The role of an mHealth intervention in improving knowledge and skills of accredited social health activists in tribal areas of Gujarat, India: a nested study within an implementation research trial

Shobha Shah (shahshobha30@gmail.com), Aakash Shinde, Ankit Anand, Dhiren Modi, Gayatri Desai, Hardik Bhatt, Ravi Gopalan, Nishith Dholakia, Prakash Vaghela, Shrey Desai, Pankaj Shah

1. Women’s Health and Training Center, Society for Education, Welfare and Action-SEWA Rural, Bharuch, Gujarat, India
2. Community Health Project, Society for Education, Welfare and Action (SEWA) Rural, Bharuch, Gujarat, India
3. Kasturba Maternity Hospital, Society for Education, Welfare and Action (SEWA) Rural, Bharuch, Gujarat, India
4. Argusoft India Ltd, Gandhinagar, Gujarat, India
5. Department of Health and Family Welfare, Government of Gujarat, Gandhinagar, Gujarat, India

ABSTRACT

Aim: To evaluate the effectiveness of an mHealth intervention in improving knowledge and skills of accredited social health activists in improving maternal, newborn and child health care in India.

Methods: This was a nested cross-sectional study within a cluster randomised controlled trial. The intervention was a mobile phone application which has inbuilt health education videos, algorithms to diagnose complications and training tools to educate accredited social health activists. A total of 124 were randomly selected from the control (n = 61) and intervention (n = 63) arms of the larger study after six months of training in Bharuch and Narmada districts of Gujarat.

Results: The knowledge of accredited social health activists regarding pregnancy (OR: 2.51, CI: 1.12–5.64) and newborn complications (OR: 2.57, CI: 1.12–5.92) was significantly higher in the intervention arm compared to the control arm. The knowledge of complications during delivery (OR: 1.36, CI: 0.62–2.98) and the postpartum (OR: 1.06, CI: 0.48–2.33) period was similar in both groups. The activists from the intervention arm demonstrated better skills for measuring temperature (OR: 4.25, CI: 1.66–10.89) of newborns compared to the control group.

Conclusion: The results suggest potential benefits of this mHealth intervention for improving knowledge and skills of accredited social health activists.

INTRODUCTION

India accounts for 19% of global maternal deaths and 21% of global childhood deaths (1). The maternal mortality ratio is 167 per 100 000 live births, and the infant mortality rate is 40 per 1000 live births (2,3). Major improvements have occurred in maternal, newborn and child health (MNCH) care coverage following the launch of the National Rural Health Mission (NRHM) programme in 2005 (4). Accredited social health activists (ASHAs) play a pivotal role in NRHM’s strategy to strengthen the healthcare delivery system in rural India. ASHAs are expected to create awareness on health and its determinants, mobilise the community towards local health planning and increase utilisation of the existing health services (5). Evaluation of

Key notes

- The need for ongoing capacity building and refresher training of the health workers remains an important implementation challenge.
- mHealth strategies might be effective in improving skills and knowledge of accredited social health activists (ASHAs) who are providing maternal, newborn and child health services in villages within the government health system in Gujarat, India.
- mHealth strategies might be useful to overcome implementation challenges to ensure trained health workforce at scale.
the methods to improve the performance of ASHAs in terms of knowledge and skills in the domain of MNCH care is crucial to achieve development goals through the NRHM.

ASHAs are incentivised front-line health workers trained to provide MNCH services in their villages. Their tasks include mobilisation of pregnant women, mothers and children for using health services such as antenatal care, childbirth, home-based care of newborns and immunisation (6). ASHAs are supplied with essential medicines, such as antibiotics for providing treatment for common illnesses and nutritional supplements. Each ASHA is a member of a Village Health and Sanitation Committee which plans various health services (6).

Previous studies assessing knowledge and skills of ASHAs have exhibited gaps in different facets of their performance (7–9). Less than a quarter of ASHAs in the state of Maharashtra, India, were able to state the danger signs for which a child with pneumonia or diarrhoea should be referred to a health facility (7). Only half of the ASHAs in Delhi knew that swelling of feet during pregnancy is a sign of severe anaemia (9). Research from central India (Madhya Pradesh) suggests that despite training sessions, gaps still exist in their understanding of various aspects of child morbidity (8). A Delhi-based study of healthcare delivery by ASHAs revealed that their knowledge was good, but their practices were inadequate. The study suggested this needs to be addressed through skills-based training related to good communication and problem-solving (9). Studies from Gujarat and Lucknow have emphasised the need for continuous capacity building to improve the knowledge and skills of ASHAs as well as improve their efficiency in the delivery of health services (10–12).

In recent years, mobile health (or mHealth) has been widely practised in low- and middle-income countries to provide health services, which include dissemination of health education, reminders, emergency response, support and monitoring (13). Due to the surge in mobile connectivity in recent years, there is an opportunity to use this platform to improve the capacity and workload of health workers in India (13,14). This study aimed to evaluate the effectiveness of an mHealth intervention [Innovative Mobile Health Technology for Community Health Operations (ImTeCHO)] in improving knowledge and skills of ASHAs in MNCH care. This study, a nested assessment within a larger cluster randomised trial, was carried out six months after an initial training to assess the effectiveness of both the training and the mHealth intervention.

**METHODOLOGY**

**About the randomised controlled trial (RCT) and intervention**

The larger RCT aims to implement and evaluate an innovative intervention based on mobile phone technology to improve the performance of ASHAs through better supervision and support in predominantly tribal and rural communities of Gujarat, India. This is a joint initiative of a voluntary organisation, SEWA Rural and the Gujarat state government. There are 11 primary health centres (PHCs) (with a catchment population of approximately 20 000 each) in each arm. ImTeCHO is an mHealth technology-based job aid locally developed to support ASHAs in performing their scheduled tasks in the field. ImTeCHO helps each ASHA in the following ways:

- scheduling her visits to infants and mothers in her village by automatic alerts via mobile phone;
- reminding all essential tasks to be performed at home visit;
- having inbuilt health education videos for behaviour change communication for effective counselling;
- providing inbuilt algorithms for diagnosis of high-risk low birthweight (LBW) infants and their treatment plans;
- training and regular updating of audio and video lectures in ImTeCHO to increase knowledge and skills;
- access to ImTeCHO helpline for improving skills and knowledge on MNCH care.

Some of the training component provided through the ImTeCHO application includes information about the importance of institutional delivery and antenatal examination, essential newborn care, exclusive breastfeeding, initiation of complimentary feeding and recognition of danger signs of pregnancy, newborn period and early infancy. The mobile platform was used to deliver short videos demonstrating the skills regarding the recognition of anaemia during pregnancy, measurement of weight and temperature of a newborn baby, measurement of breaths for recognition of pneumonia along with signs of dehydration during diarrhoea.

Along with the above-mentioned phone content to improve the knowledge and skills of ASHAs, classroom training was conducted jointly by trainers from SEWA Rural and the state government over seven days. The detailed objectives and description of the ImTECHO intervention have been published elsewhere (14).

The outcome indicators for the RCT are coverage of proven MNCH services as measured through baseline and endline surveys.

**Study setting of the present nested study**

This study was a nested cross-sectional study within the above-mentioned cluster RCT. The nested study was conducted with selected ASHAs from the study area in Bharuch and Narmada districts of Gujarat, India.

**Sample size for the nested study**

The sample size was calculated using two indicators: (i) the proportion of ASHAs with knowledge of the correct treatment for pneumonia (intervention = 0.50, control = 0.25); (ii) the proportion of ASHAs who demonstrated the correct method for weighing an infant (intervention = 0.25, control = 0.05). The formula shown was used to calculate the sample size.
The sample size was calculated at 55 ASHAs per group (assuming confidence level = 0.95 and power = 0.80) for this nested study.

**Selection of ASHAs**

In the RCT, the total number of ASHAs in the 11 intervention PHCs and 11 control PHCs were 283 and 265, respectively, with each given a unique number.

The baseline data collection occurred on the first day of training immediately after the ASHAs arrived at the training venue. Five ASHAs from each of the 11 PHCs were invited for data collection on the first day of training considering required sample size of 55 per arm. All ASHAs accepted the invitation for data collection, and therefore, 55 ASHAs were interviewed at the baseline.

After six months of completion of the training, data collection was carried out at the project headquarter. ASHAs were invited to arrive at the data collection venue on a predetermined date. Considering the required sample size of 55 per arm and potential no response rate, seven ASHAs from each of the 22 PHCs were randomly invited. So, 77 ASHAs were assessed for eligibility and invited from each arm. ASHAs who did not receive training for MNCH as per the government norms were excluded. Only ASHAs who had used the ImTeCHO mobile application for six months were selected for the nested study. Eligible ASHAs were contacted individually and invited to take part in the survey. Of 77 invited ASHAs, 63 ASHAs from the intervention arm and 61 ASHAs from the control arm were eligible and arrived at the venue for data collection.

Considering the methodology described above, the sample of ASHA for the baseline and endline evaluation was different. Detailed information and objectives of the nested study were shared with selected ASHAs. See Figure 1 for detailed information about the sample selection.

**Data collection**

Data collection was carried out using a pretested, structured questionnaire by data collectors who were trained in integrated management of newborn and childhood illness and were blinded to the study arms. Knowledge-related questions were completed in one-to-one interviews by data collectors at SEWA Rural head office, whereas questions related to the skills of ASHA were completed in the field by observation. Data collectors turned in the completed questionnaires to a quality control officer, who checked them for quality and completeness. To assess the quality of data, 10% of the sample was re-interviewed by the quality control officer. Data were entered by a data entry operator.

---

**Figure 1** Study design and flow chart.
Data collection was conducted in July 2016 over a two-week period. Each ASHA in the study was given a monthly incentive of IRs 800 (US$ 12)/month for using a mobile phone. The monthly recharge cost for the Internet connection (1GB/2G) of IRs 179 (US$ 2.74) was borne by SEWA Rural.

Statistical analysis
Cross-tabulation was performed to see the differences between intervention and control clusters. Chi-square and Fisher’s exact tests (for numbers of cases below five) were used to measure the differences between intervention and control groups. Multivariate logistic regression was used for each of the variables on knowledge and skills to generate the ORs for the intervention arm. The ORs were adjusted for caste and years of work experience as they were thought to be potential confounders. STATA version 12 was used to analyse the data (15).

Ethical issues
The trial was approved by the Ethics Review Committee of WHO and SEWA Rural Institutional Ethics Review Committee. Written informed consent from ASHAs was obtained for enrolment in the study. The confidentiality of the participants was maintained throughout the study, and personal information on ASHAs was removed from the final dataset.

RESULTS
Knowledge of ASHAs before training
During the training period, questionnaires to assess knowledge of 110 ASHAs (55 in intervention and 55 in control arm) were completed (Table 1). There was no difference between intervention and control arms in terms of knowledge on MNCH care.

Characteristics of ASHAs sampled for the survey after six months of training
Overall, 124 ASHAs (63 in intervention and 61 in control arm) were assessed. The average age of ASHAs was 32.9 years, 93% (116/124) were married, 61% (76/124) had primary education, 85% (105/124) were indigenous tribal, and 58% (72/124) had worked for more than five years (Table 2). Only 22% (45/124) covered a population of over 1000.

Knowledge of ASHAs regarding MNCH care after six months of training
The proportion of ASHAs who identified five pregnancy complications was significantly higher in the intervention (OR: 2.51, CI: 1.12–5.64) compared to the control group (Table 3). In the intervention clusters, 75% (47 of 63) of ASHAs had knowledge of at least five signs of newborn complications compared to 57% (35 of 61) in the control areas (OR: 2.57, CI: 1.12–5.92). Both ASHA groups knew about the advantages of kangaroo mother care (KMC), but knowledge regarding the impact of KMC on weight gain

### Table 1 Knowledge of ASHAs at baseline

| Knowledge area                                                                 | Intervention (n = 55) | Control (n = 55) | Unadjusted OR (95% CI) |
|--------------------------------------------------------------------------------|-----------------------|------------------|------------------------|
| Minimum number of iron tablets (100) recommended during pregnancy             | 29 (52.7)             | 29 (52.7)        | 1.00 (0.44–2.26)       |
| Any three danger signs or symptoms during pregnancy/childbirth/after childbirth| 38 (69.1)             | 43 (78.2)        | 0.62 (0.24–1.60)       |
| Breastfeeding within one hour of childbirth                                     | 52 (94.5)             | 52 (94.5)        | 1.00 (0.13–7.82)       |
| Number and timing of ASHA home visits after childbirth                           | 46 (83.6)             | 46 (83.6)        | 1.00 (0.32–3.13)       |
| Starting complementary food at six months                                       | 50 (90.9)             | 51 (92.7)        | 0.75 (0.14–3.89)       |
| Medicine (cotrimoxazole) for pneumonia which ASHA can provide                  | 0 (0)                 | 6 (10.9)         | Not applicable         |
| Medicine (ORS/Zinc) for diarrhoea which ASHA can provide                        | 45 (81.8)             | 53 (96.4)        | 0.17 (0.02–0.87)       |

### Table 2 Social and economic characteristics of ASHAs at endline (N = 124)

| Characteristics                      | Intervention (n = 63) | Control (n = 61) | Unadjusted OR (95% CI) |
|--------------------------------------|-----------------------|------------------|------------------------|
| ASHAs’ age >29 years                 | 38 (60%)              | 41 (67%)         | 0.74 (0.36–1.55)       |
| Single/widowed/divorced/separated     | 3 (4.8)               | 5 (8.2)          | 0.56 (0.08–3.45)       |
| More than eight years of formal education | 23 (36.5)             | 25 (41.0)        | 0.83 (0.38–1.82)       |
| Nontribal                            | 17 (27.0)             | 2 (3.3)          | 10.90 (2.36–100.40)    |
| Living in a joint extended family    | 31 (49.2)             | 38 (62.3)        | 0.59 (0.27–1.27)       |
| More than five years of work experience | 38 (60.3)             | 36 (59.0)        | 1.06 (0.48–2.30)       |
| Covering more than 1000 population   | 22 (34.9)             | 25 (41.0)        | 0.77 (0.35–1.70)       |
was significantly higher among the intervention group (OR: 4.08, CI: 1.61–10.32). Both groups exhibited similar knowledge about pneumonia symptoms and treatment, of giving oral rehydration solution (ORS) and zinc for diarrhoea, stopping exclusive breastfeeding once weaning is initiated, supplementary feeding practices in infants aged six months to one year. Correct knowledge about giving fruits such as bananas to a child was higher in the intervention compared to the control group (OR: 3.41, CI: 1.37–8.49; Table 3).

Skills of ASHAs regarding MNCH care after six months of training
The comparison of the skills of ASHAs by cluster is shown in Table 4. The proportion of ASHAs who washed their hands before checking newborns was significantly higher in the intervention group (OR: 2.49, CI: 1.09–5.70). ASHAs in the intervention group had significantly better counselling skills regarding supporting the whole body of the newborn (OR: 2.94, CI: 1.16–7.48) as

| Knowledge about maternal health and newborn care | Intervention clusters (n = 63) n (%) | Control clusters (n = 61) n (%) | Unadjusted OR (95% CI) | Adjusted* OR (95% CI) |
|---|---|---|---|---|
| At least five signs or symptoms of pregnancy complications | 33 (52.4) | 19 (31.1) | 2.43 (1.10–5.42) | 2.51** (1.12–5.64) |
| At least three signs or symptoms of complications during labour | 28 (44.4) | 22 (36.1) | 1.42 (0.65–3.11) | 1.36 (0.62–2.98) |
| At least three signs or symptoms of postpartum complications | 33 (52.4) | 32 (52.5) | 1.00 (0.46–2.14) | 1.06 (0.48–2.33) |
| At least five signs or symptoms of newborn complications | 47 (74.6) | 35 (57.4) | 2.18 (0.96–5.04) | 2.57** (1.12–5.92) |
| At least three signs or symptoms of infection in child | 16 (25.4) | 13 (21.3) | 1.26 (0.50–3.19) | 1.48 (0.61–3.58) |
| Low birthweight cut-off (~2500 g) | 51 (81.0) | 46 (75.4) | 1.39 (0.54–3.61) | 1.44 (0.57–3.66) |
| At least five essential practices for care of LBW newborn | 21 (33.3) | 13 (21.3) | 1.83 (0.77–4.52) | 1.72 (0.73–4.05) |
| At least three steps of KMC | 32 (50.8) | 27 (44.3) | 1.30 (0.60–2.80) | 1.10 (0.52–2.36) |
| At least three signs or symptoms of pneumonia | 30 (47.6) | 23 (37.7) | 1.50 (0.69–3.27) | 1.86 (0.86–4.07) |
| Treatment (cotrimoxazole/amoxicillin) for pneumonia in infant | 24 (38.1) | 13 (21.3) | 2.27 (0.96–5.51) | 1.98 (0.84–4.67) |

*Adjusted for caste and years of experience of ASHA.
**Statistically significant.
compared to the control group. The percentage of ASHAs having appropriate skills for preventing hypothermia by following the correct steps for wrapping the newborn (87% vs 72%), and the correct method of recording temperature (66% vs 36%) was higher in the intervention group compared to the control group.

**DISCUSSION**

Our study shows that the ImTeCHO application might be effective in improving skills and knowledge of ASHAs who are providing services in villages within the government health system. The results of the study show the potential usefulness of mHealth technology for updating knowledge and skills of ASHAs working in hard-to-reach areas to improve their work performance. However, there is a need for continuous capacity building and refresher training (16,17).

The use of mobile technology in disease control programmes (such as malaria or AIDS) has been shown to improve the overall practices of health workers (18,19). A systematic review on the effects of mHealth interventions in MNCH care has shown positive impact on utilisation of services (20). Studies in India on the use of mHealth for improving health worker capacity in MNCH care support this conclusion. The Solutions Aiding Knowledge for Health Improvement project in Nagpur demonstrated improvement in utilisation of healthcare services and recognition of danger signs of pregnancy by pregnant women (21). Another study in Bihar showed that using

| Table 4 Skills of ASHAs in providing maternal, neonatal and infant health at endline |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
|                                               | Intervention clusters (n = 63) | n (%)                                      | Control clusters (n = 61) | n (%)                                      | Unadjusted OR (95% CI)                        | Adjusted* OR (95% CI)                        |
| Hand washing                                   |                                |                                           |                            |                                           |                                              |                                              |
| Washes hands with soap and water               | 26 (41.3)                      | 14 (23)                                   | 2.36 (1.01-5.59)           | 4.95** (1.09-5.70)                        |                                              |                                              |
| Positions elbow upwards for drying             | 12 (19.0)                      | 9 (14.8)                                  | 1.36 (0.47-3.99)           | 1.44 (0.53-3.90)                        |                                              |                                              |
| Taking respiratory rate of infant              |                                |                                           |                            |                                           |                                              |                                              |
| Availability of wrist watch                    | 41 (65.1)                      | 17 (27.9)                                 | 4.82 (2.11-11.14)          | 5.15** (2.28-11.65)                      |                                              |                                              |
| Removes clothes from abdomen                   | 54 (85.7)                      | 39 (63.9)                                 | 3.39 (1.31-9.22)           | 4.37** (1.60-11.92)                      |                                              |                                              |
| Newborn silent/not crying or sleeping          | 13 (20.6)                      | 8 (13.1)                                  | 1.72 (0.60-5.21)           | 2.14 (0.77-5.94)                        |                                              |                                              |
| Counting method correct                        | 25 (39.7)                      | 5 (8.2)                                   | 7.37 (2.44-26.43)          | 6.89** (2.33-20.35)                      |                                              |                                              |
| Counted for one minute                         | 47 (74.6)                      | 19 (31.1)                                 | 6.49 (2.77-15.40)          | 5.69** (2.52-12.88)                      |                                              |                                              |
| Measurement of temperature in infant           |                                |                                           |                            |                                           |                                              |                                              |
| Availability of thermometer                    | 56 (88.9)                      | 33 (54.1)                                 | 6.79 (2.50-20.20)          | 6.71** (2.46-18.34)                      |                                              |                                              |
| Thermometer cleaned?                           | 29 (46.0)                      | 13 (21.3)                                 | 3.15 (1.35-7.56)           | 2.62** (1.14-6.00)                      |                                              |                                              |
| Correct placing of thermometer in axillary region | 42 (66.7)                      | 22 (36.1)                                 | 2.79 (1.08-7.05)           | 4.62** (1.92-9.89)                      |                                              |                                              |
| Time kept until alarm or one minute            | 53 (84.1)                      | 39 (63.9)                                 | 2.99 (1.19-7.86)           | 3.20** (1.27-8.07)                      |                                              |                                              |
| Correct reading of temperature                 | 55 (87.3)                      | 36 (59.0)                                 | 4.77 (1.81-13.48)          | 4.25** (1.66-10.89)                      |                                              |                                              |
| Weighing newborn                               |                                |                                           |                            |                                           |                                              |                                              |
| Adjust zero in weighing scale                  | 20 (31.7)                      | 17 (27.9)                                 | 1.20 (0.52-2.80)           | 1.11 (0.49-2.53)                        |                                              |                                              |
| Attach weight bag and again adjust zero         | 40 (63.5)                      | 13 (21.3)                                 | 6.42 (2.71-15.55)          | 7.23** (3.07-17.04)                      |                                              |                                              |
| Correct positioning of newborn in bag          | 56 (88.9)                      | 40 (65.6)                                 | 4.20 (1.52-12.71)          | 4.01** (1.46-10.98)                      |                                              |                                              |
| Reading weight at eye level                    | 58 (92.1)                      | 49 (80.3)                                 | 2.84 (0.85-10.94)          | 2.49 (0.78-7.95)                        |                                              |                                              |
| Supports bag with one hand when weighing newborn | 45 (71.4)                      | 40 (65.6)                                 | 1.31 (0.57-3.02)           | 1.77 (0.76-4.13)                        |                                              |                                              |
| Correct reading of weight                      | 50 (79.4)                      | 40 (65.6)                                 | 2.02 (0.84-4.95)           | 2.77** (1.10-6.97)                      |                                              |                                              |
| Wrapping of newborn                            |                                |                                           |                            |                                           |                                              |                                              |
| Asks for clean cotton cloth                    | 60 (95.2)                      | 58 (95.1)                                 | 1.03 (0.13-8.04)           | 1.69 (0.25-11.67)                      |                                              |                                              |
| Correct positioning of newborn                 | 55 (87.3)                      | 44 (72.1)                                 | 2.66 (0.97-7.75)           | 2.76** (1.02-7.51)                      |                                              |                                              |
| Except face, all parts of newborn covered       | 43 (68.3)                      | 31 (50.8)                                 | 2.08 (0.94-4.62)           | 2.39** (1.08-5.39)                      |                                              |                                              |
| Counselling about positioning of the newborn    |                                |                                           |                            |                                           |                                              |                                              |
| Neck straight or bent slightly back            | 22 (34.9)                      | 11 (18.0)                                 | 2.44 (0.99-6.22)           | 2.14 (0.89-5.16)                        |                                              |                                              |
| Newborn’s nose, face close to mother           | 12 (19.0)                      | 3 (4.9)                                   | 4.55 (1.13-26.21)          | 3.73 (0.93-14.94)                      |                                              |                                              |
| Body close to mother                           | 9 (14.3)                       | 7 (11.5)                                  | 1.29 (0.39-4.37)           | 1.05 (0.34-3.33)                        |                                              |                                              |
| Whole body supported                           | 47 (74.6)                      | 33 (54.1)                                 | 2.49 (1.09-5.74)           | 2.49** (1.10-5.63)                      |                                              |                                              |
| Counselling about attachment of the newborn    |                                |                                           |                            |                                           |                                              |                                              |
| Chin close to or touching the breast           | 25 (39.7)                      | 9 (14.8)                                  | 3.80 (1.49-10.26)          | 2.94** (1.16-7.48)                      |                                              |                                              |
| Mouth wide open                                | 15 (23.8)                      | 10 (16.4)                                 | 1.59 (0.60-4.37)           | 1.65 (0.65-4.22)                        |                                              |                                              |
| Lower lip curled back                          | 37 (58.7)                      | 25 (41.0)                                 | 2.05 (0.94-4.46)           | 1.77 (0.83-4.77)                        |                                              |                                              |
| More areola seen above the newborn’s lips than below | 56 (88.9)                      | 49 (80.3)                                 | 1.96 (0.65-6.33)           | 1.42 (0.72-5.39)                        |                                              |                                              |

*Adjusted for caste and years of experience of ASHA.

**Statistically significant.
the CommCare mHealth platform reduced inequities in the continuum of MNCH care services (22). A qualitative study in Uganda found that the use of mHealth was acceptable and perceived by women and health workers to improve implementation of newborn care practices (23). Considering the potential low cost, mHealth can become an important tool for empowering ASHAs to acquire appropriate knowledge and skills at regular intervals in remote rural areas.

The role of implementation research in the context of improving MNCH services in the public health system should be highlighted. We explored the perspectives of the health providers (ASHAs and PHC staff) to find the reasons for lower coverage of MNCH services in India through a series of interviews and field observations. Subsequently, the technology was jointly developed by SEWA Rural information technology partner and the state government to overcome some of the critical, genuine barriers faced by health providers. The motivations of health workers were leveraged for effective change management while introducing the intervention to improve its uptake. A team of investigators from multiple disciplines, including technology, voluntary sector and government, has improved the relevance of every step taken for this study starting from the articulation of the problem statement to its evaluation through a randomised trial in a real-life, project setting (14). ASHAs from the intervention arm demonstrated significant improvements in skills associated with measurement of temperature, weight and respiratory rate of neonates along with hand washing before performing examination. The knowledge about danger signs of pregnancy and neonatal period was significantly better among the ASHAs from the intervention arm compared to the control arm. Overall, the domains related to skills and knowledge which are to be demonstrated during pregnancy and neonatal period showed dramatic improvement compared to those related to postneonatal period. There might be two explanations for these results: First, ASHAs’ role is seen to be more paramount during pregnancy and neonatal period compared to the postneonatal period in India; therefore, the ASHAs might have taken deeper interest in those components of the intervention which are related to the pregnancy and postneonatal period. Secondly, the skills and knowledge domains which were repeatedly reinforced through the use of mobile phone technology showed improvement compared to those domains which were addressed only occasionally.

The strengths of this study are the robust methodology of a randomised trial, and the data collectors being blinded to the study arm. Considering the small study sample and predominantly tribal ASHAs, further studies with a larger sample in nontribal areas and a longer duration may help to make the findings generalisable.

The intervention did not include all potential mHealth strategies for improving the knowledge and skills of ASHAs. Various options, such as text messages, free voice calls and the availability of a call centre for providing support around the clock, should be examined. Therefore, more research is required using an enhanced intervention. ImTeCHO, the mHealth tool, required an Internet connection at least once daily for login and to check work logs. We faced problems with the mobile network in a few remote areas. There is a rapid expansion of mobile phone access in India, and these challenges are likely to be addressed in the near future.

CONCLUSION
This study shows that the ImTeCHO application is useful in improving the knowledge and skills of ASHAs. Mobile phone technology should be explored further to provide ongoing training to ASHAs.

ACKNOWLEDGEMENTS
We would like to acknowledge participants of the trial including the community members, ASHAs, PHC staff and government health administrators at various levels.

CONFLICT OF INTEREST
The authors declare no competing interest.

FUNDING
This study was funded (Grant number MCA-00615) by the Alliance for Health Policy and Systems Research, with support from the Norwegian Government Agency for Development Cooperation, the Swedish International Development Cooperation Agency and the United Kingdom Department for International Development. We are also grateful to the Indian Council of Medical Research (Grant ID number 5/7/589/Gujarat/2011-RCH) and John D and Catherine T MacArthur Foundation (Grant number G-108398-0) for funding this project.

References
1. Lozano R, Wang H, Foreman KJ, Rajaratnam JK, Naghavi M, Marcus JR, et al. Progress towards Millennium Development Goals 4 and 5 on maternal and child mortality: an updated systematic analysis. Lancet 2011; 378: 1139–65.
2. Office of Registrar General and Census Commissioner of India. Sample registration system, statistical report 2014. New Delhi: Office of Registrar General, 2016. Available at: http://www.censusindia.gov.in/vital_statistics/SRS_Reports_2014.html. (accessed on February 16, 2018).
3. Office of Registrar General of India. Special bulletin on maternal mortality in India 2010-12. New Delhi: Office of Registrar General, 2016. Available at: http://www.censusindia.gov.in/vital_statistics/mmr_bulletin_2011-13.pdf. (accessed on February 16, 2018).
4. Ministry of Health and Family Welfare, Government of India. Report of the working group on National Rural Health Mission (NRHM) for the twelfth five year plan (2012–2017). New Delhi: Ministry of Health and Family Welfare, 2012: 36–8. Available at: http://planningcommission.nic.in/aboutus/committee/wrkgrp12/health/WG_1NRHM.pdf. (accessed on February 16, 2018).
5. Bajpai N, Dholakia RH. Improving the performance of accredited social health activists in India. Working paper no. 1. Mumbai: Global Centers South Asia, Columbia University, 2011. Available at: http://www.academia.edu/14816233/IMPROVING_THE_PERFORMANCE_OF_ACCREDITED_SOCIAL_HEALTH_ACTIVISTS_IN_INDIA. (accessed on February 16, 2018).

6. Ministry of Health and Family Welfare, Government of India. Guidelines on ASHA. New Delhi, India. Available at: http://nhm.gov.in/communitisation/asha/about-asha. (accessed on February 16, 2018).

7. Shrivastava SR, Shrivastava PS. Evaluation of trained accredited social health activist (ASHA) workers regarding their knowledge, attitude and practices about child health. Rural Remote Health 2012; 12: 2099.

8. Waske B, Dixit S, Singodia R, Pal DK, Toppo M, Tiwari SC, et al. Evaluation of ASHA programme in selected block of Raiganj district of Madhya Pradesh under NRHM. J Evol Med Dent Sci 2014; 3: 689–94.

9. Kohli C, Shishore J, Sharma S, Nayak H. Knowledge and practice of accredited social health activists for maternal healthcare delivery in Delhi. J Family Med Prim Care 2015; 4: 359–63.

10. Choudary M, Varia K, Kothari N, Ghandi S, Makwana NR, Parmar D. Evaluation of knowledge of ASHA workers regarding various health services under NRHM in Saurashtra Region of Gujarat. Natl J Community Med 2015; 6: 60–4.

11. Gopalan SS, Mohanty S, Das A. Assessing community health workers’ performance motivation: a mixed-methods approach on India’s accredited social health activists (ASHA) programme. BMJ Open 2012; 2: e001557.

12. Darshan K, Mahavanshi K, Patel G, Kartha G, Purani SK, Nagar S, et al. A cross sectional study of the knowledge, attitude and practice of ASHA workers regarding child health (under five years of age) in Surendranagar District. Healthline 2011; 2: 50–3.

13. DeSouza SI, Rashmi MR, Vasanthi AP, Joseph SM, Rodrigues R. Mobile phones: the next step towards healthcare delivery in rural India? PLoS One 2014; 9: e104895.

14. Modi D, Gopalan R, Shah S, Venkatraman S, Desai G, Desai S, et al. Development and formative evaluation of an innovative mHealth intervention for improving coverage of community-based maternal, newborn and child health services in rural areas of India. Glob Health Action 2015; 8: 26769. https://doi.org/10.3402/gha.v8.26769.

15. StataCorp. Stata Statistical Software: release 12. College Station, TX: StataCorp LP, 2011.

16. Fathima FN, Raju M, Varadarajan KS, Krishnamurthy A, Ananthkumar SR, Mony PK. Assessment of ‘Accredited Social Health Activists’—A national community health volunteer scheme in Karnataka State, India. J Health Popul Nutr 2015; 33: 137–45.

17. Government of India, Ministry of Health and Family Welfare. Evaluation of accredited social health activists (ASHA). New Delhi: Information Bureau, 2015. Available at: http://pib.nic.in/newsite/PrintRelease.aspx?relid=116029. (accessed on February 16, 2018).

18. Zurovac D, Sudoi RK, Akhwale WS, Ndritu M, Hamer DH, Rowe AK, et al. The effect of mobile phone text-message reminders on Kenyan health workers’ adherence to malaria treatment guidelines: a cluster randomised trial. Lancet 2011; 378: 795–803.

19. Chang LW, Kagaayi J, Arem H, Nakigozi G, Ssempijja V, Serwadda D, et al. Impact of a mHealth intervention for peer health workers on AIDS care in rural Uganda: a mixed methods evaluation of a cluster-randomized trial. AIDS Behav 2011; 15: 1776.

20. Sondaal SFV, Browne JL, Amoakoh-Coleman M, Borgstein A, Miltenburg AS, Verwijs M, et al. Assessing the effect of mHealth interventions in improving maternal and neonatal care in low-and middle-income countries: a systematic review. PLoS One 2016; 11: e0154664.

21. Lata Medical Research Foundation. Mobile SAKHI Project: CommCare for improving maternal and child health. Available at: http://www.dimagi.com/wp-content/uploads/2015/01/LMRF-Case-Study.pdf. (accessed on February 16, 2018).

22. Balakrishnan R, Gopichandran V, Chaturvedi S, Chatterjee R, Mahapatra T, Chaudhuri I. Continuum of care services for maternal and child health using mobile technology—a health system strengthening strategy in low and middle income countries. BMC Med Inform Deci Mak 2016; 16: 84–91.

23. Ayiasi RM, Atuyambe LM, Kiguli J, Orach CG, Kolsteren P, Criel B. Use of mobile phone consultations during home visits by community health workers for maternal and newborn care: community experiences from Masindi and Kiryandongo districts, Uganda. BMC Public Health 2015; 15: 560–72.