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Original research

Feasibility and acceptability of Saheli, a WhatsApp Chatbot, on COVID-19 vaccination among pregnant and breastfeeding women in rural North India

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ABSTRACT

Introduction Pregnant and breastfeeding women are priority targets for COVID-19 vaccination due to adverse maternal and fetal consequences of perinatal COVID-19 infection and the opportunity for protecting infants through maternal antibodies. Saheli ('female friend') is a WhatsApp-deployed chatbot providing evidence-based guidance on COVID-19 for pregnant and breastfeeding women.

Objectives To understand the feasibility and acceptability of Saheli and its impact on COVID-19 vaccination.

Methods We pilot-tested Saheli among pregnant and breastfeeding participants of pre-existing WhatsApp educational groups led by a community-based non-governmental organisation in Haryana, India from January to March 2022 using a pre/post design.

Results 829 unique participants completed precommunity surveys or postcommunity surveys; 238 completed both. 829 individuals used Saheli, including 88% postintervention survey participants. Users reported Saheli was easy to engage with (79%), easy to understand (91%), quick (83%) and met their information needs (97%). 89% indicated it improved their COVID-19 knowledge a lot, 72% recommended it to others and 88% shared chatbot-derived information with others. Most participants received ≥1 COVID-19 vaccine (86% vs 88%, preintervention to postintervention); full vaccination was 55% and 61%, respectively. Vaccination over time increased marginally for ≥1 dose (OR 1.15, 95% CI 0.99 to 1.36) and significantly for 2 doses (OR 1.21, 95% CI 1.09 to 1.34), and increases were significant among pregnant (≥1 dose) and breastfeeding participants (2 doses). Vaccine hesitancy was low. Chatbot use was high, yet individual chatbot engagement did not alter COVID-19 vaccination.

Conclusion Chatbots are a promising health education strategy due to high acceptability and deployment potential. Interpreting community chatbot impact must acknowledge the co-occurring constellation of multilevel interventions, community and pandemic factors.

INTRODUCTION

COVID-19 infection during pregnancy substantially increases maternal mortality and morbidity as well as fetal and neonatal complications, particularly when severe.[1–4] Maternal vaccination during pregnancy effectively reduces these risks,[5] and vaccination during pregnancy or while breastfeeding extends protection to infants through COVID-19-neutralising antibody transmission.[6–8] Moreover, the safety of available COVID-19 vaccines has been established, and COVID-19 vaccination is recommended during pregnancy.[2 9–13]

India is both a major global contributor to COVID-19 cases and deaths and has one of the highest burdens of maternal and child mortality worldwide.[14] This makes mitigating the impact of the COVID-19 pandemic on maternal and child health a critical national priority. While

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WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic has required unprecedented scaling of health education campaigns, necessitating innovative strategies that sensitising populations on COVID-19 mitigation behaviours and guiding them on vaccine uptake and access. In India, significant disparities exist in COVID-19 vaccination by gender. Vaccination rates were particularly low among pregnant and breastfeeding women compared with the rest of the population despite Ministry of Health approval and evidence of significant maternal and neonatal benefit. Our formative work in northern India confirmed low COVID-19 vaccination among a sample of pregnant and breastfeeding women and identified that unvaccinated individuals held safety concerns for mother and infant. Chatbots, interactive digital programmes which simulate human conversation have great potential for efficiently reaching broad populations with targeted information, and many individuals with internet access are already engaging with chatbots for various services. Our study sought to understand chatbot engagement and acceptability and its impact on COVID-19 vaccine beliefs and uptake in a high-risk population group, pregnant and breastfeeding women.

WHAT THIS STUDY ADDS

⇒ Our study found that a simple menu-based chatbot providing evidence-based guidance on COVID-19 vaccination deployed over WhatsApp to pregnant and breastfeeding women in semiurban north India was both feasible to implement and acceptable to this population.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our findings suggest that chatbots may be a promising health education strategy among a vulnerable subpopulation with very specific health education needs in the South Asian context, for COVID-19 and other health topics.

official data remained limited, newspaper sources report severe consequences of COVID-19 among pregnant women,[15–18] particularly during India's second COVID-19 wave (2021) where symptomatic COVID-19 and case fatality rates were elevated among pregnant and breastfeeding women (28.7% and 5.7%, respectively).[19]

COVID-19 vaccines became available in India in January 2021 with the government's emergency approval of Covishield and Covaxin (figure 1) and approval was extended to pregnant and breastfeeding women in July 2021.[20] While COVID-19 vaccination among the general population was rapid with 61% of the adult population completely vaccinated in 2021,[21] significant disparities were observed across sociodemographic characteristics including gender, illuminating complexities of vaccine access and acceptance.[21] CoWIN, India's COVID-19 vaccination dashboard, does not track vaccine status by pregnancy/breastfeeding status so national data are unavailable[22]; however, research studies have identified lower vaccination among this subpopulation. For example, 12.9% of 2821 pregnant Indian participants in the Global Network for Women and Children's Health Research (GNWCHR) were vaccinated by November 2021,[23] and our formative research in Haryana found only one-third of pregnant and breastfeeding women were vaccinated.[24] At the time, COVID-19 vaccines were offered freely at government clinics and hospitals and for a fee at private facilities, thus were largely available, despite some logistical challenges with maintaining supply.[25]

Some COVID-19 vaccine hesitancy has been documented among Indian populations, largely due to fear of side effects.[26] Studies estimate that approximately 71% of the general population wanted COVID-19 vaccination (range 58%–80% across states); 66% in Haryana where our research was situated.[27] Among the general population, major reasons for vaccine hesitancy included wanting to wait for more safety data, belief that others need it more, and concern regarding side effects.[27] While COVID-19 vaccine acceptability in India is unknown for pregnant and breastfeeding individuals, education, gender and advancing age are associated with COVID-19 vaccine uptake.[26–28] Two multicountry COVID-19 vaccination studies included one meta-analysis which estimated vaccination intent at 47% among pregnant and breastfeeding women (range 18%–72% across studies),[29] and the GNWCHR study whose participants endorsed COVID-19 vaccine effectiveness although only 35.5% believed it was safe for pregnant women and 44.4% safe for a woman trying to get pregnant.[23] Main vaccination barriers for pregnant and postpartum women included fear of adverse effects (48.3%) and unsure of safety (25.1%).[23] Our formative research found low vaccination despite high healthcare provider access for antenatal care; half of unvaccinated women wanted to receive COVID-19 vaccination now (47%), 20% soon and 27% not at all.[24] Safety concerns were reported more frequently by unvaccinated participants.[24] These findings are consistent with other literature on COVID-19 vaccine concerns in India.[30]

Facilitating broad access to high-quality health education from trusted sources is important for increasing vaccine acceptance.[31] Health education must be simple, consistent, and culturally and linguistically appropriate to reach intended audiences and support behaviour change. Health education dissemination strateg innovation is critical to meet the scope and depth required for population-level coverage, particularly for novel threats. Our team's formative research identified vaccine misinformation related to pregnant and breastfeeding women, but confirmed high vaccine interest and need for tools to negotiate with other household decision-makers.[24] Additionally, we found that women were in need of trusted information sources.[24]

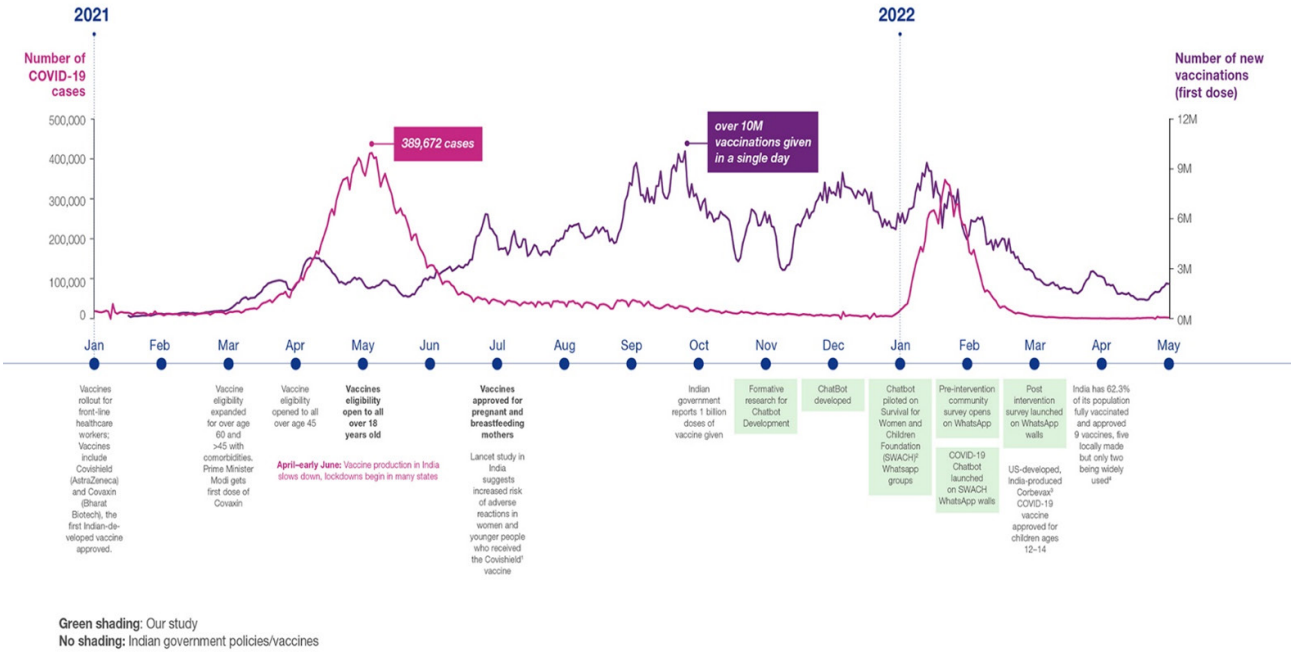

Figure 1 Saheli chatbot intervention timeline and context.

Chatbots, interactive programmes which simulate user conversation over digital platforms, have great potential for efficiently reaching large numbers of individuals to inform, respond to questions and dispel misinformation.[32–34] Individuals now regularly engage with chatbots across varied industries (eg, banking, travel, healthcare) and socially. Increasing smartphone ownership is facilitating chatbot access and adoption. India now has over 1.145 billion telecom subscribers (May 2022) representing 94% of households, about 750 million of which are smartphone owners.[35 36] While India's gender gap in mobile phone by gender persists, access is improving; for example, 54% of Indian women of reproductive age own a mobile phone (69.4% urban and 46.6% rural), and over the last decade, two-thirds of households where women were not previously using a smartphone or other internet-accessible device now have access.[35 37] COVID-19 and COVID-19 vaccine chatbots developed and tested by the WHO, the Ministry of Health India and Johns Hopkins University, among others, have been found acceptable and promising for sharing accurate health information quickly, and reaching a large number of people.[38–41] However, to date, no known chatbots specifically focus on pregnant and breastfeeding women.

The objective of our study was to develop and implement an innovative user-centred approach to meeting the educational needs of pregnant and breastfeeding women, a high-risk population group, about the benefits and risks to perinatal COVID-19 vaccination. Building on existing research and Indian guidelines, including our team's own formative research,[24] we developed and pilot tested the Saheli ('female friend') chatbot in a pre-existing online community group structure with a trusted community partner organisation. We sought to understand chatbot engagement and acceptability and impact on vaccine beliefs and uptake.

METHODS

Intervention description

Saheli menu-based chatbot was developed and implemented using WhatsApp business API and node.js at a cost of ~US$100 monthly to the research team. Hindi chatbot content was developed from formative research and Indian national health guidelines.[24] It sought to influence COVID-19 vaccine knowledge, attitudes and practices among pregnant and breastfeeding Indian women through accessible evidence-based vaccine education. Our chatbot approach combines the efficiency of an automated programme simulating human-to-human conversation with accessibility, confidentiality and targeted information.[42] Briefly, the participant initiates a conversation with the chatbot through any message to Saheli's contact number, and Saheli responds with a welcome message describing its purpose and limitations (online supplemental figure 1). It asks the participant whether they seek information on COVID-19 vaccines related to pregnancy or breast feeding or have general COVID-19 vaccine concerns. Saheli then asks whether the participant is pregnant, breast feeding or looking for resources. Depending on their answer, the participant selects from a menu of common questions addressing: COVID-19 vaccine access logistics, COVID-19 vaccines approved for pregnancy or breast feeding, vaccine effectiveness, side effects, COVID-19 precautions and other

concerns that arose from formative research: delaying vaccination until after pregnancy/breast feeding, sharing with hesitant family members and healthcare providers (example in online supplemental figure 2). Topic content prioritised simplicity and linked to Indian Ministry of Health COVID-19 guidance. After engaging with each content section, participants can review other content per interest. Participants could submit questions within the chatbot for continued topic refinement. Once Saheli responded to a participant, it waited for 1 min before asking again what information the participant sought and the conversation moved forward. If a participant did not select an option within 4 min, Saheli asked if the participant wanted to know something more. If the participant said 'yes', Saheli asked what information the participant sought. If the participant said 'no', Saheli sent a thank you message. User sessions timed out after 4 min of inactivity. After timeout, the participant could start a new conversation by messaging Saheli. After timeout, Saheli sent a three-question feedback survey to understand participant experiences: 'How did you find chatting with the chatbot?', 'Did you find the information provided by the chatbot useful?' and 'Would you like to get the COVID-19 vaccination after talking with the chatbot?'

Community-based deployment

We explored feasibility, acceptability and effectiveness of the Saheli chatbot among pregnant and breast feeding in Haryana, India from January to March 2022 using a pre/post community assessment design. Participants were women connected with pre-existing WhatsApp maternal and child health educational discussion groups (~3000 ongoing participants) led by community-based non-governmental organisation (NGO) Survival for Women and Children Foundation (SWACH; http://www.swach.org). The project timeline and surrounding COVID-19 context are depicted in figure 1.

Preintervention community data collection began on 29 January 2022. Participants were recruited to online survey hosted within Google forms through an invitation message posted within pre-established educational WhatsApp groups that were formed and facilitated by a NGO, SWACH. Follow-up daily reminders were sent for 1 week. Throughout preintervention data collection, SWACH staff continued to engage the WhatsApp educational groups in regularly planned maternal and child health topics. Saheli was deployed on 15 February, 2022. SWACH staff introduced the WhatsApp groups to Saheli and provided the access link. During deployment, SWACH staff reminded participants about Saheli twice per day from 15 February 2022 to 9 Marc 2022 except during a 2-day power outage and 0.5-day WhatsApp outage, and questions regarding Saheli or engagement challenges were answered by moderators or group members. Postintervention community data were collected from 9 March 2022 to 22 March 2022 as described above for the preintervention survey.

Study measures

Study data were captured from preintervention and postintervention community surveys, chatbot backend data and the three feedback questions asked to users within the chatbot. Community-based surveys captured information on COVID-19 vaccination, number of doses and latest vaccination dates. Unvaccinated individuals were asked whether they had tried to access COVID-19 vaccination and, if so, why they were unsuccessful (not eligible due to pregnant or breastfeeding status, not eligible for another reason, no supply or other). Unvaccinated individuals were asked for the main reasons why they were unvaccinated (until not pregnant anymore, waiting until not breast feeding anymore, healthcare worker said ineligible, family said could not, scared, other), and how likely they would be to get vaccinated if a COVID-19 vaccine were provided to them at no cost (response options: very likely, somewhat likely, not sure, somewhat unlikely, very unlikely, would not). Postintervention community survey participants were asked whether they had gotten information about COVID-19 vaccination from the SWACH WhatsApp group or the Saheli chatbot. Individuals reporting having accessed Saheli were asked how they had learnt about Saheli (SWACH WhatsApp group, family/friend), ease of chatbot interaction (easy to understand how to interact with the chatbot, initially difficult to interact with the chatbot or did not understand how to interact with the chatbot), accessibility of chatbot information (quickly, took some time, long-time), understandability of chatbot information (easily understandable, some difficulty in understanding the information, did not understand the information) and responsivity of chatbot to individual information needs (chatbot provided all, some, or none of the information required). Participants were asked what they liked most and least about interacting with Saheli. Postintervention participants were asked whether the chatbot improved their COVID-19 vaccination knowledge (yes—a lot, yes—a little bit, no) or influenced their decision-making (yes or no). Finally, they were asked whether they recommended Saheli to others (yes or no) and whether they had shared information from Saheli with others (yes or no). Participant characteristics captured on both preintervention and postintervention surveys included age, educational attainment, current pregnant and breastfeeding status, frequency of engagement with SWACH WhatsApp group, communication with family or friends in the past 2 weeks about COVID-19 vaccination, and phone number for pre/post data linkage. Measures were adapted from the Centers for Disease Control and Prevention's (CDC) Vaccine Confidence Survey Question Bank[43] and our formative research.[24] Chatbot engagement was measured through chatbot backend data of new and

repeat interactions with the chatbot and user chat logs. Chatbot user acceptability was also measured through the three-item user experience survey administered after chatbot timeout (see the Intervention description section) which included measures on participant experience using the chatbot, perceived level of usefulness and perspective on chatbot influence on COVID-19 vaccination interest.

Data analysis

Data from precommunity and postcommunity surveys were matched by participant telephone numbers, resulting in a partially matched sample (ie, some study participants completed both presurveys and postsurveys whereas others completed only the presurvey or only the postsurvey). Participant sociodemographic characteristics, chatbot engagement and chatbot acceptability were described (medians and IQR or proportions, as appropriate). Chatbot engagement among postintervention participants was compared by sociodemographic characteristics using χ^2 tests. Comparisons from preintervention to postintervention of participant sociodemographic characteristics, COVID-19 vaccination behaviours and beliefs, used logistic regression models employing a generalised estimating equation approach to accommodate for clustering within our partially matched sample. Data analyses were conducted in Stata version 17 (StataCorp) and differences were considered statistically significant where $p<0.05$.

Patient and public involvement

Patients and/or the public were not involved in the design or conduct of this study.

RESULTS

Sociodemographic characteristics

Of the 619 preintervention participants and 441 postintervention community survey participants, 829 were unique and 238 individuals participated in both preintervention and postintervention surveys. Presurvey and postsurvey participants' sociodemographic characteristics are presented in table 1. Median age was 27 (IQR 25–30). Educational attainment was relatively high, with about three-fourths having completed secondary school or higher. About one-fifth of participants were pregnant, three-fifths breast feeding and one-fifth neither. Most participants reported engaging in the SWACH WhatsApp educational groups about once per week (93%–94% across pre/post surveys).

Chatbot engagement and acceptability

Chatbot backend data identified 829 unique chatbot users. A total of 7430 messages were exchanged between participants and the chatbot (average 9 (SD 6.9), range 1–83). Most participants (77%) engaged with Saheli for 1 day only (range 1–11 days), most frequently between 6:00 and 12:00 hours (online supplemental figures 3,4). Participants explored breastfeeding-specific topics 212 times and pregnancy-specific topics 116 times. The most visited breastfeeding-specific topics were continuation of breast feeding after

Table 1 Sociodemographic characteristics of preintervention and postintervention study participants in Saheli chatbot community-based assessment

	Preintervention		Postintervention	
	n=619		n=441	
	n	%	n	%
Age				
Median (IQR)	27 (25–30)		27 (25–30)	
Min, max	19, 62		18, 62	
Educational attainment				
No formal education	3	0.5	1	0.2
Vth standard or less	4	0.7	7	1.6
Xth standard	65	10.6	44	10.0
XIIth standard	126	20.5	89	20.3
Graduation	216	35.1	156	35.5
Postgraduation	201	32.7	142	32.3
Frequency of reading information on WhatsApp group				
Once a week	543	93.8	397	93.0
A few times a month	33	5.7	24	5.6
Once a month or less	3	0.5	6	1.4
Pregnancy/breastfeeding status				
Currently pregnant	127	20.9	108	24.9
Currently breast feeding	361	59.3	242	55.8
Neither pregnant nor breast feeding	121	19.9	84	19.4

Table 2 Community engagement with Saheli chatbot and perspectives on acceptability

	Total population (n=1043)		Pregnant or breast feeding (n=838)	
	n	%	n	%
Chatbot engagement				
Got information about the COVID-19 vaccine over the WhatsApp group				
No	28	6.5	17	4.9
Yes	393	91.2	322	92.8
Not sure	10	2.3	8	2.3
Got information about COVID-19 from chatbot				
No	51	12.0	34	9.9
Yes	374	88.0	309	90.1
Source learnt about chatbot*				
SWACH WhatsApp Group	365	97.6	303	98.1
Family/friend	9	2.4	6	1.9
Chatbot experience				
How understandable found chatting style of chatbot*				
Easy to understand how to interact with the chatbot	297	78.8	249	80.1
Initially difficult but overtime became easy	59	15.6	51	16.4
Did not understand how to interact with chatbot	21	5.6	11	3.5
Timeliness of information access on chatbot*				
Quickly	307	83.2	256	83.4
Some time	57	15.4	48	15.6
Long time	5	1.4	3	1.0
How understandable found information provided by chatbot*				
Easy to understand	330	91.4	279	93.3
Some difficulty	23	6.4	16	5.4
Did not understand at all	8	2.2	4	1.3
Completeness of information provided by chatbot*				
All the required information	353	96.7	292	97.3
Some but not all information	10	2.7	8	2.7
No information	2	0.5	0	0.0
Interaction with chatbot helped you to decide in favour of the COVID-19 vaccine*				
No	12	3.2	9	2.9
Yes	361	96.8	299	97.1
Improvement in knowledge from interaction with chatbot*				
No, did not improve my knowledge	3	0.8	1	0.3
Yes, improved knowledge a little	38	10.3	33	10.8
Yes, improved knowledge a lot	327	88.9	272	88.9
Did you recommend the chatbot to others?*				
No	103	28.3	80	26.8
Yes	261	71.7	219	73.2
Did you share information from chatbot with husband and family members?*				
No	43	11.7	34	11.3
Yes	323	88.3	268	88.7

*If got information about COVID-19 from chatbot.
SWACH, Survival for Women and Children Foundation.

COVID-19 vaccination, COVID-19 vaccine suitability for breastfeeding women, and effect of COVID-19 vaccination on breastmilk. The most visited pregnancy-specific topics were COVID-19 vaccine suitability for pregnant women, optimal timing for the second COVID-19 vaccination dose during pregnancy and delaying COVID-19 vaccination. Topics common across pregnancy and breast feeding included reliable sources for vaccination, optimal vaccine timing and COVID-19 infection after the first dose. User queries included the following COVID-19 vaccine-related topics: postvaccination menstrual irregularity and vaccine suitability during menstruation, vaccine boosters, initiation of breastfeeding postvaccination

Table 3 Saheli chatbot engagement by sociodemographic characteristics

	N	Accessed chatbot N=380		Didn't access chatbot N=52		P value
		n	%	n	%	
Age						0.36
18–24	80	71	88.8	7	7.9	
25–29	231	204	88.3	23	26.0	
30–34	102	86	84.3	15	17.8	
35+	23	17	73.9	4	5.4	
Educational attainment						0.20
10th grade or below	52	43	82.7	9	10.9	
12th grade	89	71	79.8	12	15.0	
Bachelor	156	142	91.0	12	13.2	
Postgraduate	142	122	85.9	19	22.1	
Frequency of reading information on WhatsApp group						0.026
Once a week	397	347	87.4	41	46.9	
A few times a month	24	18	75.0	6	8.0	
Once a month or less	6	4	66.7	2	3.0	
Pregnancy/breastfeeding status						0.022
Pregnant	108	94	87.0	12	13.8	
Breast feeding	242	215	88.8	22	24.8	
Neither pregnant nor breast feeding	84	65	77.4	17	22.0	

and suitability of COVID-19 vaccination after miscarriage (eg, 'If someone had a miscarriage, should she get the COVID-19 vaccine or not?'). Other user queries focused generally on pregnancy, breast feeding, family planning and childcare (eg, 'Till when should a baby be breastfed?') Among those who responded to the three-question postchatbot survey (online supplemental table 1), most participants liked chatting with the chatbot (45.3% liked it a lot, 30.5% liked it), found the information provided by the chatbot useful (43.2% strongly agree, 41.8% agree) and would like to get the COVID-19 vaccine after talking with the chatbot (50.8% strongly agree, 35.2% agree).

Most postintervention survey participants reported receiving COVID-19 vaccination information from Saheli (88.0% overall, 90.1% of pregnant or breastfeeding participants; table 2), and nearly all learnt about Saheli from the WhatsApp group. Pregnant or breastfeeding participants reported Saheli was easy to interact with (80.1%) and provided information quickly (83.4%). Information provided by Saheli was considered easy to understand (93.3%) and met user information needs (97.3%). Most participants shared information from Saheli with their husband and other family members (88.7%); slightly fewer reported recommending Saheli to others (73.2%).

Postintervention community survey data revealed no difference in chatbot engagement by age group or educational attainment (table 3); however, individuals who participated less frequently in the SWACH WhatsApp groups were less likely to have engaged with Saheli. Pregnant and breastfeeding participants were more likely to have engaged with Saheli.

COVID-19 vaccination

COVID-19 vaccination was relatively high both preintervention and postintervention (table 4) and increased over time. Most participants had received at least one COVID-19 vaccination dose (86.2% preintervention and 87.7% postintervention); over half reported two doses (54.0% preintervention and 60.7% postintervention). COVID-19 vaccination rates were similar by pregnancy/breastfeeding status (table 4). Changes in vaccination status from preintervention to postintervention were marginal overall for at least one vaccination (table 5; OR 1.15, 95% CI 0.99 to 1.36, p=0.064) but increases were statistically significant for full vaccination (OR 1.20, 95% CI 1.09 to 1.34, p<0.001). Among pregnant respondents, increases in at least one vaccination over the intervention period were statistically significant (OR 1.31, 95% CI 1.12 to 1.53, p=0.001) whereas increases in full vaccination were not. The reverse was observed for breastfeeding respondents for whom full vaccination increased significantly over the intervention period (OR 1.32, 95% CI 1.13 to 1.55, p=0.001) but increases in at least one vaccination were not statistically significant.

Most unvaccinated respondents reported they would be very or somewhat likely to get vaccinated for COVID-19 if offered to them at no cost (76.8% preintervention and 71.7% postintervention). Few unvaccinated participants reported they would not consider vaccination (12.2% preintervention

Table 4 COVID-19 vaccination, vaccination intent, vaccine hesitancy and vaccine communication across study follow-up

	Pregnant or breast feeding				Neither pregnant nor breast feeding			
	Preintervention		Postintervention		Preintervention		Postintervention	
	n=488		n=350		n=121		n=84	
	n	%	n	%	n	%	n	%
COVID vaccination								
Vaccinated against COVID-19								
No	82	16.9	52	15.0	2	1.7	1	1.2
Yes, 1 dose	182	37.4	106	30.5	12	10.1	10	12.0
Yes, 2 doses	222	45.7	189	54.5	105	88.2	72	86.7
Months since latest vaccination*								
Median, IQR	2 (1.0–4.0)		2 (1.0–4.0)		3 (1.0–5.0)		2 (1.0–5.0)	
Min, max	(0, 10)		(0, 11)		(0, 9)		(0, 10)	
Vaccination intent								
Unsuccessfully tried to get vaccinated†								
No	10	12.5	7	13.7	1	50.0	0	0.0
Yes, told could not be vaccinated because of pregnancy or breast feeding	57	71.3	33	64.7	1	50.0	0	0.0
Yes, told could not be vaccinated for another reason	13	16.3	11	21.6	0	0.0	1	100.0
Likelihood of getting COVID-19 vaccine if offered at no cost†								
Very likely	42	52.5	30	57.7	1	50.0	1	100.0
Somewhat likely	19	23.8	7	13.5	1	50.0	0	0.0
I am not sure	7	8.8	5	9.6	0	0.0	0	0.0
Somewhat unlikely	1	1.3	0	0.0	0	0.0	0	0.0
Very unlikely	1	1.3	1	1.9	0	0.0	0	0.0
No, but would consider for future	10	12.5	9	17.3	0	0.0	0	0.0
Vaccine hesitancy								
Reason for non-vaccination								
Waiting until no longer pregnant	28	35.0	20	38.5	0	0.0	0	0.0
I am waiting until I am not breastfeeding	31	38.8	21	40.4	1	50.0	0	0.0
Healthcare worker said I could not	6	7.5	2	3.8	0	0.0	1	100.0
Family said I could not	8	10.0	3	5.8	0	0.0	0	0.0
I am scared	1	1.3	2	3.8	1	50.0	0	0.0
Other	6	7.5	4	7.7	0	0.0	0	0.0
Vaccine communication								
Recent communication with friends/family re-COVID-19 vaccine								
No	148	30.6	132	38.0	38	31.4	37	44.0
Yes	287	59.4	193	55.6	72	59.5	37	44.0
Not sure	48	9.9	22	6.3	11	9.1	10	11.9

*If vaccinated 1–2 doses.
†If unvaccinated.

and 17.0% postintervention). Major reasons for non-vaccination included wanting to wait until no longer pregnant or breast feeding. Over half of unvaccinated participants indicated they would be very likely to get the COVID-19 vaccination if offered to them at no cost (52.4% preintervention and 58.5% postintervention). No differences were identified in the proportion of unvaccinated

Table 5 COVID-19 vaccination over study time, overall and by pregnancy/breastfeeding status

	Preintervention	Postintervention	1 or more vaccine doses			2 vaccine doses		
	N	N	OR	95% CI	P value	OR	95% CI	P value
All participants	609	434	1.15	(0.99 to 1.36)	0.064	1.20	(1.09 to 1.34)	<0.001
Pregnant	127	108	1.31	(1.12 to 1.53)	0.001	1.11	(0.98 to 1.28)	0.097
Breast feeding	361	242	1.08	(0.80 to 1.46)	0.604	1.32	(1.13 to 1.55)	0.001
Neither pregnant nor breast feeding	121	84	1.30	(0.13 to 15.53)	0.785	0.80	(0.40 to 1.58)	0.518

individuals who sought vaccination or in intention to be vaccinated from preintervention to postintervention (not shown).

DISCUSSION

Our study found that a basic menu-based chatbot providing evidence-based guidance on COVID-19 vaccination deployed over WhatsApp to pregnant and breastfeeding women in semiurban north India was feasible to implement and acceptable to this population. Chatbots may be a promising health education modality for pregnant and breastfeeding Indian women and their families, complementing India's efforts to improve maternal health,[44–46] and our study findings contribute to the developing evidence base on chatbot user experience and utility.[47]

Observed chatbot engagement was consistent with Saheli's basic structure, straightforward educational goals, and study population characteristics (eg, 60% breast feeding). Our team's prioritisation of simplicity in design and messaging could have been responsible for most users only interacting with the chatbot for 1 day, which would be consistent with the high satisfaction reported; however, it is possible that other factors may have influenced this finding and further elucidation of this pattern of low use with high satisfaction would be informative. Greater engagement among more frequent SWACH WhatsApp group participants likely reflects self-selection based on digital literacy or greater exposure to group reminders, both important for future consideration. In particular, the optimal frequency of chatbot reminders remains an outstanding question; our team's twice-daily chatbot reminders could be unfeasible or undesirable in a real-world situation, though this delivery strategy did not result in reduced broader WhatsApp group engagement among participants. Sharing of Saheli with friends and family outside of the group signalled user trust and reiterated educational need. Our participants' chatbot use to access COVID-19 vaccination information and as a means of asking other health-related questions via submitted text suggests chatbots could have broader value to this population if expanded to include other topics.

Attributing community impact of Saheli is challenging due to our study design, high COVID-19 vaccination among community survey respondents, high chatbot use among both vaccinated and unvaccinated, temporal trends in COVID-19 vaccination and other contextual efforts to increase COVID-19 vaccine education and access. Despite observing significant increases in COVID-19 vaccination over time among pregnant (one dose or more) and breastfeeding (full vaccination) participants, these increases cannot be attributable to Saheli exposure. Interpreting chatbot community impact must acknowledge the constellation of multilevel interventions, community and pandemic factors co-occurring during this time (figure 1).

The high acceptability of Saheli identified in our study suggests that educational modalities using chatbots have high scalability potential, but logistics must be carefully considered. Some feasibility and acceptability of our chatbot implementation was likely due to increasing smartphone ownership[35 36] and broad familiarity with WhatsApp,[48 49] the delivery platform for our chatbot, likely facilitating use and trust for using our chatbot. Basic menu-based chatbots can be relatively inexpensive to develop and deploy and can use pre-existing software structures for rapid contextual and topical adaptation. Chatbots employing natural language processing, versus our simple menu-based format, can provide better user-chatbot communication yet require significant data inputs and functionality is limited by language. Chatbot engagement is participant led and requires linkage through a trusted source.[50] Saheli was deployed within pre-existing WhatsApp educational groups led by a trusted community partner, which may not be broadly replicable. More research on optimal channels for health education chatbot deployment for population engagement is needed, including the identification of long-term hosts for iteration and deployment costs. NGOs, for example, could be involved to design localised relevant content for ongoing chatbot integration. They could also encourage chatbot adoption in the community.

Optimising digital health interventions requires a deep understanding of the social context, including gender and social norms, for increasing health equity.[51] Chatbot engagement requires literacy, including digital literacy and smart phone access, which are patterned by gender in low-income and middle-income country contexts.[52] Our team's formative research identified social norms around household decision-making and differential mobility based on gender or household status influenced vaccination among pregnant and breastfeeding women, which need to be considered.[24] Designed appropriately, digital health interventions may successfully reach underserved populations who traditionally experience worse access to healthcare and social services, improving health information equity and informed health decision-making.

Strengths of our study include our community-based evaluation, which may have better evaluated impact of our chatbot intervention through incorporating both the direct and indirect influences of targeted health education through individual education and dissemination through community social networks.[53] We also explicitly focused on evaluating acceptability and characteristics of chatbot user experience, which have been relatively less focused on in this literature.[47] Limitations to the research included our pre–post design which excluded a control group, resulting in our inability to distinguish chatbot-specific impacts distinctly from the many other co-occurring influences (eg, other educational interventions, community social norms and the course of the pandemic). We

were also unable to gain a nuanced understanding of factors responsible for our combination of low usage but high reported satisfaction. This pattern could be explained both by our simple design and information or by response bias. Finally, we did not explicitly assess participant perspectives of trust and privacy concerns with chatbot use, which will have important implications for scalability.[54]

CONCLUSION

Chatbot approaches can efficiently disseminate information population-wise, including those with specific health education needs. With high adaptability and scalability potential, consideration of deployment strategies and topics is key. Our chatbot created opportunities for women to access relevant and desired health information in a private, safe space. It also helped to arm them with the knowledge they needed for informed health conversations with other household decision-makers. Adaptations to incorporate other desired health education topics should be explored, especially with women of childbearing age.

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