BMJ Open Effectiveness of SMS-based interventions in enhancing antenatal care in developing countries: a systematic review

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ABSTRACT

Objectives Pregnant women in low- and middleincome countries (LMICs), including Mali, often face challenges such as limited access to comprehensive health information and services. Mobile health (mHealth) interventions, particularly SMS-based interventions, have shown promise in addressing maternal health challenges. This review aims to provide an overview of existing SMSbased antenatal care (ANC) applications and assess their effectiveness in improving maternal and child health outcomes

Design A systematic literature review was conducted based on updated PRISMA 2020 guidelines.

Data sources PubMed, Scopus, Web of Science, Cochrane Library, Association for Information Systems eLibrary, Direct Science and Google Scholar were searched through 25 March 2024.

Eligibility criteria Studies that focused on SMS-based interventions designed to improve ANC information and attendance, published in English or French, conducted in LMICs and published between 2014 and 2024 were included. Exclusion criteria eliminated studies that did not report primary outcomes or did not directly involve SMSbased interventions for ANC.

Data extraction and synthesis Relevant data were systematically extracted, including study characteristics. intervention details, and outcome measures. The risk of bias was assessed using the Cochrane Risk of Bias tool for randomised trials (RoB 2), the Risk Of Bias In Nonrandomised Studies-of Interventions (ROBINS-I) and the Checklist for Reporting the Development and Evaluation of Complex Interventions in Healthcare (CReDECI), depending on the study design. A subgroup analysis was performed to explore variations in outcomes by region and study design. **Results** The review identified a range of SMS-based interventions (n=12) that differed in target audience, message frequency (weekly, pregnancy stage-oriented) and content (reminders (91.7% of cases, 11/12), educational (75%) and danger signs (16.7%)). Regional analysis highlighted significant research activity in East Africa but with mixed significance levels. The study design analysis revealed that randomised controlled trials yielded the most significant results, with five of eight studies showing full significance, whereas quasiexperimental studies demonstrated consistent but less frequent effectiveness. Implementation tools varied from SMS gateways to custom applications and third-party

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correlate with maternal mortality in sub-Saharan Africa.² Poor antenatal and maternal health awareness among pregnant women contributes to inadequate health behaviours and care-seeking, causing avoidable morbidity and mortality.

ANC is a critical component of maternal healthcare that aims to monitor and enhance the health outcomes of pregnant women and their unborn children. Regular ANC visits enable healthcare providers to detect and manage potential health problems, educate women about pregnancy and childbirth and advocate for healthy behaviours that benefit both the mother and the child.^{3–5} Despite the global recognition of ANC's importance, significant challenges persist in ensuring comprehensive care for all pregnant women, particularly in low- and middle-income countries (LMICs). Studies have shown that maternal education, household income and cultural beliefs significantly affect the utilisation of ANC services, with disparities in access and use across different socioeconomic and demographic groups.⁵⁶ Addressing these challenges requires targeted interventions to improve the access, awareness and affordability of ANC services for pregnant women in these regions.

The rapid growth of mobile technology has led to innovative ways of increasing healthcare access and engaging patients. SMS-based systems have become vital for closing information gaps and boosting engagement with ANC services. These applications offer a platform for delivering timely, relevant information directly to the mobile phones of pregnant women, thus increasing awareness of the importance of ANC, reminding women of their upcoming appointments and providing crucial health-related guidance.⁷⁻¹² Studies have demonstrated the potential of mobile health (mHealth) interventions to monitor prenatal care among pregnant women in LMICs¹³ and have evaluated the effectiveness of SMS on focused ANC visits and skilled birth attendance in such settings.⁷

For instance, a meta-analysis found that mHealth interventions improved the uptake of four or more ANC visits among pregnant women in LMICs, with both one-way and two-way communication methods showing positive effects.¹⁴ SMS support during pregnancy was also associated with a decreased risk of perinatal death compared with routine prenatal care in one study.¹⁵ Interestingly, while SMS interventions generally improved ANC utilisation, their impact varied across contexts. In settings where facility delivery rates were already high, SMS interventions showed unclear effects. However, in areas with lower facility delivery rates, these interventions significantly increase facility-based deliveries.¹⁴

Despite rapid advancements in mobile health technologies, basic SMS remains a cornerstone in regions where limited internet access and low smartphone penetration hinder the adoption of complex systems. This review addresses the utility and effectiveness of SMS-based interventions in settings in which basic utilities such as electricity or the internet may be unreliable. By exploring

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Identification of new studies via databases and registers



Figure 1 Flow diagram of the search.

were conducted to ensure the inclusion of the most up-todate and relevant literature.

Search strategy

The formulated research questions guided the construction of the search strings, leading to their combination through logical connectors. The resulting string was [("SMS-based applications" OR "text messaging" OR "mobile health" OR "mHealth") AND ("antenatal care" OR "prenatal care" OR "pregnancy care" OR "ANC") AND ("developing countries" OR "low-income countries" OR "resource-limited settings")]. This process was adapted according to the requirements of each electronic database. Science Direct, for example, did not accept more than eight logical connectors in a single search. The author translated the search string into French by combining words and expressions used in the English search. The resulting string was ("applications basées sur SMS" OU "messagerie texte" OU "santé mobile" OU "mSanté") ET ("soins prénatals" OU "soins anténataux" OU "soins pendant la grossesse" OU "CPN") ET ("pays en développement" OU "pays à faible revenu" OU "contextes à ressources limitées"). The process used for searching and selecting different publications is summarised in a Diagram Flow and presented in figure 1. The flow diagram of the search

was created using the R-developed online tool by Haddaway *et al.*¹⁹ Online supplemental eTable 1 summarises the full search strategy, and online supplemental eTable 2 details the results per database.

Selection criteria

Initially, 776 publications were found, as detailed in **G** online supplemental eTable 2. Additional inclusion and exclusion criteria were applied to shift the initial findings to pinpoint studies pertinent to our goals. Consequently, these publications underwent a rigorous screening process based on the inclusion and exclusion criteria. These criteria were defined to ensure the relevance and quality of the analysed data. The study design criteria included randomised controlled trials (RCTs), quasi-experimental, observational and qualitative studies that provided data on the implementation, usage and outcomes of SMS-based ANC interventions. Editorials, reviews, opinion pieces and studies lacking primary data or clear outcomes related to ANC and SMS-based interventions were excluded.

The population criteria focused on studies involving pregnant women in LMICs encompassing women of all ages, ethnicities and stages of pregnancy. For the intervention criteria, the studies needed to focus on SMS-based systems designed to improve ANC information and attendance. These included interventions promoting health education, appointment reminders, health monitoring and support through text messaging. Studies that did not specifically use SMS-based communication as the primary method for delivering ANC information or support were excluded. Criteria such as comparators, outcomes, publication dates and languages were also used. Online supplemental eTable 3 provides a detailed description of the inclusion and exclusion criteria, along with the rationale for each criterion. In the subsequent phase, the process involved verifying the presence of duplicate papers given that multiple databases were used for the search. This resulted in identifying and removing 11 duplicate documents from the dataset. Full texts of papers were then retrieved and checked. Following this meticulous selection phase, a final count of 12 papers was deemed appropriate and suitable for review (figure 1).

Data extraction

After completing the selection process, we extracted information from the selected papers. The study identification items included author names, paper title, journal, publication year, study design type and the country where the study was conducted. Details regarding the study participants were also extracted, including an accurate description of the study population, sample size and primary inclusion and exclusion criteria. Information on the intervention details extracted includes a description and purpose of the SMS-based application as presented in the paper, the content of messages, frequency of sending, resources and tools for implementation and intervention duration. Additionally, control or comparator interventions were retrieved as reported, if applicable. The reported outcomes (primary and secondary) were then extracted. Key findings related to the indicated outcomes, statistical significance where applicable and any reported limitations were also extracted. The complete data extraction form is provided in online supplemental eTable 4.

Tools and analysis

The data set was managed using the open-source desktopbased application Mendeley version 1.19.8. The extracted items were stored and used to generate descriptive statistics using JabRef (version 5.13), Microsoft 365 Excel (version 2403) and IBM SPSS Statistics 20.

Patient and public involvement None.

Data characteristics

A bibliometric overview of the selected papers is described in table 1. Each paper was assigned a numerical identifier and categorised according to the year of publication, from oldest to most recent and by source.

Risk-of-bias assessment

In this study, the dataset comprised 12 scholarly articles. Each article was evaluated for potential bias, with assessment criteria varying according to the study design. Three distinct tools were used to conduct this assessment: version 2 of the Cochrane Risk-of-Bias tool for randomised trials (RoB 2)²⁰ was applied to eight studies, the Risk Of Bias In Non-randomised Studies-of Interventions (ROBINS-I) tool²¹ to three studies and the Checklist for Reporting the Development and Evaluation of Complex Interventions in Healthcare²² were conveniently used for one study. Visual representations of the assessments, including craffic light plots (see online supplemental eFigure 1,2) and summary plots (see online online supplemental eFigures 3,4), were created for the two groups (RoB two and 8 pyright, ROBINS-I). Refer to online supplemental eFigures 5 to the assess the study using the checklist. These plots were generated using the Risk Of Bias VISualisation tool.²³ The including overall risk assessment for the papers was categorised as 'some concerns'. Consequently, we did not exclude any of the documents included due to the absence of many significant high/critical issues with individual papers. for uses related

RESULTS

SMS app inventory (RQ1) **Overview of apps**

The dataset consists of 12 applications. These ranged from basic, one-way SMS-sending apps to more complex, bidirectional communication platforms that connect pregnant women with healthcare providers throughout and sometimes beyond the pregnancy period. Table 2 provides an overview of the identified apps and offers details on each app's target population, key features and study design employed to evaluate its effectiveness. App names are given where the authors gave specific names to ≥ their developed apps.

Detailed app descriptions

training, and This subsection comprehensively describes each application based on extracted data. Essential intervention similar technolog details, such as message content, sending frequencies and the development tools used (see table 3), are provided.

Effectiveness Evidence (RQ2)

Overview of studies

Among the 12 studies, six primary outcomes were identified and further classified into effectiveness and safety $\overline{\mathbf{g}}$ domains, as well as primary and secondary categories. Primary effectiveness outcomes included improved attendance (n=9) and skilled delivery attendance (n=4). The primary safety outcomes included a reduction in neonatal mortality (n=1) and reduced complications (n=1). Secondary effectiveness outcomes included increased knowledge (n=3) and patient satisfaction (n=1). Online supplemental eTable 5 provides a detailed breakdown of these outcomes categorised by study design.

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ID	Author(s)	Title	Journal/Conf	Country (region)	Year	Source
01	Lund <i>et al</i> ¹²	Mobile Phone Intervention Reduces Perinatal Mortality in Zanzibar: Secondary Outcomes of a Cluster Randomized Controlled Trial	JMIR mHealth and uHealth	Tanzania (Zanzibar)	2014	PubMed
02	Masoi & Kibusi ⁹	Improving pregnant women's knowledge on danger signs and birth preparedness practices using an interactive mobile messaging alert system in Dodoma region, Tanzania: a controlled quasi- experimental study	Reproductive Health	Tanzania (Dodoma)	2019	
03	Nuhu <i>et al⁸</i>	Impact of mobile health on maternal and child health service utilization and continuum of care in Northern Ghana	Scientific Reports Ghana		2023	
04	Alhaidari <i>et al²⁷</i>	Feasibility and acceptability of text messaging to support antenatal healthcare in Iraqi pregnant women: A pilot study.	Journal of Perinatal Medicine	Iraq	2018	Scopus
05	Ronen <i>et al</i> ¹⁰	Evaluation of a two-way SMS messaging strategy to reduce neonatal mortality: rationale, design and methods of the Mobile WACh NEO randomised controlled trial in Kenya.	BMJ Open	Kenya	2021	AISeL
06	Batool <i>et al⁸³</i>	Maternal complications: Nuances in mobile interventions for maternal health in urban Pakistan	Proceedings of the Ninth International Conference on Information and Communication Technologies and Development	Pakistan	2017	Google Scholar
07	Atnafu <i>et al²⁸</i>	The role of mHealth intervention on maternal and child health service delivery: findings from a randomized controlled field trial in rural Ethiopia	mHealth	Ethiopia	2017	
08	Omole et al ³¹	The effect of mobile phone short message service on maternal health in south-west Nigeria	The International Journal of Health Planning and Management	Nigeria	2018	
09	Thompson <i>et al³²</i>	Connecting mothers to care: Effectiveness and scale-up of an mHealth program in Timor-Leste.	Journal of Global Health	Timor-Leste	2019	
10	Muhoza <i>et al</i> ²⁴	A mobile-based technology to improve male involvement in antenatal care.	Kabale University Interdisciplinary Research Journal	Uganda	2022	
11	Oliveira-Ciabati et al ³⁴	SISPRENACEL - MHealth tool to empower PRENACEL strategy.	Procedia Computer Science	Brazil	2017	Science Direct
12	Kawakatsu <i>et al³⁵</i>	Cost-effectiveness of SMS appointment reminders in increasing vaccination uptake in Lagos, Nigeria: A multi- centered randomised controlled trial	Vaccine	Nigeria	2020	
Re (incl ners ² remi cases dang them	egarding the mean buding women a 24), the key ther inders (observed s), educational co ger alerts (16.7% hes (66.7% of cas	ssage content sent to participan nd, in one case, their male par nes revolved around appointmer in 11 studies, representing 91.7% of ntent (75% of cases), emergency of of cases) and combinations of thes es).Online supplemental eFigure	ts frequency varied b week during the first trimester and three variations were no or that used weekly SN from delivery to 2 6 in apps using varied	by pregnancy stages st trimester, two per per week in the t ted in eight stud MS during certain weeks postpartum I frequencies was	e: one hird trir lies, inc phases . ¹⁰ A co a system	message in the see nester. T luding s or daily mmon t natic inc

Regarding the message content sent to participants (including women and, in one case, their male partners²⁴), the key themes revolved around appointment reminders (observed in 11 studies, representing 91.7% of cases), educational content (75% of cases), emergency or danger alerts (16.7% of cases) and combinations of these themes (66.7% of cases).Online supplemental eFigure 6 illustrates the frequency of SMS content types across the different apps. For the detailed content types per study, please refer to table 3.

The SMS-sending frequency was consistent across the studies. In five studies, messages were sent weekly, while in other cases, the frequency was adjusted according to the pregnancy stage or specific contextual timing. For instance, in the setup described by Masoi and Kibusi,⁹ the in apps using varied frequencies was a systematic increase in message intervals as the delivery date approached. Table 2 provides detailed information on each application. The intervention durations varied, with some lasting less than 3 months (16.7%), others ranging from 3 to 6 months (16.7%), some spanning 6 to 12 months (41.7%)and three studies exceeding 12 months (25%).

The breakdown of development tools or approaches for app implementation is as follows. An SMS gateway

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Table 2 Overview of apps						
App name	Country (region)	Target population	Ke	ey features	Study design	
The Wired Mothers	Tanzania (Zanzibar)	Pregnant women attending ANC at 24 primary healthcare facilities across six districts on the island of Unguja	•	Unidirectional text messaging A mobile phone voucher system for two-way communication between pregnant women and their primary healthcare providers.	Pragmatic, cluster RCT	
N/A	Tanzania (Dodoma)	Pregnant women	•	Provide simple health education (obstetric danger signs, newborn danger signs, individual birth preparedness, complication readiness) Engage expecting parents (mother and father) with essential health information. Two-way communication	A quasi-experimental study with a control group is characterised explicitly as a 'pre- and post-test with a control group'.	
T4MCH	Ghana	Pregnant women	•	Automated messaging (SMS/voice messages)	Standard guidelines for reporting quasi-experimental studies using the Transparent Reporting of Evaluations with Non-randomised Design/Quasi-Experimental Study Design (TREND)	
N/A	Iraq	Pregnant women attending an antenatal clinic linked to Al Elwiya Maternity Teaching Hospital		Automated SMS	Controlled experimental study	
Mobile WACh NEO system	Kenya	Pregnant women were recruited from four different facilities in Kenya.		Two-way communication Automated messaging Support for multiple languages Response management Participant tracking Cost-free for participants	RCT	
N/A	Pakistan	Pregnant women enrolled in the trial conducted at Female Willingdon Hospital in Lahore	• • •	Multi-modal communication (SMS and automated voices) Automated delivery Data tracking	RCT	
Customised FrontLineSMS	Ethiopia	Women aged 15–49 years who had at least one child		Automated messaging Data exchange between CHW and CHW Contraceptive stock management	Community-based RCT	
Maternal Health Plus	Nigeria	Pregnant women attending ANC within the Ife-Ijesa zone.		Automatic delivery of SMS Two-way communication Database management Language preference	RCT	
Liga Inan	Timor-Leste	Women aged 15–49 years with a child up to 24 months of age.		Web-based platform connected to a GSM Automatic delivery of SMS Voice communication	Quasi-experimental design.	
N/A	Uganda	Pregnant women and their partners		Cloud-based platform Monitoring ANC-seeking behaviour Automatic delivery of SMS	Pragmatic randomised trial	
SISPRENACEL	Brazil	Pregnant women	* * * * *	Automatic delivery of SMS Two-way communication Individualised interaction management (chat-like format) Researcher access Private cloud deployment	A socio-technical approach using the prototype method.	

Continued

Table 2 Continued	d				
App name	Country (region)	Target population	Key features	Study design	
N/A	Nigeria	Pregnant women	 Automatic delivery of SMS Customisation (depending on the type of health service) Cloud server Unique QR code for each user 	Multi-centred RCT	
ANC, antenatal care; CHW, community health worker; GSM, Global System for Mobile Communications; N/A, Not Available; RCT, randomised controlled trial.					

(26.67% usage rate among evaluated apps) facilitates the efficient delivery and receipt of text messages, making it suitable for large-scale messaging campaigns due to its simplicity.²⁵ Custom apps (36.67%) provide personalised features like interactive messaging and data analytics, demanding substantial development resources while offering significant customisation. Third-party platforms (16.67%) are pre-built solutions with scheduling and often analytics features but may lack the flexibility of custom apps. A combined approach (20% usage rate) combines the strengths of multiple tools, such as using a custom app for analytics along with an SMS gateway or a third-party platform for messaging, allowing for simplicity, customisation and scalability tailored to various SMS interventions.²⁶ The specific names and/or platforms used by each app (when provided in the article corpus) are listed in table 2.

Study findings

Unsurprisingly, all studies highlighted the significant impact of SMS-based interventions on maternal healthcare. Lund *et al*¹² discovered a substantial rise in ANC attendance, with women adhering to the WHO recommendations for four or more visits. The same has been observed in other studies.⁸ ²⁴ ²⁷ ²⁸ Moreover, they¹² observed an increase in skilled delivery attendance among urban women, with an OR of 5.73 (95% CI: 1.51 to 21.81). Notably, it significantly reduced perinatal mortality, with an OR of 0.50 (95% CI: 0.27 to 0.93). Ronen et al,¹⁰ in the pilot phase²⁹ of their ongoing randomised controlled study (Mobile WACh NEO RCT), identified that among women residing in areas with elevated rates of stillbirth, perinatal and infant mortality, increasing maternal age was the sole predictor of stillbirth. It is essential to highlight that although we included their main study in our dataset, the results have not yet been compiled and published as of the writing of this paper. The trial concluded with participant enrolment (5020 participants) on 30 June 2022, and follow-up was scheduled to continue until February 2023.³⁰ Consequently, we relied on the pilot-phase results.²⁹ Table 4 shows the different studies along with the effect sizes and statistical significance of their primary outcomes, as reported in the content of the papers.

Subgroup analysis

Protected by copyright, includ Subgroup analysis explored the distribution and outcomes of the interventions across regions, study designs and intervention types, providing a better understanding of the factors influencing their effectiveness.

Regional distribution and significance

Regional distribution analysis revealed notable differences in the number of studies, outcomes and study-level significance across global regions. Five studies were conducted in East Africa (Ethiopia, Kenya, Tanzania and Uganda). Of these studies, four reported outcomes that were statistically significant, 9 12 24 28 and one did not indicate significance (pilot).²⁹ This highlights the region's robust research activity. Three studies in West Africa (Ghana and Nigeria) emphasised the effectiveness of interventions in this region.^{8 31} Asia (Pakistan and Timor-Leste), tex the Middle East (Iraq), and South America (Brazil) are tand underrepresented with only one study per country.

Impact of study designs

data mi RCTs dominated the dataset, with eight studies spanning East and West Africa and Asia. Of these, five demonstrated all outcomes as significant, while two reported partial significance (see online supplemental eTable 6). This reflects the robustness of the RCT design in yielding significant findings, although with some variations. Quasiexperimental studies, the second most common design, include three studies from Ghana, Tanzania and Timor-Leste. Two of these achieved full significance, while one fell under the 'not applicable' category. A sociotechnical approach using a prototype method is less common, as represented by a single study. It reports fully significant technologies outcomes, indicating potential but limited generalisability due to their low frequency.

Effectiveness of intervention types

The intervention-type analysis revealed critical trends in the study's effectiveness and applicability. Mixed interventions (educational and reminders) are the most prevalent, with six studies across diverse regions including Africa, Asia and the Middle East. Among these, five reported full significance, while one indicated partial significance. Educational messages, implemented in Brazil, Kenya and Tanzania, are associated with three studies, of which two demonstrated significant outcomes and one was

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Table 3 Detailed app descriptions				
Study ID	Content of messages	Frequency	Tools/resources employed for implementation	Duration of the intervention
01	Health education on danger signs in pregnancy, the importance of skilled delivery attendance and reminders for upcoming antenatal care (ANC) visits.	The frequency of the messages varied throughout the pregnancy, with an increase in frequency to weekly messages during the last 4 weeks before delivery.	Specific software name or platforms used for development is not mentioned.	The study followed the women until 42 days post-delivery to assess the impact of the mobile phone intervention on perinatal outcomes.
02	Obstetric and newborn danger signs and birth preparedness and complication readiness.	First trimester: one message per week. Second trimester: two messages per week. Third trimester: three messages per week.	Specific software name or platform used for development is not mentioned	From the initial ANC visit until the point of delivery
03	The messages include the importance of regular ANC visits, the benefits of facility- based deliveries, and the necessity of postnatal care.	Weekly	Savana signatures: design and execution of the project; Salasan Inc: technological framework; Mustimuhw Information Solutions: software solutions	1 August 2017 to 30 September 2017.
04	General health messages, Reminders to visit PHCC, Nutritional advice, Lifestyle education.	Weekly, every Friday between 4 PM and 6 PM	forat-sms.com: bulk messaging platform	Not specified
05	Critical information on pregnancy, birth planning, infant care, and emergency responses	From delivery to 2 weeks postpartum, mothers get two daily messages to bolster care practices and offer continuous support.	Detailed in another paper ³⁷	From enrolment at 28–36 weeks of gestation until 6 weeks postpartum
06	Information about prenatal care, reminders for ultrasound tests, encouragement to follow medical advice and attend scheduled appointments.	It is not specified, but it is mentioned that the app could manage diverse messaging needs across distinct stages of pregnancy.	SMS Service Provider: API SMSAII.pk Telephony software: for automated calls, Asterisk was used, coupled with a Primary Rate Interface (PRI) line to manage multiple concurrent calls.	2 months
07	ANC reminders and Child immunisation	Health extension workers (HEWs) received ANC appointment reminders at gestational weeks 14, 24, 30 and 36. Vaccination appointment reminders were sent at 6, 10 and 14 weeks, and 9 months. HEWs then sent a reminder 1 week prior to monthly vaccinations.	Mobile phones equipped with customised FrontLineSMS and Central server and Local network and Short-code System and GSM Modem subscription	September 2012 to October 2013: 13 months
08	Clinic reminders, specific pregnancy-related health tips, general tips	Delivered periodically, based on the ANC appointment schedule of each participant.	Mobile devices, SMS Enabler version 2.5.5, A MySQL database	December 2013 to December 2014
09	Reminders for care-seeking and promoted safe pregnancy and delivery practices.	Messages were sent twice weekly, precisely every Monday and Thursday.	Mobile devices, web-based applications connected to a GSM gateway	2 years
10	Appointment reminders	Weekly	A cloud-based platform, AfricasTalking API.	9 months
11	Information on ANC, pregnancy, and delivery topics.	Not specified but likely according to pregnancy stages.	Client-server architecture, CakePHP and MySQL for data storage, AdminLTE version 1.0 for GUI.	April 2015 to May 2016
12	Visit reminder messages.	SMS text reminder 2 days before their scheduled appointments. If clients did not attend their appointments, an additional reminder was sent 7 days after the original appointment date as a defaulter tracing measure.	Mobile application linked to a cloud server, with a unique QR code for each user.	first April to 30th June 2019

Table 4 Effectiveness evidence						
Study	Main outcomes and significance	Conclusion				
12	Significant effect on antenatal care (ANC) attendance, with an OR of 2.39 and a 95% CI of 1.03 to 5.55. Increased skilled delivery attendance among urban women, with an OR of 5.73 and a 95% CI of 1.51 to 21.81. Significant reduction in perinatal mortality with the mobile phone intervention, with an OR of 0.50 and a 95% CI of 0.27 to 0.93.	The study illustrates that the mobile phone intervention effectively improved critical maternal health outcomes and significantly reduced perinatal mortality.				
9	Significant increase in knowledge about obstetric and newborn danger signs (large effect size 85%). Higher scores in birth preparedness and complication readiness (effect size of 90%).	The significant effect sizes in both primary outcomes suggest that the intervention had a robust impact on the participants.				
8	Increased ANC attendance, with an average treatment effect (ATE) of about 18%. Increase in the number of women opting for facility-based delivery (14%). PNC attendance also increased with the intervention (27%).	The results underscore the intervention's positive effect on maternal health, notably increasing attendance and utilisation of essential maternal and child health services.				
27	Over 85% of the participants in the intervention group expressed satisfaction with the SMS-based support. Statistically significant increase in the median number of ANC visits compared.	The intervention significantly increased engagement in ANC, and positive feedback was received from participants regarding satisfaction.				
29	The stillbirth rate observed was sixteen per 1000 pregnancies. There were 17 neonatal deaths during the study period, leading to a neonatal mortality rate of 22 per 1000 live births. The perinatal death rate (including stillbirths and neonatal deaths up to 6 days of age) was 36 per 1000 pregnancies.	This pilot phase identified that among women residing in areas with elevated rates of stillbirth, perinatal and infant mortality, increasing maternal age was the sole predictor of stillbirth.				
33	Significant improvements in knowledge about pregnancy and childbirth. No significant difference in the number of follow-up visits among the groups.	The study revealed substantial knowledge gains about pregnancy among participants, but the effect of increasing follow-up visits remained ambiguous due to social norms and logistical challenges.				
28	Significant increase in the proportion of mothers attending more than four ANC visits in the intervention. Ezha (treatment 1): increased from 45.32% to 59.84%; Abeshge (treatment 2): increased from 15.8% to 31.5% ; Sodo (control): decreased from 24.48% to 23.27% ; P value: p<0.001 for Ezha and Abeshge. There was a significant increase in deliveries attended by skilled health workers in the intervention areas Ezha (treatment 1): increased from 26.79% to 55.23%; Abeshge (treatment 2): Increased from 41.96% to 63.54% ; Sodo (control): Increased from 21.79% to 52.05%. p<0.001 in Ezha, indicating robust improvement.	These findings highlight the improvements in healthcare services delivered to mothers and children due to the mobile intervention, with the most significant impact seen inANC attendance and skilled deliveries. However, limitations in the intervention's effectiveness were noted in contraceptive utilisation and immunisation coverage.				
31	There was a significant increase in the proportion of facility-based deliveries among the intervention (29%) and control groups (13%). 96.6% of participants in the intervention group expressed support for the SMS intervention as a platform for maternal health promotion.	The intervention significantly improved maternal health behaviour by increasing the rate of facility-based deliveries among pregnant women.				
32	No significant increase in the number of women receiving four or more ANC visits ($OR=1.0$ (95% CI: 0.54 to 0.9)). Significant increase in the likelihood of women having a skilled birth attendant present during delivery ($OR=1.9$ (95% CI: 1.1 to 3.2)). Significant increase in the likelihood of women delivering in a health facility ($OR=1.9$ (95% CI: 1.1 to 3.6)).	The Liga Inan programme significantly improved skilled birth attendance, facility deliveries, postpartum care and newborn health checks, though it did not notably affect ANC visits.				
24	Increase in male involvement in ANC with a 50% adherence rate among male partners, meaning 10 out of the 20 male partners attended four consecutive antenatal visits. Improved ANC-seeking behaviour among pregnant mothers.	The results suggest that SMS-based interventions can positively impact male participation in ANC and improve pregnant mothers' attendance rates.				
34	The system received a high overall score of 6.33 out of 7 in usability, with the highest scores in system usefulness (6.61) and the lowest in information quality (6.03). High engagement with 22296 scheduled SMS delivered, received 1249 messages from participants and 1823 SMS inquiries answered. The system could be adapted for national-level deployment	These results underscore the app's effectiveness in achieving high user satisfaction and engagement and the potential for broader application in maternal health interventions.				
35	Significant increase in the return rate for child vaccinations in the intervention group (4.8% to 6.0% higher return rate). No significant differences were observed in the return rates for ANC and family planning services between the intervention and control groups (adjusted ORs close to 1)	The results indicate that SMS reminders can enhance adherence to vaccination schedules, though their effectiveness may differ across health services, likely influenced by recipients' perceived urgency or importance of the service. ³⁵				

categorised as 'not applicable'. Reminders applied in Ethiopia, Nigeria and Uganda show similar proportions, with two studies achieving full significance and one partial significance (refer to online supplemental eFigure 7).

DISCUSSION

The findings underscore the potential of SMS-based interventions to enhance ANC attendance, maternal health knowledge and service utilisation in LMICs. Across the studies reviewed, SMS interventions demonstrated varying degrees of effectiveness (see table 4), reflecting diversity in implementation approaches, population contexts and healthcare systems.

Studies^{12 28} highlighted substantial improvements in ANC attendance and skilled delivery rates, with ORs and effect sizes indicating robust effects. These findings suggest that SMS reminders and educational messages can effectively address common barriers to maternal healthcare, such as a lack of awareness or forgetfulness. However, the mixed outcomes observed in some studies, such as³² who reported a limited impact on ANC visits despite significant improvements in skilled delivery and facility-based births, indicate the need for context-specific tailoring of message content and delivery frequency.

The review highlights the strong influence of SMSbased interventions on maternal health knowledge and birth preparedness. For instance, Masoi and Kibusi⁹ reported large effect sizes in knowledge about obstetric and newborn danger signs, while Batool *et al*^{β 3} emphasised knowledge gains despite the limited impact on follow-up visits. Effective interventions appear to combine timely reminders with actionable health education, reinforcing preparedness and engagement. Participant satisfaction was consistently high across studies such as Alhaidari et al^{27} and Oliveira-Ciabati *et al*,³⁴ where users expressed positive feedback about the usability and relevance of SMS interventions. High engagement levels, including two-way communication and interactive features, were associated with better adherence to health recommendations. These results suggest that user-centred design and feedback mechanisms are critical to the success and sustainability of SMS interventions. However, interactive features in some cases might not be ideal in low-resource settings as it implies the use of advanced technologies (smartphones) that are not necessarily accessible to the targeted women.

Our subgroup analysis revealed regional, methodological and intervention-type variations in the effectiveness of the SMS-based ANC interventions. East Africa had the highest research activity, with most studies reporting statistically significant outcomes, whereas other regions, including West Africa, Asia, the Middle East and South America, were underrepresented. RCTs demonstrated the strongest evidence. Mixed interventions combining educational messages and reminders were the most effective, highlighting the importance of multifaceted approaches over stand-alone reminders or educational

messages. These findings emphasise the need for further research in underrepresented regions and deeper exploration of intervention strategies to optimise SMS-based maternal health programmes.

Despite these positive findings, this review also revealed limitations in the effectiveness of SMS interventions. For instance, Kawakatsu *et al^{\beta 5}* reported variability in effectiveness across different health services, such as higher adherence to vaccination schedules but no significant improvement in ANC or family planning return rates. Others³³ have identified logistical barriers and social norms as factors that limit follow-up visits. These mixed outcomes emphasise the need for comprehensive programme designs that account for broader systemic **Z** and sociocultural factors influencing maternal health 8 behaviours.

Moreover, based on our risk assessment, most studies were categorised as having 'some concerns', with no studies excluded because of critical methodological flaws. While this suggests a moderate level of reliability, certain biases may still affect the interpretation of the results. For example, it¹² exhibited high bias in two domains (D2: bias due to deviations from intended intervention and D4: bias in the measurement of outcomes), which may impact the validity of its reported reduction in perinatal mortality and maternal health improvements. Similarly, Muhoza et al^{24} had a high D2, suggesting potential concerns regarding deviations from the intended intervention (see online supplemental eFigure 1). In the case of⁸⁹ serious bias due to confounding factors (D1, ROBINS-I) may influence the observed significant effect sizes in primary outcomes and maternal health benefits. Additionally, Thompson et al_{i}^{32} who demonstrated improvements in skilled birth \vec{a} attendance and facility deliveries, had a serious concern \exists . with D5 (bias due to missing data), potentially affecting the reliability of their findings see online supplemental eFigure 2. The study,³⁴ assessed with a checklist for ≥ ability (D8), which may limit its long-term applicability **(**see online supplemental eFigure 5). Despite these biases (1

the positive impact of SMS-based interventions on ANC attendance, maternal health outcomes and service utilisa-

Limitations and future research Our study acknowledges several limitations that may sinfluence the generalisability and applicability of the findings. This systematic findings. This systematic review was not pre-registered in a database, which may be considered a limitation. However, as no clinical data were involved, registration was not mandatory. We ensured methodological transparency by outlining our search strategy, inclusion criteria and quality assessment approach. The review process was conducted by a single reviewer, which, despite ensuring a consistent approach, could introduce bias and limit

the breadth of interpretation typically enriched by multi-reviewer analyses. Resource constraints and the availability of language-proficient subject matter experts necessitate this approach. To mitigate potential bias, rigorous adherence to predefined inclusion and exclusion criteria was maintained throughout the process. Although not optimal, this approach ensured the feasibility of the study within the available resources. Moreover, given that this study is focused solely on a systematic review, as stated, we did not conduct quantitative statistical analyses typically required for meta-analysis, such as pooled effect size calculations or heterogeneity tests (eg, prediction Intervals, or I²).³⁶ While these methods could have added quantitative depth, they were not necessary to achieve the primary objective of synthesising and qualitatively analysing the evidence to inform our research focus. This methodological void should be addressed in future studies. Although we identified a concentration of studies from East Africa (5 of 12), this likely reflects the higher volume of SMS-based ANC interventions conducted and published in this region. Despite our comprehensive search strategy, studies from other LMICs may have been underrepresented or uncaptured, highlighting the need for further research in diverse geographical contexts to improve generalisability.

CONCLUSION

This review shows that mobile health interventions hold significant promise for improving maternal health outcomes, particularly in LMICs (see online supplemental eFigure 8). The interventions demonstrated positive effects on ANC attendance, health knowledge and general maternal health behaviours, underscoring the value of digital health tools in resource-limited settings. However, the effectiveness of these interventions varied widely and was influenced by factors such as the content and frequency of messages and the implementation tools used. Continued efforts in this field can significantly reduce barriers to ANC and improve maternal and child health outcomes.

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REFERENCES

- Azuh DE, Azuh AE, Iweala EJ, et al. Factors influencing maternal mortality among rural communities in southwestern Nigeria. Int J Womens Health 2017;9:179–88.
- 2 Buor D, Bream K. An Analysis of the Determinants of Maternal Mortality in Sub-Saharan Africa. J Womens Health (Larchmt) 2004;13:926–38.
- 3 Meskele B, Kerbo AA, Baza D, et al. The magnitude of sub-optimal child spacing practices and its associated factors among women of childbearing age in Wolaita zone, Sodo Zuria District, Southern Ethiopia: community based cross-sectional study. Pan Afr Med J 2023;44:62.
- 4 Al-Ateeq MA, Al-Rusaiess AA. Health education during antenatal care: the need for more. *Int J Womens Health* 2015;7:239–42.
- 5 Tola W, Negash E, Sileshi T, et al. Late initiation of antenatal care and associated factors among pregnant women attending antenatal clinic of Ilu Ababor Zone, southwest Ethiopia: A cross-sectional study. PLoS ONE 2021;16:e0246230.
- 6 Simkhada B, Teijlingen ER van, Porter M, *et al*. Factors affecting the utilization of antenatal care in developing countries: systematic review of the literature. *J Adv Nurs* 2008;61:244–60.
- 7 Wagnew F, Dessie G, Alebel A, et al. Does short message service improve focused antenatal care visit and skilled birth attendance? A systematic review and meta-analysis of randomized clinical trials. *Reprod Health* 2018;15:191.
- 8 Nuhu AGK, Dwomoh D, Amuasi SA, *et al.* Impact of mobile health on maternal and child health service utilization and continuum of care in Northern Ghana. *Sci Rep* 2023;13:3004.
- 9 Masoi TJ, Kibusi SM. Improving pregnant women's knowledge on danger signs and birth preparedness practices using an interactive mobile messaging alert system in Dodoma region, Tanzania: a controlled guasi experimental study. *Reprod Health* 2019;16:177.
- 10 Ronen K, Choo EM, Wandika B, et al. Evaluation of a two-way SMS messaging strategy to reduce neonatal mortality: rationale, design

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and methods of the Mobile WACh NEO randomised controlled trial in Kenya. *BMJ Open* 2021;11:e056062.

- 11 Lund S, Nielsen BB, Hemed M, et al. Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial. BMC Pregnancy Childbirth 2014;14:29:1–10:.
- 12 Lund S, Rasch V, Hemed M, et al. Mobile phone intervention reduces perinatal mortality in zanzibar: secondary outcomes of a cluster randomized controlled trial. JMIR Mhealth Uhealth 2014;2:e15.
- 13 Mishra M, Parida D, Murmu J, et al. Effectiveness of mHealth Interventions for Monitoring Antenatal Care among Pregnant Women in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *Healthcare (Basel)* 2023;11:2635.
- 14 Rahman MO, Yamaji N, Nagamatsu Y, et al. Effects of mHealth Interventions on Improving Antenatal Care Visits and Skilled Delivery Care in Low- and Middle-Income Countries: Systematic Review and Meta-analysis. J Med Internet Res 2022;24:e34061.
- 15 Acharya D, Singh JK, Kadel R, et al. Maternal Factors and Utilization of the Antenatal Care Services during Pregnancy Associated with Low Birth Weight in Rural Nepal: Analyses of the Antenatal Care and Birth Weight Records of the MATRI-SUMAN Trial. Int J Environ Res Public Health 2018;15:2450.
- 16 Coleman J, Bohlin KC, Thorson A, et al. Effectiveness of an SMSbased maternal mHealth intervention to improve clinical outcomes of HIV-positive pregnant women. AIDS Care 2017;29:890–7.
- 17 Malqvist M, Powell N. Health, sustainability and transformation: a new narrative for global health. *BMJ Glob Health* 2022;7:e010969.
- 18 Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Syst Rev 2021;10:1–11.
- 19 Haddaway NR, Page MJ, Pritchard CC, et al. PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. Campbell Syst Rev 2022;18:e1230.
- 20 Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;366:I4898.
- 21 Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355.
- 22 Craig P, Dieppe P, Macintyre S, *et al.* Developing and evaluating complex interventions: the new Medical Research Council guidance. *BMJ* 2008;337.
- 23 McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. *Res Synth Methods* 2021;12:55–61.
- 24 Muhoza GB, Ssemaluulu PM, Mabirizi V. A mobile based technology to improve male involvement in antenatal care. *Kabale Univ Interdiscip Res J* 2022;1:79–86.

- 25 Watterson JL, Walsh J, Madeka I. Using mHealth to Improve Usage of Antenatal Care, Postnatal Care, and Immunization: A Systematic Review of the Literature. *Biomed Res Int* 2015;2015:153402.
- 26 Iribarren SJ, Brown W 3rd, Giguere R, *et al.* Scoping review and evaluation of SMS/text messaging platforms for mHealth projects or clinical interventions. *Int J Med Inform* 2017;101:28–40.
- 27 Alhaidari T, Amso N, Jawad TM, et al. Feasibility and acceptability of text messaging to support antenatal healthcare in Iraqi pregnant women: A pilot study. J Perinat Med 2018;46:67–74.
- 28 Atnafu A, Otto K, Herbst CH. The role of mHealth intervention on maternal and child health service delivery: findings from a randomized controlled field trial in rural Ethiopia. *Mhealth* 2017;3:39.
- 29 Hedstrom AB, Choo EM, Ronen K, *et al.* Risk factors for stillbirth and neonatal mortality among participants in Mobile WACh NEO pilot, a two-way SMS communication program in Kenya. *PLOS Glob Public Health* 2022;2:e0000812.
- 30 WACh G. Mobile wach neo randomized controlled trial achieves milestone to enroll 5,020 research participants | global wach. 2022. Available: https://depts.washington.edu/globalwach/2022/08/03/ mobile-wach-neo-randomized-controlled-trial-achieves-milestoneto-enroll-5020-research-participants/
- 31 Omole O, Ijadunola MY, Olotu E, et al. The effect of mobile phone short message service on maternal health in south-west Nigeria. Int J Health Plann Manage 2018;33:155–70.
- 32 Thompson S, Mercer MA, Hofstee M, et al. Connecting mothers to care: Effectiveness and scale-up of an mHealth program in Timor-Leste. J Glob Health 2019;9:020428.
- 33 Proceedings of the Ninth International Conference on Information and Communication Technologies and Development. *Maternal Complications* 2017;1–12.
- 34 Oliveira-Ciabati L, Alves D, Barbosa-Junior F, et al. SISPRENACEL mHealth tool to empower PRENACEL strategy. Procedia Comput Sci 2017;121:748–55.
- 35 Kawakatsu Y, Oyeniyi Adesina A, Kadoi N, *et al.* Cost-effectiveness of SMS appointment reminders in increasing vaccination uptake in Lagos, Nigeria: A multi-centered randomized controlled trial. *Vaccine* (*Auckl*) 2020;38:6600–8.
- 36 Borenstein M. How to understand and report heterogeneity in a meta-analysis: The difference between I-squared and prediction intervals. *Integr Med Res* 2023;12:101014.
- 37 Perrier T, Dell N, DeRenzi B, et al. Engaging pregnant women in kenya with a hybrid computer-human sms communication system. CHI '15; Seoul Republic of Korea, April 18, 2015 10.1145/2702123.2702124 Available: https://dl.acm.org/doi/ proceedings/10.1145/2702123

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