for the benefit in terms of their knowledge gain.

- Training Acceptance: since ASHAs are responsible for doing majority of the household work, it was important to understand their acceptability of these kinds of training interventions. ASHAs welcomed the intervention in a form of refresher training as it gave them opportunity to enhance knowledge without being relocated. Most of the them preferred to receive such training after a gap of every 5-6 months, with two sessions per week.

- System Benefits: ASHAs mentioned the training benefits in their home visits as they felt more confident while counseling women. 18 ASHAs reported direct health benefits to the families. A supporting quote from an ASHA about her experience of mother counseling: *"I had a delivery case in my area, in which the mother on discovering the birth of a girl child, cried a lot and went into depression. I pacified her patiently and explained in detail the value of breast feeding, play and communication and measures of reducing depression. Now she is happy and is also feeding her baby".* On the other hand, the NGO head who played the role of doctor mentioned the benefits as: *"The system is very beneficial for us because it helped us in building the capacity of ASHA on home based newborn care remotely which becomes difficult logistically in face to face training session. 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"*

5. CONCLUSION & FUTURE WORK

Our approach used Internet in an efficient way to benefit the hard-to-reach populations through the use of both the simple and smart mobile phones and opens new research directions for building sustainable mobile learning applications for CHWs. The user experience gives us design requirements for future systems. For instance, many ASHAs used to record the session calls for future reference and sharing with others. For which we plan to create a content library, that can be made accessible to ASHAs through IVR based system. Since, around 30% of ASHAs who had smartphones showed keen interest in receiving the visual content.In future, we plan to extend our system for smartphone users also to provide more interactive components of learning. Similar to the learning environments provided by MOOCs such as Coursera, we can extend our system to incorporate mobile apps for the ASHAs that will act as a learning management system offering features of accessing content in form of courses including exercises, discussion forums etc. While MOOCs targets large audience, our system will be focused on ASHA community tuned according to the local context. Following are the potential future directions that we aim to pursue for empowering CHWs through mobile learning solutions:

- Improve Interaction Experience: to provide a rich experience of learning for smartphone userbase, we would explore the feature to allow controlled and synchronous video watching. This means that the video playbacks (play/pause/seek) in the devices of the ASHAs will be controlled by the trainer's app. Here, we assume that the video content is present with the ASHAs in advance. To achieve this in near real time, we will have to take care of the network delay and execution delay.

- Content Generation and Editing Tools: There are two stakeholders for content generation. First are the trainers and second are the consumer themselves. Combination of the two gives content suitable to the local needs. In the constraints of low resource settings, content creation tools should be such which are low-cost, portable and adaptable to the intermittent power supply. Smartphone is a viable medium, but we need to design apps that can be used by the rural people, majority of whom do not have the basic digital literacy levels. Likewise, the editing tools must be intuitive for use by the non-experts.

- Automatic Content Curation: significant amount of data get generated during screening of the shows which is directly useful for building a good content library. This library can assume forms such as show highlights, question banks, ASHA favorite questions, experts' opinions etc. Library maintenance is an important requirement for platforms like ours to become scalable. However, its creation entails screening and categorizing of the content through a dedicated team of moderators which often becomes a barrier as highlighted by the existing work [29]. In this regard, technology based content curation is a potential thread of research. We will explore the techniques that can automatically extract the useful content.

6. REFERENCES

[1] Sheetal K Agarwal, Anupam Jain, Arun Kumar, and Nitendra Rajput. The world wide telecom web browser. In *Proceedings of the First ACM Symposium on Computing for Development*, page 4. ACM, 2010.

[2] Molly Bogan, Jan van Esch, Gayo Mhila, Brian DeRenzi, Caroline Mushi, Timothy Wakabi, Neal Lesh, and Marc Mitchell. *Improving standards of care with mobile applications in Tanzania*. W3C, 2009.

[3] J Nell Brownstein, Alberta M Mirambeau, and Katherine B Roland. News from the cdc: using web-based training to translate evidence on the value of community health workers into public health action. *Translational behavioral medicine*, 3(3):229–230, 2013.

[4] Emily Das, Dharmendra Singh Panwar, Elizabeth A Fischer, Girdhari Bora, and Martha C Carlough. Performance of accredited social health activists to provide home-based newborn care: A situational analysis. *Indian pediatrics*, 51(2):142–144, 2014.

[5] Brian DeRenzi, Neal Lesh, Tapan Parikh, Clayton Sims, Werner Maokla, Mwajuma Chemba, Yuna Hamisi, Marc Mitchell, Gaetano Borriello, et al. E-imci: Improving pediatric health care in low-income countries. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 753–762. ACM, 2008.

[6] Dimagi. Commcare. https://www.commcarehq.org/home/, 2017. [Online; accessed 04-January-2017].

[7] Jim Elsenheimer. Job aids in the technology age. *Performance Improvement*, 37(8):32–35, 1998.

[8] Brittany Fiore-Silfvast, Carl Hartung, Kirti Iyengar, Sharad Iyengar, Kiersten Israel-Ballard, Noah Perin, and Richard Anderson. Mobile video for patient education: the midwives' perspective. In *Proceedings of the 3rd ACM Symposium on Computing for Development*, page 2. ACM, 2013.

[9] Jose F Florez-Arango, M Sriram Iyengar, Kim Dunn, and Jiajie Zhang. Performance factors of mobile rich media job aids for community health workers. *Journal of the American Medical Informatics Association*, 18(2):131–137, 2011.

[10] Freeswitch. Freeswitch. https://www.freeswitch.org/, 2016. [Online; accessed 05-February-2017].

[11] Caroline OH Jones, Beatrice Wasunna, Raymond Sudoi, Sophie Githinji, Robert W Snow, and Dejan Zurovac. âĂIJeven if you know everything you can forgetâĂİ: health worker perceptions of mobile phone text-messaging to improve malaria case-management in kenya. *PLoS One*, 7(6):e38636, 2012.

[12] Konstantinos Kazakos, Siddhartha Asthana, Madeline Balaam, Mona Duggal, Amey Holden, Limalemla Jamir, Nanda Kishore Kannuri, Saurabh Kumar, Amarendar Reddy Manindla, Subhashini Arcot Manikam, et al. A real-time ivr platform for community radio. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 343–354. ACM, 2016.

[13] Arun Kumar, Sheetal K Agarwal, and Priyanka Manwani. The spoken web application framework: user generated content and service creation through low-end mobiles. In *Proceedings of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A)*, page 2. ACM, 2010.

[14] Vishwajeet Kumar, Saroj Mohanty, Aarti Kumar, Rajendra P Misra, Mathuram Santosham, Shally Awasthi, Abdullah H Baqui, Pramod Singh, Vivek Singh, Ramesh C Ahuja, et al. Effect of community-based behaviour change management on neonatal mortality in shivgarh, uttar pradesh, india: a cluster-randomised controlled trial. *The Lancet*, 372(9644):1151–1162, 2008.

[15] Darshan K Mahyavanshi, Mitali G Patel, Girija Kartha, Shyamal K Purani, and Sunita S Nagar. A cross sectional study of the knowledge, attitude and practice of asha workers regarding child health (under five years of age) in surendranagar district. *infection*, 72:55–38, 2011.

[16] Government of India Ministry of Health & Family Welfare. Support mechanism for asha. http://bit.ly/2mBlzqt, 2016. [Online; accessed 18-December-2016].

[17] Preeti Mudliar, Jonathan Donner, and William Thies. Emergent practices around cgnet swara, voice forum for citizen journalism in rural india. In *Proceedings of the Fifth International Conference on Information and Communication Technologies and Development*, pages 159–168. ACM, 2012.

[18] Vasant Narasimhan, Hilary Brown, Ariel Pablos-Mendez, Orvill Adams, Gilles Dussault, Gijs Elzinga, Anders Nordstrom, Demissie Habte, Marian Jacobs, Giorgio Solimano, et al. Responding to the global human resources crisis. *The Lancet*, 363(9419):1469–1472, 2004.

[19] Anya J Nartker, Liz Stevens, Alyson Shumays, Martin Kalowela, Daniel Kisimbo, and Katy Potter. Increasing health worker capacity through distance learning: a comprehensive review of programmes in tanzania. *Human resources for health*, 8(1):1, 2010.

[20] Telecom Regulatory Authority of India. The indian telecom services performance indicators. "http://bit.ly/2cy0yLy, 2016. [Online; accessed 20-October-2016].

[21] Updates on Asha Programme July 2013. Ministry of health & family welfare. http://bit.ly/2l2ftD0, 2015. [Online; accessed 20-October-2016].

[22] World Health Organization. *Global age-friendly cities: A guide*. World Health Organization, 2007.

[23] World Health Organization. Taking stock: Task shifting to tackle health worker shortages. http://bit.ly/2m1FVeU, 2010. [Online; accessed 27-December-2016].

[24] Neil Patel, Deepti Chittamuru, Anupam Jain, Paresh Dave, and Tapan S Parikh. Avaaj otalo: a field study of an interactive voice forum for small farmers in rural india. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 733–742. ACM, 2010.

[25] Divya Ramachandran, John Canny, Prabhu Dutta Das, and Edward Cutrell. Mobile-izing health workers in rural india. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1889–1898. ACM, 2010.

[26] Sherie Lou Z Santos, Erin K Tagai, Min Qi Wang, Mary Ann Scheirer, Jimmie L Slade, and Cheryl L Holt. Feasibility of a web-based training system for peer community health advisors in cancer early detection among african americans. *American journal of public health*, 104(12):2282–2289, 2014.

[27] Derek Treatman and Neal Lesh. Strengthening community health systems with localized multimedia. *Proceedings of M4D 2012 28-29 February 2012 New Delhi, India*, 28(29):7, 2012.

[28] Johns Hopkins University. Training and learning programs for volunteer community health worker. http://bit.ly/2mzmHyV, 2016. [Online; accessed 17-December-2016].

[29] Aditya Vashistha, Edward Cutrell, Gaetano Borriello, and William Thies. Sangeet swara: A community-moderated voice forum in rural india. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 417–426. ACM, 2015.

[30] Andrea Zurawski, Miriam Komaromy, Venice Ceballos, Christie McAuley, and Sanjeev Arora. Project echo brings innovation to community health worker training and support. *Journal of Health Care for the Poor and Underserved*, 27(4):53–61, 2016.