Preliminary efficacy 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

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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%).

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Key words: Digital health, postpartum, health education, social support, India, infant morbidity, care seeking

Introduction

India has made substantial improvements in child survival from 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 while 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% 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 receipt of postnatal care is associated with reduced neonatal mortality [10] and receipt of appropriate among sick infants and children is also correlated with reduced risk of severe wasting [11]. Postnatal education is one of the evidence-based strategies to improve newborn health and nutrition as well as maternal knowledge of general infant health and care [12]. While national data suggests that 79% infants receive 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 do not receive any 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].

The postnatal period presents a crucial opportunity for engaging in appropriate healthcare practices, including identifying and management of complications, breastfeeding education, child vaccination, and offering social support to new mothers. However, in India, the postnatal period of maternal, newborn, and child health remains neglected. Various barriers hinder postnatal care, 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 these barriers and improving postnatal maternal

knowledge, social connectedness, and maternal and child health-related behaviors.

The proliferation of mobile phones in the past decade has created an extensive landscape of possibilities for leveraging mHealth interventions. A scoping review summarizing evidence from 28 studies across low-and-middle-income countries (LMICs) suggests that providing mHealth-based text and voice message reminders to beneficiaries improved immunization coverage and increased adherence to immunization schedule [27]. Another systematic review of 16 studies found that mHealth education interventions were associated with increased interactions between clients, particularly young mothers and healthcare workers antenatally, during delivery, and postnatally in LMICs [28]. An Indian systematic review conducted by Bassi and colleagues (2018) highlighted that majority of the mHealth interventions were tested in the southern part of India and primarily targeted non-communicable diseases or other non-specified diseases, with fewer interventions specifically addressing maternal or child health concerns, underscoring an important gap in the field [29]. Moreover, nearly all reviews emphasized the need for more rigorous studies to examine the impact of mHealth interventions in LMICs [28–31].

Majority of the earlier mHealth interventions were text-based short message service (SMS), voice messages, or interactive voice response (IVR) without the need for a smartphone. In a randomized controlled study in Nigeria, mothers who received one-way text reminders were 50% more likely to attend their postnatal appointments [32]. A pilot intervention trial in urban India that delivered weekly phone-based counselling and daily text messages for personalized lactation improved both early initiation of breastfeeding and exclusive breastfeeding rates at six months postpartum [33]. Other mHealth intervention studies in LMICs outside India using voice and text messages found improvements in protein consumption [34], breastfeeding [31,35] and general infant and young child feeding practices [36]. IVR has been another popular mode of reaching beneficiaries with limited literacy. A large-scale IVR-based messaging intervention (Kilkari) in India found that enrolled beneficiaries had better knowledge of child immunization [37] and better adherence to child immunization schedule at 10-weeks, though no improvement in other maternal, newborn and child health behaviors such as exclusive breastfeeding were noted [38]. Smartphone-based mHealth applications in India have been used to improve service delivery of community health and nutrition workers, with a primary emphasis on the prenatal phase, although some extend to the postnatal period. However, these apps predominantly target frontline health and nutrition workers [39,40] rather than the beneficiaries themselves [30].

Use of social media platforms such as WhatsApp, with a large user base in many LMICs have been used to provide virtual social support and health education using smartphones through the feature of ‘WhatsApp groups’. A few recent studies have highlighted WhatsApp groups as feasible and acceptable for a range of maternal and child health themes, including improved self-efficacy and knowledge of breastfeeding [41,42], nutritional counseling on infant and young child feeding practices [43] and pregnancy and postpartum care [33,44,45], though few of these studies tested multiple mHealth modalities at once. Few studies are underway to test the effectiveness of WhatsApp groups in improving maternal and health outcomes using rigorous approaches [46].

While the text, IVR and smartphone applications been effective in providing information through pregnancy and postpartum period, and in improving the quality of services provided to women and infants, most mHealth interventions are unidirectional and do not offer social support. Integration of participatory learning and action cycles with women’s groups have been recommended by the World Health Organization and recognized as important in promoting better postnatal health as young mothers are at increased risk of social isolation as well as poor psychosocial health [47]. Group-oriented mHealth intervention that combine the dual benefits of group-based learning and social

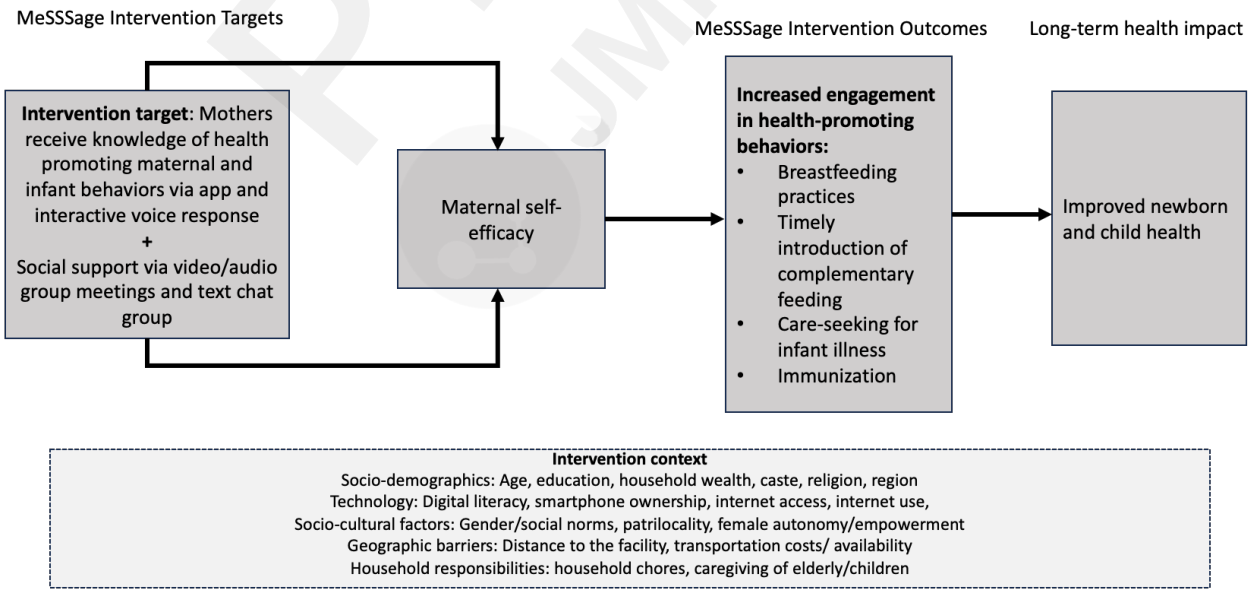
support along with greater reach of mHealth modalities for women in the postnatal period may be logistically convenient, feasible, acceptable, and effective in improving postnatal maternal and infant health outcomes, particularly given the increased mobile ownership and greater access to low-cost internet. However, the combined impact of group-based social support delivered via mHealth modalities such as group voice calls or Zoom have been understudied in LMICs. Further, their feasibility, acceptability, and potential efficacy remain to be examined.

To address these gaps raised above, we designed a provider-facilitated group mHealth intervention for perinatal women called *MeSSSSage* (*Maa Shishu Swasthya Sahayak Samooh* in Hindi translating to maternal and child health support group). Informed by the capabilities, opportunities, motivation and behavior (COM-B) [48,49] framework, we designed the intervention to enhance maternal knowledge of health-promoting behaviors and promote maternal self-efficacy and empowerment to improve health-related knowledge, behaviors, and outcomes for both mothers and children (Figure 1). The intervention aimed to improve knowledge, facilitate referrals to in-person care as necessary, 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].

Objective of this study

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.

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



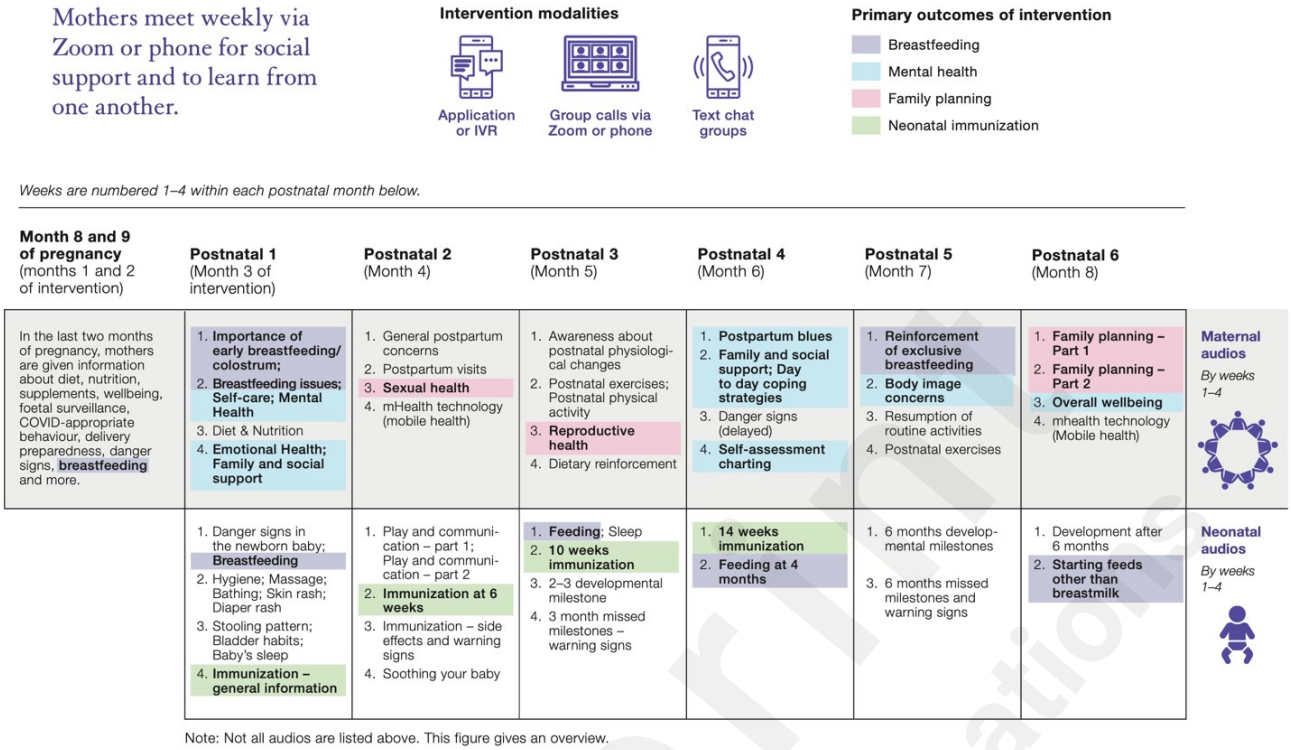
MeSSSSage intervention

In broad terms, the *MeSSSSage* intervention was administered to women from late pregnancy through six months postpartum. The *MeSSSSage* intervention included weekly audio or audio-video group calls, group text chats, and audio educational content provided via automated interactive voice response or *MeSSSSage* application (Table 1 and Figure 2). 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 education and social support. These sessions incorporated icebreakers and group-building activities, facilitated discussions based on weekly themes (Figure 2), and allowed for open question 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 between 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.
***MeSSSSage* mobile application (App)**	Weekly educational audio messages focused 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



Methods

Study design

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

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 the 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 encompassed difficulty reaching participants via cell phone (due to it being switched off or out of service), incorrect numbers, no longer pregnant (miscarriage or preterm birth), inconsistent access to mobile phones,

and lack of interest.

Participants were recruited, and 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 were collected through interviewer administration over the phone.[1]

Based on existing research on IVR and Apps for maternal and child health in India, our focus shifted to examining the supplementary impact of group calls. 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. This consolidation aimed to facilitate a comparison of feasibility, acceptability, and preliminary efficacy between asynchronous and synchronous communication arms, as well as intervention engagement levels. We anticipated that participants engaged in group calls would experience higher levels of social connectedness compared to those solely utilizing the educational app or IVR, as the former allowed for direct interaction with others, fostering a sense of community and support.

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.

Study measures

Our exposure was three intervention categories explained above: a synchronous arm, an asynchronous arm, and a control arm.

The primary outcomes of this study were 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 understanding of the appropriate age for introducing various food groups, such as 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 at post-intervention were assessed, including infant health status, access to healthcare, infant vaccination status, and infant feeding behaviors. Infant postnatal health

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

characteristics were assessed through various questions, including inquiries about postpartum care check-ups. These check-ups were 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. Other behaviors examined included infant and young child feeding practices, such as ever breastfeeding, early initiation of breastfeeding, and complementary feeding. 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.

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).

Analysis

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, accounted for multiple discrepancies in underlying demographics between the arms pre-intervention [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 (either synchronous, asynchronous, and control 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].

Results

Sociodemographic characteristics

At the time of 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 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 arm as well as 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 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 (Columns A-C in Table 4).

Breastfeeding and complementary food introduction

Initiation of breastfeeding within the first hour after birth was low across all arms. 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. 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 being assigned to synchronous arm had a beneficial impact on participants' knowledge regarding infant danger signs and greater 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 groups 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 [40] 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 [39,40]. 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 the optimal timing for sending messages and IVR calls, and devise strategies to enhance engagement and participation in mHealth interventions. Finally, future studies could explore incentives such as discounted call rates to motivate participants to carefully listen to all messages, as suggested in a study conducted in Afghanistan [63].

The primary objective of this study was to assess the feasibility and acceptability of the intervention rather than robustly evaluating its efficacy on primary outcomes. Several limitations exist regarding the estimation of preliminary effectiveness. The sample size was determined based on these feasibility considerations, resulting in significant differences in socio-demographic characteristics among 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 assessment of effectiveness and potential mechanisms of impact. 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 but offered promising insights into its preliminary effectiveness. Such interventions, integrating mHealth-based education and communication with social support, hold significant promise 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.

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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 parameter (95% CI)	**p-value**	**Time parameter (95% CI)**	**p-value**	**Arm*Time Parameter (95% CI)**	**p-value**	**Arm parameter (95% CI)**	**p-value**	**Time parameter (95% CI)**	**p-value**	**Arm*Time Parameter (95% CI)**	**p-value**	**Arm parameter (95% CI)**	**p-value**	**Time parameter (95% CI)**	**p-value**	**Arm*Time Parameter (95% CI)**	**p-value**
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																		