

Preliminary effectiveness of a postnatal mHealth and virtual social support intervention on newborn and infant health and feeding practices in Punjab, India: a quasi-experimental pre-post pilot study

Garima Singh Verma, Lakshmi Gopalakrishnan, Alison El Ayadi, Nadia Diamond-Smith, Rashmi Bagga, Navneet Gill, Vaibhav Miglani, Naveen Mutyala, Ankita Kankaria, Pushpendra Singh, Jasmeet Kaur, Shashi Kant Dhir, Alka Ahuja, Vijay Kumar, Mona Duggal

Submitted to: JMIR Pediatrics and Parenting
on: August 20, 2024

Disclaimer: © The authors. All rights reserved. This is a privileged document currently under peer-review/community review. Authors have provided JMIR Publications with an exclusive license to publish this preprint on its website for review purposes only. While the final peer-reviewed paper may be licensed under a CC BY license on publication, at this stage authors and publisher expressly prohibit redistribution of this draft paper other than for review purposes.

Table of Contents

Original Manuscript.....	5
Supplementary Files.....	28

Preprint
JMIR Publications

Preliminary effectiveness of a postnatal mHealth and virtual social support intervention on newborn and infant health and feeding practices in Punjab, India: a quasi-experimental pre-post pilot study

Garima Singh Verma^{1*} BDS, MPH; Lakshmi Gopalakrishnan^{2*} PHD; Alison El Ayadi^{3*} ScD MPH; Nadia Diamond-Smith^{2*} MSc PhD; Rashmi Bagga¹ MD; Navneet Gill¹ PHD; Vaibhav Miglani¹ M-STAT; Naveen Mutyala¹ M-STAT; Ankita Kankaria⁴ MD; Pushpendra Singh⁵ PHD; Jasmeet Kaur⁵; Shashi Kant Dhir⁶ MD; Alka Ahuja⁷ PHD; Vijay Kumar⁸ MD; Mona Duggal^{7*} MD

¹ Postgraduate Institution of Medical Education and Research Chandigarh IN

² University of California San Francisco, USA California US

³ Bixby Center for Global Reproductive Health, Department of Obstetrics, Gynecology, & Reproductive Sciences Department of Epidemiology & Biostatistics University of California San Francisco, USA California US

⁴ AIIMS, Bhatinda, India Bhatinda IN

⁵ Indraprastha Institute of Information Technology Delhi IN

⁶ Guru Gobind Singh Medical College & Hospital, Faridkot, India Faridkot IN

⁷ Department of Community Ophthalmology, Advanced Eye Centre Postgraduate Institute of Medical Education and Research, Chandigarh, India Chandigarh IN

⁸ SWACH Panchkula IN

*these authors contributed equally

Corresponding Author:

Mona Duggal MD

Department of Community Ophthalmology, Advanced Eye Centre
Postgraduate Institute of Medical Education and Research, Chandigarh, India
AEC, PGIMER, Chandigarh, India
Chandigarh
IN

Abstract

Background: We evaluated a pilot mHealth intervention aimed at improving postnatal maternal and infant health. The intervention featured provider-led group sessions for education, healthcare communication, in-person care referrals, and virtual support for postpartum mothers through weekly calls, texts, interactive voice response, and an application.

Objective: In this study, we aimed to assess the preliminary effectiveness of the pilot mHealth intervention, MeSSSSage, which delivered educational content and social support through various mHealth modalities, on maternal knowledge of infant danger signs and knowledge of infant and young child feeding at six months postpartum. The other outcomes of interest included changes in maternal care-seeking behaviors for infants, adherence to age-appropriate immunization, and infant and young child feeding practices such as early initiation of breastfeeding and complementary feeding.

Methods: We evaluated the preliminary effectiveness of an intervention on maternal health knowledge among 135 participants in Punjab, India, who completed pre- and post-intervention surveys. The intervention, led by research personnel with backgrounds similar to CHOs, aimed to empower society and support universal health coverage if successful. We assessed changes in knowledge of maternal danger signs and the appropriate age for introducing different food groups over six months postpartum. Additionally, we examined post-intervention differences in health-seeking behavior for infants, adherence to age-appropriate immunizations, and adoption of breastfeeding and complementary feeding practices among women in the synchronous (group call), asynchronous (IVR and app), and control arms.

Results: Of 12 infant risk factors, maternal knowledge of infant danger signs remained low (mean range: 1.85 to 2.31 pre-intervention and 1.81 to 2.22 post-intervention). Participants in the synchronous arm had a statistically significant higher mean increase (mean difference: 0.87; 95%CI: 0.06-1.69) compared to the control arm. Participants in synchronous arm had nearly

three-fold increased odds of infant health check-up by a clinical provider than asynchronous arm participants (OR 2.72; 95%CI: 1.02, 7.23). No significant differences noted in age-appropriate vaccine coverage among infants between arms, though vaccination coverage was more than 80% across all arms. Early initiation of breastfeeding remained low across all arms (~47%).

Conclusions: Our pilot study on group-based mHealth education and virtual social support during the postnatal phase showed modest yet promising results. Rigorous testing is crucial to strengthen the limited evidence base for group-oriented mHealth approaches Clinical Trial: Clinical trials registration: NCT04693585.

(JMIR Preprints 20/08/2024:65581)

DOI: <https://doi.org/10.2196/preprints.65581>

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**

Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.

Only make the preprint title and abstract visible.

No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain visible to all users.

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in a JMIR journal, my full manuscript will be made available to all users.

No. Please do not make my accepted manuscript PDF available to anyone.

Original Manuscript

Preliminary effectiveness of a postnatal mHealth and virtual social support intervention on newborn and infant health and feeding practices in Punjab, India: a quasi-experimental pre-post pilot study

Target journal: JMIR Pediatrics and Parenting



Abstract (400 words max)

Background: We evaluated a pilot mobile health (mHealth) intervention aimed at improving postnatal maternal and infant health. The intervention featured provider-led group sessions for education, healthcare communication, in-person care referrals, and virtual mHealth support for postpartum mothers through weekly calls, texts, interactive voice response (IVR), and a phone application.

Methods: We evaluated the preliminary effectiveness of an intervention on maternal health knowledge among 135 participants in Punjab, India, who completed pre- and post-intervention surveys. The intervention, led by research personnel with backgrounds similar to Community Health Officers (CHO)'s, aimed to empower society and support universal health coverage if successful. We assessed changes in knowledge of maternal danger signs and the appropriate age for introducing different food groups over six months postpartum. Additionally, we examined post-intervention differences in health-seeking behavior for infants, adherence to age-appropriate immunizations, and adoption of breastfeeding and complementary feeding practices among women in the synchronous (group call), asynchronous (IVR and app), and control arms.

Results: Of 12 infant risk factors, maternal knowledge of infant danger signs remained low (mean range: 1.85 to 2.31 pre-intervention and 1.81 to 2.22 post-intervention). Participants in the synchronous arm had a statistically significant higher mean increase (mean difference: 0.87; 95%CI: 0.06-1.69) compared to the control arm. Participants in synchronous arms had nearly three-fold increased odds of infant health check-up by a clinical provider than asynchronous arm participants (OR 2.72; 95%CI: 1.02, 7.23). No significant differences noted in age-appropriate vaccine coverage among infants between arms, though vaccination coverage was more than 80% across all arms. Early initiation of breastfeeding remained low across all arms (~47%).

Conclusion: Our pilot study on group-based mHealth education and virtual social support during the postnatal phase showed modest yet promising results. Rigorous testing is crucial to strengthening the limited evidence base for group-oriented mHealth approaches

Clinical trials registration: NCT04693585.

Key words: Digital health, mHealth, postpartum, health education, social support, India, infant morbidity, health-seeking behavior

Introduction

India has made substantial improvements in child survival through a 54% reduction in neonatal mortality rate from 52 per 1000 live births in 1990 to 23.7 per 1000 live births in 2017 (1,2). About 75% of newborn deaths occur in the first week of life highlighting the importance of intervening in the early postnatal period (3). Further, child undernutrition accounts for over 20% of deaths and remains a major risk factor for disease burden in children younger than five years in India (2,4). The latest national survey suggests that 35.5% of children in India are stunted, 32.1% are underweight, and 19.3% are wasted with substantial variation both across and within Indian states (5).

There is a robust evidence-base of interventions spanning the continuum of care from pregnancy through postpartum and through the first 1000 days of life, including appropriate infant and young child feeding practices (IYCF) to improve newborn, and child health and nutrition outcomes (6,7). India, backed by a two million+ female community health worker program, has adopted a comprehensive and universally available package of maternal and neonatal evidence-based interventions through its multiple national government programs, including the Integrated Child Development Services, National Health Mission, and National Nutrition Mission (8,9). However, national surveys suggest that coverage of nutrition interventions, particularly in the postnatal and newborn period, remains low. Only 41.8% children were breastfed within an hour of birth, 46% children 6-8 months were initiated on complementary food, and 11% of children below 6-23 months received adequate diet with disparities by geographical region, socio-economic status, and rural-urban residence (5).

Prior research from India suggests that postnatal care is associated with reduced neonatal mortality (10) and appropriate care for sick infants and children is correlated with reduced risk of severe wasting (11). Postnatal education is an evidence-based strategy to improve newborn health and nutrition and maternal knowledge of general infant health and care (12). While national data suggests that 79% infants receive a postnatal check-up by skilled health personnel within two days of childbirth (5), a recent study of 13000+ respondents from three large Indian states (including Punjab, one of our study states) highlights that 55% mothers receive no postnatal education with considerable knowledge gaps in appropriate newborn care practices, including skin-to-skin care, cord care, warning signs of infant illness, among other related topics (13). Beyond postnatal education, enhancing social support for mothers through interpersonal connections is associated with reduced risk of postpartum depression (14,15), improved maternal self-efficacy (16,17), higher postnatal care attendance of mothers and infants (18), increased healthy maternal physical activity and nutritional intake (14) and better infant and young child feeding practices (19). However, various barriers hinder postnatal care in India, including logistical challenges exacerbated by geographic distance and cultural factors (20–22). Factors such as lower levels of women's autonomy, restricted freedom of movement, and social isolation further compound these challenges, particularly during the postnatal period when women are traditionally confined to their homes for forty days after delivery (23). Additional barriers include poverty, limited education, lack of male involvement, absence of health insurance, financial constraints, and perceptions of inadequate quality, or lack of benefit of services (24–26).

Leveraging mHealth-based interventions holds promise in addressing barriers to postnatal care and improving postnatal maternal knowledge, social connectedness, and maternal and child health-related behaviors given increasing mobile phone ownership and internet access. A scoping review of 28 studies across low-and-middle-income countries (LMICs) found improved immunization coverage and increased adherence to immunization schedule through mHealth-based text and voice

message reminders (27), while another systematic review of 16 studies in LMICs found mHealth education interventions to increase perinatal interactions between young mothers and healthcare workers (28). Individual studies reporting on mHealth interventions using text and voice messaging have improved perinatal care attendance (29), early initiation of breastfeeding and exclusive breastfeeding (30–32), protein consumption (33), general infant and young child feeding practices (34), knowledge of child immunization (35) and better adherence to child immunization schedule (36).

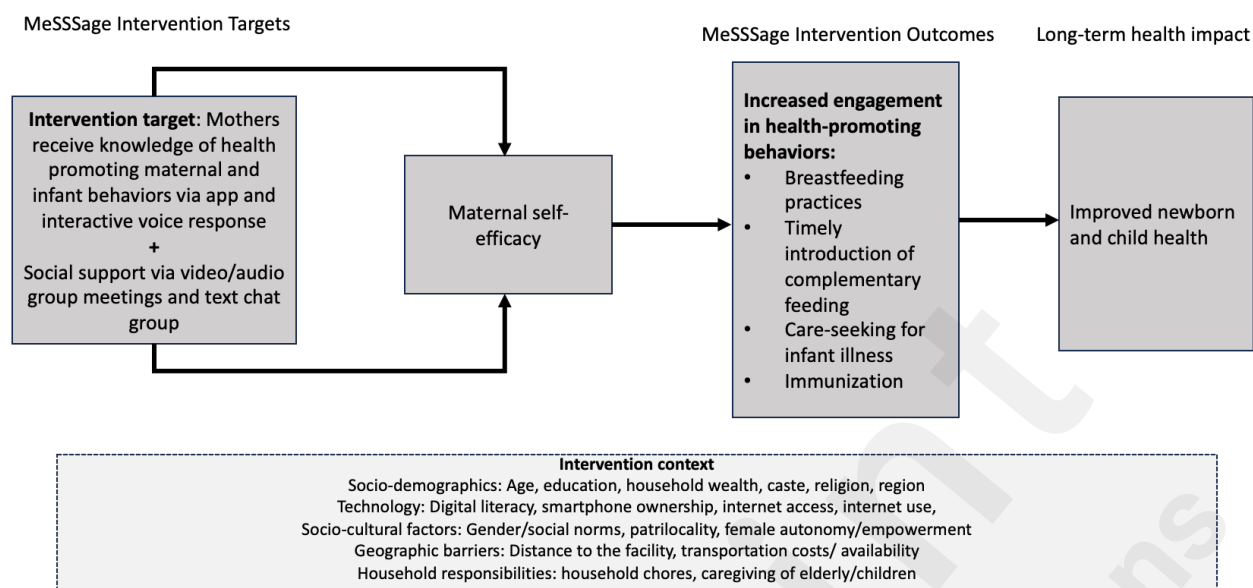
Key gaps in the evidence base on the impact of mHealth interventions on postpartum and neonatal health in India include fewer interventions focused on this topic area, with most targeting frontline health and nutrition workers to improve service delivery (37–40), limited interactions and social support provision among those targeting beneficiaries (30–32,41), and the need for more rigorous studies (28,30,37,40). Group-oriented mHealth interventions combining group-based learning and social support may overcome prevalent barriers given convenience, feasibility, acceptability, and preliminary effectiveness in improving postnatal maternal and infant health outcomes (32,42–47). However, the combined impact of interactive group-based social support delivered via mHealth modalities such as group voice calls or Zoom have been understudied in LMICs.

To address these gaps, we designed a provider-facilitated group perinatal mHealth intervention called *MeSSSSage* (*Maa Shishu Swasthya Sahayak Samoo*h; maternal and child health support group). Informed by the capabilities and motivation constructs of the capabilities, opportunities, motivation and behavior (COM-B) (48,49) framework, the intervention was designed to enhance maternal knowledge of health-promoting behaviors and promote maternal self-efficacy and empowerment to improve health-related knowledge, behaviors, and maternal and child outcomes (Figure 1). The intervention aimed to improve knowledge, facilitate referrals to in-person care, and foster connections with a virtual social support group for postnatal mothers with infants of similar ages through various mHealth modalities, including weekly group calls and text chat. Our development process included two iterative rounds of pilot testing – the first to inform the mHealth components and design factors, (50) and the second to understand feasibility and acceptability of our revised intervention (51) and explore preliminary effectiveness on health outcomes.

Objective of this study

In the current analysis, we aimed to assess the preliminary effectiveness of the pilot mHealth intervention, *MeSSSSage*, on infant health knowledge, behaviors and outcomes at six months postpartum. We focus on maternal knowledge of infant danger signs and optimal young child feeding practices at six months postpartum and also evaluate maternal care-seeking behaviors for infants, adherence to age-appropriate immunization, and infant and young child feeding practices such as early initiation of breastfeeding and complementary feeding.

Figure 1: Conceptual Framework of Intervention Context, MeSSSSage Intervention Targets, Outcomes and Anticipated Long-Term Impacts



MeSSSSage intervention

The *MeSSSSage* intervention was administered to women from late pregnancy through six months postpartum. It included weekly audio or audio-video group calls, group text chats, and audio educational content provided via automated interactive voice response (IVR) or *MeSSSSage* application (Table 1 and Figure 2). Groups and group-based content (i.e., audio-video group calls and group text chats) were facilitated by trained intervention moderators with backgrounds in public health or social work and supported by a Gynecologist and Neonatologist. The detailed description is published elsewhere (51).

Table 1: MeSSSSage intervention modalities

mHealth modalities/ arms	Description
Audio-video group sessions	Trained moderators led weekly group sessions focusing on increasing education and social support. These sessions incorporated icebreakers and group-building activities, facilitated discussions based on weekly themes (Figure 2), and allowed open questions and discussion sessions. Prenatally, a gynecologist participated in one call per month, while postnatally, both a gynecologist and a neonatologist participated in one call per month. Participants could choose to connect to their group as audio-only sessions on the TATA platform or video sessions on the Zoom platform.
WhatsApp-based group text chat	Trained moderators led weekly WhatsApp-based group chats by sharing audio and visual messages based on themes (Figure 2). Group participants were expected to engage by asking questions, and group discussion was facilitated.
MeSSSSage mobile application (App)	Weekly educational audio messages focus on key information regarding weekly themes (Figure 2). The mobile app structured sections for these weekly audio messages, offering women the flexibility to access health education content at their convenience.
Interactive Voice Response (IVR)	IVR calls were scheduled to reach participants once a week at designated days and times. To maximize the chances of participants receiving the calls, they were sent out three times within a 15-minute interval. These brief audio calls, lasting between 5 to 10 minutes each, addressed essential topics concerning

perinatal, neonatal, and child health. IVR calls persisted up to six months post-delivery.

Figure 2: Weekly maternal and neonatal content of MeSSSSage intervention

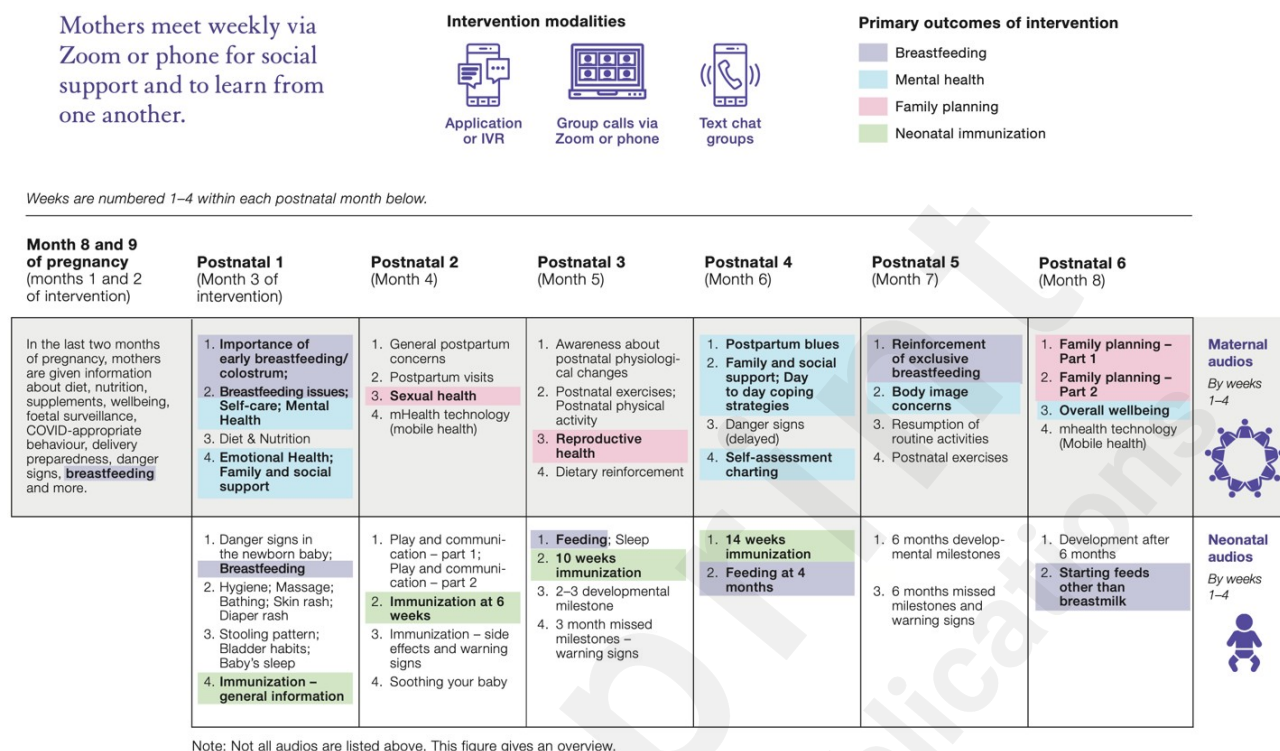


Figure 2 provides the summary intervention plan. While this table offers the general structure of IVR call and audio-video group discussion topics, the audio-video group discussion topics were dynamically adjusted based on the queries and concerns shared by the new mothers, ensuring a responsive and participant-focused approach.

Methods

Study design

This open-label pilot study on an mHealth-based perinatal health support intervention targeted women in late pregnancy through six months postpartum in Boothgarh block of the state of Punjab, northern India. We utilized a pretest-post-test nonrandomized control group design. Quantitative survey data were collected at study enrollment and intervention completion (approximately six months postpartum).

Study participants

Participants were eligible for inclusion in the study if they met the following criteria: (i) aged 18 years or older, (ii) between 28–32 weeks pregnant, (iii) residing in the study area, and (iv) not experiencing a serious maternal complication. Participants with high-risk pregnancy and parity more than two were ineligible.

Study procedures

Our study team utilized antenatal clinic registry data maintained by community health workers to pre-screen pregnant women in the seventh month of gestation. We then contacted these potential participants over the phone, screened them, and if found eligible, invited them to participate. We led them through an informed consent process, which included discussing study procedures, risks, and benefits. All participants provided informed consent verbally.

Out of the 397 women we tried to reach, we successfully recruited a total of 180 participants. These participants were then sequentially assigned to one of five arms: (1) app only (n=20), 2) IVR only (n=20), (3) Group call+WhatsApp+App (3 separate arms, n=60), (4) Group call+WhatsApp+IVR (3 separate arms, n=60), and finally the control arm (n=20) at baseline. All participants, including the control arm, received the standard of care which in this setting, comprised of community health worker-led home visits, counseling, and immunization services. Reasons for non-enrollment included being unable to reach the potential participant over the phone as their phone was either switched off or out of service. Some women provided false information, while others were no longer pregnant due to a miscarriage or preterm birth. A few participants also described having irregular access to mobile phones since they used either their husband's or an immediate family member's phone and only had access to it in the evening when their husband or family member returned home from work. Some individuals did not respond to our calls, while the others faced language challenges.

After enrollment the eight groups/arms were formed in a staggered fashion, leading to a study timeline from August 2021 to November 2022. Participant engagement in the intervention spanned a total of eight months. Enrollment of participants and administration of the baseline survey occurred between August and December 2021. Intervention implementation spanned from August 2021 to July 2022, and our endline quantitative survey was conducted between May and December 2022. All data was collected through interviewer administration over the phone,¹ and directly entered into the REDCap data collection application.

Study measures

Based on existing research on IVR and Apps for maternal and child health in India, we focused on examining the supplementary impact of group calls. We anticipated that participants engaged in group calls would experience higher levels of social connectedness compared to those utilizing the educational app or IVR, as the former allowed for direct interaction with others, fostering a sense of community and support. For analysis, we consolidated study participants into three intervention categories: a synchronous arm (combining arms 3 and 4 described above comprising all group call participants), an asynchronous arm (combining arms 1 and 2 described above comprising those in App and IVR), and a control arm.

The primary outcomes of this analysis were the change in maternal knowledge of infant danger signs and maternal knowledge of infant and young child feeding (IYCF) practices between pre- and post-intervention. Knowledge of infant danger signs was defined as women's ability to recall symptoms indicating infants may require medical attention within the first month of birth. We developed a cumulative score based on women's recall of various danger signs, including diarrhea, fever, cough/cold, difficulty breathing, absence of crying, chest problems, blue tongue and lips, lack of milk intake, failure to gain weight, premature birth, jaundice, coldness to touch, and others (scores ranging from 0 to 13). Women's knowledge of IYCF practices was assessed by their correct reporting

¹ For individuals who were not able to be reached for endline survey, local ASHAs were engaged to facilitate in-person quantitative survey administration.

of the appropriate age for introducing the following foods: water, rice, bread, legumes (dal), green leafy vegetables, pumpkin, carrot, fruits (banana, papaya, mango, orange), meats (chicken, mutton, fish), eggs, and different types of milk (cow, goat, powdered, etc.). Women who correctly identified 6 months or older as the appropriate age for introducing all food groups except cow's/goat's milk (12 months) were coded as 1; otherwise, they were coded as 0. We developed a cumulative score based on women's correct responses.

Additional outcomes assessed at post-intervention included infant health status, access to healthcare, infant vaccination status, and infant feeding behaviors. Infant postnatal health characteristics were assessed through various questions. Postnatal care was assessed based on women's self-reports regarding whether their infants received a check-up within six weeks of birth, the frequency of these check-ups, and the type of provider conducting the check-up (clinical or community). Infant vaccination coverage was determined by whether the infant had received all age-appropriate vaccines. Infant and young child feeding practices were evaluated through breastfeeding, early initiation of breastfeeding (defined as within one hour of birth), and complementary feeding (defined as whether other liquids or foods had been introduced to the infant). All variables were coded as indicator variables (yes/no).

Participant sociodemographic characteristics collected at pre-intervention included age, relationship status, educational attainment, religion, caste, ration card and type, parity, and mobile phone ownership.

Analysis

At baseline, 120 participants were in the synchronous arm, 40 participants in the asynchronous arm, and 20 in the control arm. At endline, we had 94 participants (78.3% retention rate) in the synchronous arm, 28 participants (70% retention rate) in the asynchronous arm, and 13 (65%) in the control arm. With our primary focus on temporal change, we restricted the analytic sample for this paper to participants with both baseline and endline data, resulting in a sample size of 135 participants.

We compared the sociodemographic characteristics of the three analysis arms (synchronous, asynchronous, and control arm) by identifying standardized differences (52). Due to significant disparities across arms in the distribution of age, age at marriage, household composition, educational attainment, household income, ration card possession, mobile phone ownership, and smartphone access, we utilized inverse probability weighting to ensure comparability of participants across arms. This approach, similar to direct standardization, balanced pre-intervention discrepancies in sociodemographic between the arms (53,54).

We summarized sociodemographic characteristics using proportions and means of the matched, reweighted study population surveyed pre- and post-intervention stratified by three arms (synchronous, asynchronous, and control). We then assessed the association of being in each intervention arm on primary outcomes (changes in maternal knowledge of infant danger signs and knowledge of infant and young child feeding practices) using mixed effects linear regression including a random intercept for participant with robust standard errors to adjust within individual clustering due to the longitudinal structure of the data. The difference-in-difference coefficient (*Beta*) is the interaction term between a categorical variable denoting the time (before vs. after the intervention was implemented) and the intervention arm (synchronous vs. asynchronous modes; synchronous vs. control; asynchronous vs. control). We interpreted this term as the differential

change over time associated with being in each intervention arm compared to the reference group. For outcomes collected only at endline, we analyzed the differences between the arms (synchronous vs. asynchronous modes; synchronous vs. control; asynchronous vs. control) using logistic regression. Differences where $p < 0.05$ were considered statistically significant. All analyses are presented using weighted estimates. Data entry was done through REDCap, and all statistical analyses were conducted using Stata 15 (55).

Ethical approvals

This study received approval from the Indian Council of Medical Research and senior health authorities of the Government of Punjab and Mission Director, National Health Mission, India. The study protocol was approved by the University of California, San Francisco Institutional Review Board (19-299723); the Ethics Committee of the Post Graduate Institute of Medical Education and Research (IEC-03/2020-1567); the Collaborative Research Committee of the Post Graduate Institute of Medical Education and Research (79/30-Edu-13/1089-90); and the Indian Council of Medical Research (ID 2020-9576).

Results

Sociodemographic characteristics

At study enrollment, participants had an average age of 26.8 years, and almost all were married (99.3%; Table 2). The majority had either a high school education (44.8%) or higher education (44.3%). Nearly two-thirds of the sample belonged to the Sikh religion (65.3%) and one-third of the sample belonged to marginalized caste (scheduled caste and scheduled tribe; 36.4%). Less than half possessed a ration card (48.0%), an official government document given to eligible poor families to get subsidized food grains from government fair price shops. Parity was one (53.3%) or more (46.8%). Mobile phone ownership at the household-level was near-universal (99.2%), and most women owned their own phone (92.5%).

Maternal knowledge of infant danger signs

Despite increases noted across time, maternal knowledge of infant danger signs remained relatively low (Table 3). Of the twelve infant risk factors, the mean number known across arms ranged between 1.85 to 2.31 pre-intervention and 1.81 to 2.22 post-intervention (Table 3; Table S1). Being in synchronous arm was associated with a small but significantly greater increase in the mean number of infant danger signs known when compared to those in the control arm (mean difference 0.87; 95% CI 0.06-1.69; Table 3). No differences were identified between synchronous versus asynchronous arms or between asynchronous versus control arm participants.

Maternal knowledge of appropriate infant and young child feeding practices

Maternal knowledge of appropriate initiation of varied food groups was high pre-intervention, and no increase was observed over time (Table 3). Of nine food groups in total, the mean number of food groups that women reported the correct knowledge for ranged from 6.48 to 7.56 pre-intervention and 6.51 to 7.89 post-intervention. No group differences were identified.

Infant health check-up and infant vaccination

Table 4 presents a post-intervention comparison of outcomes. Over 50% participants in the synchronous arm and 40% participants in the asynchronous arm reported receiving a health check-up for their infants, compared to 28.9% in the control arm. However, no statistically significant difference was noted between arms. Regarding receipt of infant health check-up by a clinical

provider, a higher proportion (53.2%) of participants in the synchronous arm reported receiving a health check-up from a clinical provider compared to the other two arms. Participants in synchronous arm had 2.72 times greater odds (OR: 2.72; 95%CI: 1.02, 7.23; $p < 0.05$) of infant health check-up by a clinical provider compared to asynchronous arm. There were no statistically significant differences between the synchronous arm and control arm or between the asynchronous arm and control arm. The coverage of all four age-appropriate vaccines (BCG, polio, DPT, and Hepatitis B) was high across all arms, ranging from 89.0% in synchronous arm, 84.0% in the asynchronous arm, and 80.3% in control arm. No differences were noted in the post-intervention between arms comparison.

Breastfeeding and complementary food introduction

Initiation of breastfeeding within the first hour after birth was low across all arms (Table 4). The intention to breastfeed for more than 24 months was highest in asynchronous arm at 37.6%, followed by 19.8% in the synchronous arm and 14.9% in the control arm. No differences in breastfeeding initiation or intention were noted in the post-intervention between arms comparison. In terms of the introduction of complementary foods, a greater proportion of participants in the synchronous arm (92.6%) and the asynchronous arm (95.3%) did compared to control arm (52.2%).

Discussion

Our pilot study on the preliminary effectiveness of the *MeSSSSage* mobile health education and virtual social support intervention found that synchronous arm assignment had a beneficial impact on participants' knowledge regarding infant danger signs and odds of obtaining an infant health check-up from a clinical provider, when compared to control participants. We also noted no differences by arm in maternal knowledge of appropriate infant and young child feeding practices, number of infant health check-ups, and early initiation of breastfeeding. Given the pilot nature of this investigation including our study design limitations in conjunction with our previously reported results supporting intervention feasibility and acceptability (51), these findings support continued investigation into the effectiveness of mHealth-based interventions targeting postnatal maternal and newborn health using robust research designs.

Our findings that the *MeSSSSage*'s synchronous arm that included group calls on education and social support increased maternal knowledge of infant danger signs are consistent with existing literature. Previous literature has demonstrated the effectiveness of mHealth interventions in empowering mothers to recognize infant danger signs (28), while interventions layering health education within women's self-help groups have shown promise in improving maternal knowledge across a range of outcomes (56,57). Group-based mHealth education and social support interventions can promote health-seeking behaviors through the mechanism of "positive psychological support" among mothers (58). On the other hand, we found less improvement in participants assigned to asynchronous modes of mHealth intervention, potentially due to unidirectional messaging and lack of social support. Our findings underscore the potential for integrating mHealth delivery into comprehensive interventions that combine both social support and health education, thereby enhancing their impact and effectiveness.

Our study findings noted no difference between pre- and post-intervention on maternal knowledge of appropriate infant and young child feeding practices, though scores were high (7 out of 9) at pre-intervention. It is possible that high baseline levels of maternal knowledge precluded changes over time. A similar lack of effect was also noted in another Indian evaluation of a mHealth intervention for maternal knowledge of infant and child feeding practices (39) and other global studies (59). Moreover, large-scale evaluations of mHealth interventions in India have failed to observe changes

in infant and young child feeding practices (38,39). Nonetheless, insights from another evaluation in India, including those utilizing innovative approaches like audiovisual tools and interactive messaging, highlight the potential for future mHealth interventions to effectively impact maternal knowledge and practices concerning infant and young child feeding (60).

The synchronous arm of our mHealth intervention demonstrated the greatest impact, particularly in improving infant health check-ups by clinical providers. In contrast, our asynchronous intervention arm, comprising solely of audio educational messages, showed lower effectiveness. This could be attributed to various factors such as missed calls, insufficient attention to messages, or competing household obligations, resulting in null results for the intervention. Additionally, the absence of impact from the asynchronous modality may also be attributed to instances where participants' phones were with their husbands during the day, rendering it impossible for them to listen to the IVR messages. Similar challenges were encountered in a study conducted in Punjab, North India, where participants faced connectivity issues and missed messages due to household chores or not having access to their shared phone at the time (61,62). To address these challenges, future research should identify the optimal timing for sending messages and IVR calls, and devise strategies to enhance engagement and participation in mHealth interventions such as exploring incentives such as discounted call rates to motivate participants to carefully listen to all messages, as suggested in a study conducted in Afghanistan (63). Given these challenges, combined effectiveness and implementation designs for mHealth research are likely to be more informative, particularly those that engage qualitative research methods.

The primary objective of our overall study was to assess the feasibility and acceptability of the intervention rather than robustly evaluating its effectiveness, thus the preliminary effectiveness analysis reported here represents a secondary objective of the study and interpretation of these findings should consider study limitations. The sample size was determined for our feasibility and acceptability outcomes, resulting in significant differences in sociodemographic characteristics between the three intervention groups at baseline. While weighting techniques were employed to address this imbalance, more robust experimental designs with a larger sample size will allow for better assessment of effectiveness and potential mechanisms of impact. We also noted differential retention across the study by intervention group, which may have influenced our findings. Furthermore, our study design also limited our ability to assess whether intervention effectiveness differed by sociodemographic characteristics and considering the important influence of social and structural factors on women of reproductive age and their influence on perinatal health, future research should focus on understanding the potential of interventions to specifically mitigate health disparities.

Conclusion

The postnatal period presents a critical opportunity to engage new mothers in enhancing their knowledge and practices concerning infant and young child feeding, infant health check-ups and care-seeking behaviors, child vaccinations, and providing social support. Our pilot study on the *MeSSSSage* mobile health education and virtual social support intervention delivered mostly in the postnatal period yielded modest results and offered promising insights into its preliminary effectiveness. Such interventions, integrating mHealth-based education and communication with social support, hold significant promises but warrant further exploration to optimize their impact. With smartphones and social media platforms like WhatsApp increasingly prevalent even in low-resource settings, there is an urgent need for more rigorous experimental research to

comprehensively evaluate the impact of mHealth interventions and their underlying mechanisms. Our team is currently conducting a fully powered randomized controlled trial to examine the effectiveness and potential mechanisms of impact of an mHealth educational and social support intervention for perinatal women across multiple sites in India, with results expected in the coming years.



References

1. Sankar MJ, Neogi SB, Sharma J, Chauhan M, Srivastava R, Prabhakar PK, et al. State of newborn health in India. *J Perinatol*. 2016 Dec;36(3):S3–8.
2. Dandona R, Kumar GA, Henry NJ, Joshua V, Ramji S, Gupta SS, et al. Subnational mapping of under-5 and neonatal mortality trends in India: the Global Burden of Disease Study 2000–17. *The Lancet*. 2020 May 23;395(10237):1640–58.
3. UNICEF. United Nations Inter-agency Group for Child Mortality Estimation. Levels & Trends in Child Mortality [Internet]. 2019 [cited 2023 Sep 2]. Available from: <https://childmortality.org/wp-content/uploads/2019/10/UN-IGME-Child-Mortality-Report-2019.pdf>
4. Swaminathan S, Hemalatha R, Pandey A, Kassebaum NJ, Laxmaiah A, Longvah T, et al. The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. *Lancet Child Adolesc Health*. 2019 Dec 1;3(12):855–70.
5. International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-5), 2019-21 [Internet]. Mumbai: International Institute for Population Sciences; 2021 [cited 2022 May 5]. Available from: http://rchiips.org/nfhs/NFHS-5Reports/NFHS-5_INDIA_REPORT.pdf
6. Bhutta ZA, Das JK, Bahl R, Lawn JE, Salam RA, Paul VK, et al. Can available interventions end preventable deaths in mothers, newborn babies, and stillbirths, and at what cost? *The Lancet*. 2014 Jul 26;384(9940):347–70.
7. Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *The Lancet*. 2013 Aug 3;382(9890):452–77.
8. Ministry of Health and Family Welfare. NHM Components :: National Health Mission [Internet]. [cited 2023 Sep 8]. Available from: <https://nhm.gov.in/index1.php?lang=1&level=0&linkid=353&lid=444>
9. Woman and Child Development. POSHAN Abhiyaan | Ministry of Women & Child Development [Internet]. [cited 2023 Sep 8]. Available from: <https://wcd.nic.in/schemes/poshan-abhiyaan>
10. Fadel SA, Ram U, Morris SK, Begum R, Shet A, Jotkar R, et al. Facility Delivery, Postnatal Care and Neonatal Deaths in India: Nationally-Representative Case-Control Studies. *PLoS One*. 2015;10(10):e0140448.
11. Choudhary TS, Srivastava A, Chowdhury R, Taneja S, Bahl R, Martinez J, et al. Severe wasting among Indian infants <6 months: Findings from the National Family Health Survey 4. *Matern Child Nutr*. 2019;15(4):e12866.

12. Bryanton J, Beck CT, Montelpare W. Postnatal parental education for optimizing infant general health and parent-infant relationships. *Cochrane Database Syst Rev* [Internet]. 2013 [cited 2023 Sep 3];(11). Available from: <https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD004068.pub4/full>
13. Subramanian L, Murthy S, Bogam P, Yan SD, Delaney MM, Goodwin CDG, et al. Just-in-time postnatal education programmes to improve newborn care practices: needs and opportunities in low-resource settings. *BMJ Glob Health*. 2020 Jul 1;5(7):e002660.
14. Faleschini S, Millar L, Rifas-Shiman SL, Skouteris H, Hivert MF, Oken E. Women's perceived social support: associations with postpartum weight retention, health behaviors and depressive symptoms. *BMC Womens Health*. 2019 Nov 21;19(1):143.
15. Vaezi A, Soojoodi F, Banihashemi AT, Nojomi M. The association between social support and postpartum depression in women: A cross sectional study. *Women Birth*. 2019 Apr 1;32(2):e238–42.
16. Chen CM, Kuo SF, Chou YH, Chen HC. Postpartum Taiwanese women: their postpartum depression, social support and health-promoting lifestyle profiles. *J Clin Nurs*. 2007;16(8):1550–60.
17. Leahy-Warren P, McCarthy G, Corcoran P. First-time mothers: social support, maternal parental self-efficacy and postnatal depression. *J Clin Nurs*. 2012;21(3–4):388–97.
18. Cardona Cordero NR, Ramos JP, Tavaréz ZQ, McIntosh S, Avendaño E, DiMare C, et al. Relationship between perceived social support and postpartum care attendance in three Latin American countries: a cross-sectional analytic study. *Glob Health Res Policy*. 2021 May 7;6(1):16.
19. Ickes SB, Wu M, Mandel MP, Roberts AC. Associations between social support, psychological well-being, decision making, empowerment, infant and young child feeding, and nutritional status in Ugandan children ages 0 to 24 months. *Matern Child Nutr*. 2018;14(1):e12483.
20. Adams V, Craig S, Samen A, Bhatta S. It Takes More than a Village: Building a Network of Safety in Nepal's Mountain Communities. *Matern Child Health J*. 2016 Dec 1;20(12):2424–30.
21. Syed U, Khadka N, Khan A, Wall S. Care-seeking practices in South Asia: using formative research to design program interventions to save newborn lives. *J Perinatol*. 2008 Dec 5;28(S2):S9–13.
22. Lewis S, Lee A, Simkhada P. The role of husbands in maternal health and safe childbirth in rural Nepal: a qualitative study. *BMC Pregnancy Childbirth*. 2015 Aug 4;15:162.
23. Withers M, Kharazmi N, Lim E. Traditional beliefs and practices in pregnancy, childbirth and postpartum: A review of the evidence from Asian countries. *Midwifery*. 2018 Jan 1;56:158–70.

24. Griffiths P, Stephenson R. Understanding users' perspectives of barriers to maternal health care use in Maharashtra, India. *J Biosoc Sci.* 2001 Jul;33(3):339–59.
25. Kumar G, Choudhary TS, Srivastava A, Upadhyay RP, Taneja S, Bahl R, et al. Utilisation, equity and determinants of full antenatal care in India: analysis from the National Family Health Survey 4. *BMC Pregnancy Childbirth.* 2019 Sep 5;19(1):327.
26. Vidler M, Ramadurg U, Charantimath U, Katageri G, Karadiguddi C, Sawchuck D, et al. Utilization of maternal health care services and their determinants in Karnataka State, India. *Reprod Health.* 2016 Jun 8;13 Suppl 1(Suppl 1):37.
27. Venkataramanan R, Subramanian SV, Alajlani M, Arvanitis TN. Effect of mobile health interventions in increasing utilization of Maternal and Child Health care services in developing countries: A scoping review. *Digit Health.* 2022 Jan 1;8:20552076221143236.
28. Dol J, Richardson B, Tomblin Murphy G, Aston M, McMillan D, Campbell-Yeo M. Impact of mobile health (mHealth) interventions during the perinatal period for mothers in low- and middle-income countries: a systematic review. *JBIM Evid Synth.* 2019 Aug;17(8):1634–67.
29. Adanikin AI, Awoleke JO, Adeyolu A. Role of reminder by text message in enhancing postnatal clinic attendance. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet.* 2014 Aug;126(2):179–80.
30. Colaci D, Chaudhri S, Vasan A. mHealth Interventions in Low-Income Countries to Address Maternal Health: A Systematic Review. 2017 Mar 8;82(5):922.
31. Lau Y, Htun TP, Tam WSW, Klainin-Yobas P. Efficacy of e-technologies in improving breastfeeding outcomes among perinatal women: a meta-analysis. *Matern Child Nutr.* 2016;12(3):381–401.
32. Patel A, Kuhite P, Puranik A, Khan SS, Borkar J, Dhande L. Effectiveness of weekly cell phone counselling calls and daily text messages to improve breastfeeding indicators. *BMC Pediatr.* 2018 Oct 30;18(1):337.
33. Downs SM, Sackey J, Kalaj J, Smith S, Fanzo J. An mHealth voice messaging intervention to improve infant and young child feeding practices in Senegal. *Matern Child Nutr.* 2019;15(4):e12825.
34. Tang S, Ghose B, Hoque MR, Hao G, Yaya S. Women Using Mobile Phones for Health Communication Are More Likely to Use Prenatal and Postnatal Services in Bangladesh: Cross-Sectional Study. *JMIR MHealth UHealth.* 2019 Feb 28;7(2):e10645.
35. Chakraborty A, Mohan D, Scott K, Sahore A, Shah N, Kumar N, et al. Does exposure to health information through mobile phones increase immunisation knowledge, completeness and timeliness in rural India? *BMJ Glob Health.* 2021 Jul 1;6(Suppl 5):e005489.
36. LeFevre AE, Shah N, Scott K, Chamberlain S, Ummer O, Bashingwa JJH, et al. The impact of a direct to beneficiary mobile communication program on reproductive and child health

- outcomes: a randomised controlled trial in India. *BMJ Glob Health*. 2022 Jul 1;6(Suppl 5):e008838.
37. Chen H, Chai Y, Dong L, Niu W, Zhang P. Effectiveness and Appropriateness of mHealth Interventions for Maternal and Child Health: Systematic Review. *JMIR MHealth UHealth*. 2018 Jan 9;6(1):e8998.
38. Patil SR, Nimmagadda S, Gopalakrishnan L, Avula R, Bajaj S, Diamond-Smith N, et al. Can digitally enabling community health and nutrition workers improve services delivery to pregnant women and mothers of infants? Quasi-experimental evidence from a national-scale nutrition programme in India. *BMJ Glob Health*. 2022 Jul 1;6(Suppl 5):e007298.
39. Modi D, Dholakia N, Gopalan R, Venkatraman S, Dave K, Shah S, et al. mHealth intervention “ImTeCHO” to improve delivery of maternal, neonatal, and child care services —A cluster-randomized trial in tribal areas of Gujarat, India. *PLOS Med*. 2019 Oct 24;16(10):e1002939.
40. Bassi A, John O, Praveen D, Maulik PK, Panda R, Jha V. Current Status and Future Directions of mHealth Interventions for Health System Strengthening in India: Systematic Review. *JMIR MHealth UHealth*. 2018 Oct 26;6(10):e11440.
41. World Health Organization. Thinking healthy: a manual for psychosocial management of perinatal depression, WHO generic field-trial version 1.0, 2015 [Internet]. World Health Organization; 2015 [cited 2023 Sep 3]. Report No.: WHO/MSD/MER/15.1. Available from: <https://apps.who.int/iris/handle/10665/152936>
42. Lok KY, Ko RW, Fan HS, Chau PH, Wong JY, Wang MP, et al. Feasibility and Acceptability of an Online WhatsApp Support Group on Breastfeeding: Protocol for a Randomized Controlled Trial. *JMIR Res Protoc*. 2022 Mar 9;11(3):e32338.
43. Prieto JT, Zuleta C, Rodríguez JT. Modeling and testing maternal and newborn care mHealth interventions: a pilot impact evaluation and follow-up qualitative study in Guatemala. *J Am Med Inform Assoc*. 2017 Mar 1;24(2):352–60.
44. Yadav D, Dabas K, Malik P, Bhandari A, Singh P. “Should I visit the clinic”: Analyzing WhatsApp-mediated Online Health Support for Expectant and New Mothers in Rural India. In: *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* [Internet]. New York, NY, USA: Association for Computing Machinery; 2022 [cited 2023 Aug 15]. p. 1–20. (CHI '22). Available from: <https://doi.org/10.1145/3491102.3517575>
45. Pilus FM, Ahmad N, Zulkefli NAM, Shukri NHM. Effect of Face-to-Face and WhatsApp Communication of a Theory-Based Health Education Intervention on Breastfeeding Self-Efficacy (SeBF Intervention): Cluster Randomized Controlled Field Trial. *JMIR MHealth UHealth*. 2022 Sep 14;10(9):e31996.
46. Fan HSL, Ho MY, Ko RWT, Kwok JYY, Chau PH, Wong JYH, et al. Feasibility and effectiveness of WhatsApp online group on breastfeeding by peer counsellors: a single-blinded, open-label pilot randomized controlled study. *Int Breastfeed J*. 2022 Dec

22;17(1):91.

47. Prabhu S, Prabhu A, Sahu KK. The Use of Whatsapp Social Media Group for Nutrition Counselling among Parents with Children of Congenital Heart Defects. *Int J Public Health Res* [Internet]. 2023 Mar 10 [cited 2023 Sep 3];13(1). Available from: <https://spaj.ukm.my/ijphr/index.php/ijphr/article/view/392>
48. Hale N, Picklesimer AH, Billings DL, Covington-Kolb S. The impact of Centering Pregnancy Group Prenatal Care on postpartum family planning. *Am J Obstet Gynecol*. 2014 Jan;210(1):50.e1-7.
49. Shakespear K, Waite PJ, Gast J. A comparison of health behaviors of women in centering pregnancy and traditional prenatal care. *Matern Child Health J*. 2010 Mar;14(2):202–8.
50. El Ayadi AM, Duggal M, Bagga R, Singh P, Kumar V, Ahuja A, et al. A Mobile Education and Social Support Group Intervention for Improving Postpartum Health in Northern India: Development and Usability Study. *JMIR Form Res*. 2022 Jun 29;6(6):e34087.
51. Diamond-Smith NG, El Ayadi AM, Duggal M, Bagga R, Kaur J, Sharma P, et al. Feasibility and acceptability of a multi-component mhealth group social support and education intervention for postpartum women in India. *Rev*.
52. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. *Stat Med*. 2009 Nov 10;28(25):3083–107.
53. Hernán MA, Hernández-Díaz S, Robins JM. A structural approach to selection bias. *Epidemiol Camb Mass*. 2004 Sep;15(5):615–25.
54. Shade SB, Steward WT, Koester KA, Chakravarty D, Myers JJ. Health information technology interventions enhance care completion, engagement in HIV care and treatment, and viral suppression among HIV-infected patients in publicly funded settings. *J Am Med Assoc JAMA*. 2015 Apr;22(e1):e104-111.
55. StataCorp,. *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LLC; 2017.
56. Mehta KM, Irani L, Chaudhuri I, Mahapatra T, Schooley J, Srikantiah S, et al. Health layering of self-help groups: impacts on reproductive, maternal, newborn and child health and nutrition in Bihar, India. *J Glob Health*. 2020 Dec;10(2):021007.
57. Mozumdar A, Khan ME, Mondal SK, Mohanan PS. Increasing knowledge of home based maternal and newborn care using self-help groups: Evidence from rural Uttar Pradesh, India. *Sex Reprod Healthc*. 2018 Dec 1;18:1–9.
58. Kabongo EM, Mukumbang FC, Delobelle P, Nicol E. Explaining the impact of mHealth on maternal and child health care in low- and middle-income countries: a realist synthesis. *BMC Pregnancy Childbirth*. 2021 Mar 9;21(1):196.

59. Chen H, Chai Y, Dong L, Niu W, Zhang P. Effectiveness and Appropriateness of mHealth Interventions for Maternal and Child Health: Systematic Review. *JMIR MHealth UHealth*. 2018 Jan 9;6(1):e8998.
60. Ward VC, Raheel H, Weng Y, Mehta KM, Dutt P, Mitra R, et al. Impact of mHealth interventions for reproductive, maternal, newborn and child health and nutrition at scale: BBC Media Action and the Ananya program in Bihar, India. *J Glob Health*. 2020 Dec;10(2):021005.
61. Pendse RS, Ayadi AME, Sharma P, Ahuja A, Basavarajappa DH, Duggal M, et al. Access to and Use of Mobile Phone by Postpartum, Married Women in Punjab, India: Secondary Analysis of mHealth Intervention Pilot Data. *JMIR Form Res*. 2022 May 12;6(5):e34852.
62. Ayadi AME, Duggal M, Bagga R, Singh P, Kumar V, Ahuja A, et al. A Mobile Education and Social Support Group Intervention for Improving Postpartum Health in Northern India: Development and Usability Study. *JMIR Form Res*. 2022 Jun 29;6(6):e34087.
63. Lebrun V, Dulli L, Alami SO, Sidiqi A, Sultani AS, Rastagar SH, et al. Feasibility and Acceptability of an Adapted Mobile Phone Message Program and Changes in Maternal and Newborn Health Knowledge in Four Provinces of Afghanistan: Single-Group Pre-Post Assessment Study. *JMIR MHealth UHealth*. 2020 Jul 20;8(7):e17535.

Tables

Table 2. Sociodemographic characteristics of intervention participants (n=135)

	Synchronous (n=94)	Asynchronous (n=28)	Control (n=13)	Total (n=135)
Age, mean (SD)	26.7 (0.38)	26.8 (0.61)	26.7 (1.57)	26.7 (0.33)
Relationship status				
Married or domestic partnership	94 (100%)	27 (98%)	13 (100%)	134 (99.8%)
Separated	0 (0%)	1 (1.2%)	0 (0%)	1 (0.2%)
Educational attainment				
None	0 (0%)	2 (7.2%)	1 (6%)	3 (1.5%)
Up to secondary	9 (9.6%)	1 (3.1%)	3 (22.2%)	13 (9.4%)
Higher secondary	41 (43.6%)	15 (50.1%)	6 (47.1%)	62 (44.8%)
Diploma or higher	44 (46.8%)	10 (39.6%)	3 (24.7%)	57 (44.3%)
Religion				
Hindu	23 (24.5%)	11 (32.2%)	4 (26.3%)	38 (25.7%)
Muslim	9 (9.6%)	0 (0%)	3 (21.8%)	12 (9%)
Sikh	62 (66%)	17 (67.8%)	6 (51.9%)	85 (65.3%)
Caste				
General	41 (43.6%)	16 (55.7%)	5 (39.9%)	62 (45.2%)
Schedule caste/tribe	36 (38.3%)	6 (21.2%)	6 (48.3%)	48 (36.4%)
Other backward class	15 (16%)	3 (9.8%)	2 (11.8%)	20 (14.8%)
Other	2 (2.1%)	3 (13.3%)	0 (0%)	5 (3.6%)
Ration card				
Yes	45 (47.9%)	16 (45.7%)	5 (35.9%)	66 (48.0%)
No	49 (52.1%)	12 (54.3%)	8 (64.1%)	69 (52.0%)
Parity				
1	50 (53.2%)	14 (51.6%)	8 (60.2%)	72 (53.4%)
≥1	44 (46.8%)	14 (48.4%)	5 (39.8%)	63 (46.6%)
Mobile phone ownership				
Individual	93 (98.9%)	25 (91.6%)	9 (80.6%)	122 (92.5%)
Household	88 (93.6%)	28 (100%)	13 (100%)	134 (99.2%)

Table 3. Comparisons between pre and post-intervention newborn health-related knowledge by intervention arm (N=135)							
	T	Mean (95% CI)			Arm*Time Parameter (95% CI)		
		Synchronous	Asynchronous	Control	Synchronous vs. asynchronous	Synchronous vs. control	Asynchronous vs. control
Maternal knowledge of infant danger signs (total possible score=12)	Pre-	1.85 (1.61, 2.08)	2.06 (1.47,2.65)	2.31 (1.19, 3.44)	0.56 (-0.22 - 1.35)	0.87* (0.06 - 1.69)	0.31 (-0.75 - 1.37)
	Post-	2.22 (2.00, 2.44)	1.87 (1.32,2.43)	1.81 (1.02, 2.60)			
Maternal knowledge of appropriate infant and young child feeding practices (total possible score=9)	Pre-	7.56 (7.23, 7.89)	6.48 (5.56, 7.40)	6.84 (5.05, 8.65)	-0.75 (-1.96 - 0.45)	0.66 (-2.07 - 3.40)	1.42 (-1.55 - 4.40)
	Post-	7.89 (7.77, 8.01)	7.56 (6.95, 8.18)	6.51 (4.74, 8.28)			
Notes: Time (T): Pre (pre-intervention) vs. post- (post-intervention); *** p<0.001, ** p<0.01, * p<0.05; Full model output for these analyses is presented in Table S1. Synchronous arm (combining all participants assigned to weekly group call), asynchronous arm (combining those participants assigned to App and IVR), and a control arm.							

Table 4. Post-intervention comparison of infant health care seeking, vaccination uptake, and infant and young child feeding practices at endline (n=135)						
	Synchronous	Asynchronous	Control	Synchronous vs. asynchronous (A)	Synchronous vs. control (B)	Asynchronous vs. control (C)
	% (n)	% (n)	% (n)	OR 95%CI	OR 95%CI	OR 95%CI
Infant health check-up						
Participants who had a postnatal health check for infant within the 6 weeks after giving birth	57.5% (54)	40.9% (8)	28.9% (2)	1.94 (0.71, 5.30)	3.32 (0.64, 17.02)	1.70 (0.25, 11.37)
Health check-up conducted by clinical provider (Ref: no health check-up by a clinical provider)	53.2% (50)	29.5% (7)	24.8% (2)	2.72* (1.02, 7.23)	3.44 (0.69, 17.06)	1.26 (0.20, 7.90)
Mothers whose infants fell sick in the past 3 months						
	38.3% (36)	33.1% (7)	46.3% (5)	1.25 (0.44, 3.52)	0.71 (0.17, 3.06)	0.57 (0.10, 3.28)
Infant received BCG, Polio, DPT, Hep-B vaccines						
BCG vaccination	92.6% (87)	96.1% (23)	100.0% (11)			
Polio vaccination	100.0% (94)	96.6% (24)	93.5% (10)			
DPT vaccination	98.9% (93)	100.0% (24)	100.0% (11)			
Hep B vaccination	97.9% (92)	100.0% (24)	100.0% (10)			
Received all four vaccines (Ref: Received fewer than four vaccines)*	89% (84)	84% (22)	80.3% (10)	1.59 (0.48,5.22)	2.06 (0.45, 9.28)	1.28 (0.23, 7.15)
Early initiation of breastfeeding their infant						
Within 1 hr of delivery (Ref: After 1 hour of delivery)	47.0% (41)	42.1% (9)	56.0% (5)	1.25 (0.47, 3.29)	0.71 (0.18, 2.79)	0.56(0.11, 2.85)
Intended length of breastfeeding						
Intend to breastfeed for >24 months (Ref: <24 months)	19.8% (17)	37.6% (9)	14.9% (2)	0.40 (0.15, 1.13)	1.40 (0.25, 7.86)	3.43 (0.50, 23.4)
Mothers who have introduced complementary foods post-intervention						
	92.6% (87)	95.3% (20)	52.2% (6)	0.61(0.06, 5.50)	11.37*** (2.49, 51.88)	18.37* (1.48, 228.20)
*** p<0.001, ** p<0.01, * p<0.05						

Supplementary Table S1

	Synchronous vs. asynchronous arm						Synchronous vs. control arm						Asynchronous vs. control arm					
	Arm param eter (95% CI)	p- valu e	Time param eter (95% CI)	p- valu e	Arm*Ti me Param eter (95% CI)	p- valu e	Arm param eter (95% CI)	p- valu e	Time param eter (95% CI)	p- valu e	Arm*Ti me Param eter (95% CI)	p- valu e	Arm param eter (95% CI)	p- valu e	Time param eter (95% CI)	p- valu e	Arm*Ti me Param eter (95% CI)	p- valu e
Maternal knowledge of infant danger signs	-0.20	0.52	-0.19	0.61	0.56	0.16	-0.44	0.43	-0.51	0.19	0.87*	0.03	-0.25	0.69	-0.50	0.2	0.31	0.56
	(-0.82 - 0.42)		(-0.91 - 0.53)		(-0.22 - 1.35)		(-1.54 - 0.66)		(-1.30 - 0.25)		(0.06 - 1.69)		(-1.52 - 1.01)		(-1.27 - 0.26)		(-0.75 - 1.37)	
Maternal knowledge on infant and young child feeding practices	1.08*	0.03	1.08	0.06	-0.75	0.22	0.71	0.44	-0.33	0.81	0.66	0.63	-0.37	0.72	-0.33	0.35	1.42	0.35
	(0.11 - 2.05)		(-0.07 - 2.24)		(-1.96 - 0.45)		(-1.10 - 2.53)		(-3.05 - 2.38)		(-2.07 - 3.40)		(-2.39 - 1.66)		(-3.07 - 2.40)		(-1.55 - 4.40)	
Robust ci in parentheses																		
*** p<0.001, ** p<0.01, * p<0.05																		

Supplementary Files