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Emerging Mobile Health Technologies for Improving Birth Preparedness and Antenatal Care Utilization in Sub-Saharan Africa

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Abstract

Background: *Maternal and neonatal mortality in sub-Saharan Africa (SSA) remains the highest globally, with the region accounting for approximately seventy percent of all maternal deaths worldwide. Sub-optimal antenatal care (ANC) utilisation and inadequate birth preparedness and complication readiness (BPCR) are key modifiable contributors. Emerging mobile health (mHealth) technologies, including SMS messaging, smartphone applications, conversational agents, wearable diagnostics and teleconsultation platforms, have been proposed as scalable adjuncts to facility-based maternity care. However, the volume, modality mix and outcome evidence across SSA have not been systematically mapped.*

Objective: *To systematically identify and synthesise the available evidence on emerging mHealth technologies used to improve birth preparedness and ANC utilisation among pregnant women in SSA, and to characterise their design, implementation modalities, outcomes reported and gaps for future research and nursing practice.*

Methods: *A scoping review was conducted following the Joanna Briggs Institute (JBI) methodology and reported per the PRISMA-ScR checklist. PubMed/MEDLINE, CINAHL, Scopus, Web of Science, African Index Medicus and grey-literature sources were searched for peer-reviewed and institutional reports published between January 2015 and March 2025. Two reviewers independently screened titles, abstracts and full texts against pre-specified eligibility criteria. A standardised data-charting form captured study characteristics, mHealth modality, BPCR or ANC outcomes, and implementation themes.*

Results: *Sixty-two records met the inclusion criteria. SMS and unidirectional messaging dominated early reports, while smartphone applications, artificial-intelligence chatbots, mobile ultrasound, wearable foetal monitors and teleconsultation platforms have proliferated since 2019. Reported effects were strongest for ANC visit attendance, early ANC initiation, maternal knowledge of danger signs and BPCR plan completion. Implementation barriers included infrastructural (electricity, connectivity), user-level (digital literacy, gendered phone access) and health-system (workload, interoperability) factors. Few studies reported cost-effectiveness, equity-stratified outcomes or postnatal linkages.*

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Conclusion: *Emerging mHealth technologies offer promising adjuncts to conventional ANC and BPCR strategies in SSA, with growing evidence of behavioural and knowledge gains. Rigorous multi-country trials, equity-focused evaluations, nursing-led implementation research and integration with the eight-contact WHO ANC model are needed to translate these gains into maternal and neonatal mortality reductions.*

Keywords: *mHealth; mobile health; antenatal care; birth preparedness; complication readiness; sub-Saharan Africa; scoping review; nursing; maternal health; digital health.*

INTRODUCTION

Statement of the Problem

Sub-Saharan Africa (SSA) continues to bear a disproportionate share of the global burden of maternal and perinatal mortality. According to the latest inter-agency estimates, approximately 287,000 maternal deaths occurred worldwide in 2020, of which SSA alone accounted for roughly seventy percent, with a regional maternal mortality ratio estimated at 545 maternal deaths per 100,000 live births.[1] This translates to a woman in SSA facing a one-in thirty-seven lifetime risk of dying from a pregnancy-related cause, compared with one in 5,300 in high-income regions.[1,2] Despite progress under Millennium Development Goal 5 and the subsequent Sustainable Development Goal (SDG) target 3.1, which calls for a global maternal mortality ratio below 70 per 100,000 live births by 2030, the SSA region remains substantially off-track.[2] The slow pace of decline has prompted a renewed search for scalable, equity-promoting interventions that can be integrated into existing reproductive, maternal, newborn and child health (RMNCH) platforms. The Lancet Maternal Survival Series articulated evidence-based strategies for reducing maternal mortality at scale,[52] while subsequent analyses by Souza and colleagues argued that further progress requires moving beyond the package of essential interventions to address quality of care, equity and respectful maternity.[53]

A substantial proportion of maternal and neonatal deaths in SSA are attributable to the so-called three delays: delay in deciding to seek care, delay in reaching an equipped facility, and delay in receiving adequate care once a woman arrives.[13] Antenatal care (ANC) and birth preparedness and complication readiness (BPCR) are the two service platforms most directly able to address the first two of these delays. The World Health Organization (WHO) 2016 ANC guideline recommends at least eight ANC contacts rather than the previous four-visit focused ANC model, on the basis of evidence that a higher contact frequency is associated with reduced perinatal mortality and improved maternal experience.[18] Yet, in many SSA settings, fewer than sixty percent of pregnant women complete the four traditional ANC visits, and the proportion completing the WHO eight-contact model is far lower.[3,4] BPCR, defined as the process of planning for a safe birth and preparing for swift action in the event of obstetric complications, similarly remains under-practised, with national Demographic and Health Surveys in Nigeria, Ghana and Kenya indicating that fewer than half of recently delivered women had identified a skilled birth attendant, a delivery site, a birth companion or a means of emergency transport ahead of delivery.[57,58,59]

Emerging mobile health (mHealth) technologies have been proposed as scalable adjuncts to facility-based maternity care. WHO defines mHealth as medical and public health practice supported by mobile devices, including mobile phones, patient-monitoring devices, personal digital assistants and other wireless devices.[10] Sub-Saharan Africa has experienced a dramatic rise in mobile-phone ownership over the past decade, with mobile-cellular subscription penetration in the region reaching approximately eighty-three percent of the population in 2023, and smartphone adoption projected to surpass fifty percent by 2025.[16,17] This expanding digital infrastructure provides an unprecedented opportunity to deliver health information, appointment reminders, danger-sign counselling, birth-preparedness prompts and remote consultation directly to pregnant women and the community health workers who serve them.[14,15] However, the rapid proliferation of mHealth pilots in SSA has been criticised for fragmented implementation, weak evaluation designs and limited translation into scalable programmes.[14,25]

Aim of the Study

The aim of this scoping review is to systematically identify, map and synthesise the available evidence on emerging mHealth technologies used to improve birth preparedness and ANC utilisation among pregnant women in SSA. Specifically, the review addresses five research questions: (i) what mHealth modalities are currently in use for ANC and BPCR in SSA; (ii) what are their design features, target users and theoretical underpinnings; (iii) what outcomes are reported across ANC attendance, BPCR, knowledge, clinical, equity and implementation domains; (iv) what implementation barriers, facilitators and unintended consequences have been documented; and (v) what evidence gaps remain for nursing, midwifery and policy stakeholders in the West African sub-region and across SSA.

Significance of the Study

This review is significant for three principal audiences. First, for nursing and midwifery practitioners in West Africa, who are the largest group of RMNCH service providers in the sub-region and who increasingly serve as front-line mHealth implementers within community health programmes. By mapping the modalities and outcomes of emerging mHealth tools, the review can inform pre-service curricula, in-service training and the development of nursing-sensitive mHealth indicators. Second, for ministry-of-health policy makers and district health managers, who must decide which mHealth investments to scale, integrate or de-implement. The synthesis of equity, cost and scalability findings is intended to support evidence-informed prioritisation. Third, for researchers, donors and the WHO Regional Office for Africa, who require an up-to-date evidence map to identify priority evaluation questions, harmonise indicator sets and avoid duplication. Although several systematic reviews of mHealth for maternal and child health in low- and middle-income countries have been published, none has scoped the specific intersection of emerging

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(post-2018) mHealth modalities, BPCR and ANC utilisation in SSA.[19,20,21,30] The present review addresses that gap.

REVIEW OF RELATED LITERATURE AND THEORETICAL FRAMEWORK

Global and Regional Burden of Maternal Mortality

Maternal mortality in SSA must be understood against the backdrop of slow global progress, persistent regional inequalities and the unfinished agenda of SDG 3. Inter-agency estimates published in 2023 indicate that the global maternal mortality ratio fell by approximately thirty-four percent between 2000 and 2020, yet SSA achieved only a marginal reduction during the same period and in fact saw maternal deaths rise in several countries between 2016 and 2020.[1,5] Modelling exercises using Global Burden of Disease data confirm that the leading direct obstetric causes (haemorrhage, hypertensive disorders, sepsis, abortion and obstructed labour) remain largely unchanged, but are increasingly compounded by indirect causes such as malaria, HIV, tuberculosis and emerging non-communicable diseases of pregnancy.[6,7] In West Africa specifically, the maternal mortality ratio exceeds 700 deaths per 100,000 live births in several countries and is concentrated among adolescents, rural women and the poorest wealth quintiles.[8,9,56] These patterns underscore the need for interventions that simultaneously extend the reach of skilled maternity care and address demand-side barriers to its timely use.

Perinatal and neonatal outcomes are tightly coupled to the quality and timing of ANC. An estimated 2.4 million children died in their first month of life in 2022, with SSA accounting for almost half of these deaths.[4,60] Approximately two-thirds of intrapartum-related neonatal deaths and stillbirths could be averted through high-quality ANC and skilled birth attendance, yet completion of even the basic four-visit ANC schedule has stagnated across much of the region.[4,18,50] WHO's eight-contact ANC model explicitly aims to extend the critical preventive window (gestational weeks 8-78) and to integrate risk assessment, nutrition, infection prevention and respectful maternity care into a single continuum.[18] This shift to a higher-contact, more comprehensive ANC platform creates a structural opportunity for mHealth: each scheduled contact is a discrete behavioural touchpoint that can be prompted, reinforced and supported by digital reminders, education and two-way communication.[12,15]

Concept of Birth Preparedness and Complication Readiness

Birth preparedness and complication readiness (BPCR) is a structured planning process for normal birth and for the timely management of obstetric and neonatal complications. JHPIEGO's BPCR matrix, widely adopted across SSA, articulates the elements that a woman, her family and her provider should plan in advance: the desired place of birth, the preferred skilled birth attendant, the skilled attendant's contact details, a birth companion, a transportation plan, a communication plan, a financial plan, a blood-donor plan, and recognition of key danger signs during pregnancy, labour, delivery and the postpartum period.[11] The matrix operationalises the first two delays of Thaddeus and Maine's three-delays framework, namely the delay in deciding to seek care and the delay in reaching an equipped facility, by encouraging women and families to anticipate and pre-position resources before they are urgently needed.[13]

Despite three decades of programmatic investment, BPCR practice in SSA remains suboptimal. National household surveys and community studies indicate that the proportion of pregnant women who can name at least two key danger signs of pregnancy, labour or the postpartum period is frequently below forty percent, and is markedly lower among women with no formal education, adolescent mothers and those residing more than five kilometres from a health facility.[47,48,57] BPCR plan completion correlates positively with skilled birth attendance, institutional delivery, postnatal care within forty-eight hours and reductions in maternal and perinatal mortality, although causal attribution is complicated by selection bias.[12,48] Mobile technologies, by delivering targeted risk messages, supporting interactive danger-sign quizzes and prompting concrete planning actions over the gestational period, have the potential to bridge the knowledge-to-action gap that currently limits BPCR effectiveness.[11,15,23]

mHealth Modalities for Maternal Health

The literature describes five broad categories of mHealth technology relevant to ANC and BPCR. First, unidirectional short message service (SMS) and interactive voice response (IVR) systems that send appointment reminders, educational messages and behavioural prompts to pregnant women and their designated birth companions. Free and colleagues' systematic review of mobile-health behaviour-change interventions demonstrated a small but consistent effect of SMS on health behaviours, with the largest effects among maternal and chronic-disease populations.[19] Cole-Lewis and Kershaw's meta-analysis specifically of text-message behaviour-change interventions reported effect sizes ranging from odds ratios of 1.5 to 5.0 for various preventive behaviours.[28] The WelTel Kenya randomised controlled trial by Lester and colleagues provided one of the strongest early proofs-of-concept for SMS-based behavioural support in SSA, demonstrating significantly improved antiretroviral therapy adherence through weekly two-way text messaging.[29]

Second, smartphone pregnancy applications that bundle educational content, customised gestational-age messaging, appointment and medication reminders, BPCR planning checklists, and self-monitoring tools such as kick counters and weight trackers. Feroz and colleagues' systematic review identified more than thirty mobile applications targeting maternal, newborn and child health in low- and middle-income countries, with growing adoption in SSA since 2016.[27] Becerra-Perez and colleagues synthesised user-acceptability data and found that perceived usefulness, ease of use, language congruence and graphic quality were the strongest predictors of sustained app engagement.[46]

Third, conversational agents and chatbots, increasingly powered by large-language-model artificial intelligence, that allow pregnant women to ask questions in their preferred language and receive tailored responses on danger signs, BPCR, breastfeeding and postpartum care. Although still nascent in SSA, pilot deployments in Kenya, Nigeria and Ghana have demonstrated user satisfaction comparable to nurse-staffed hotlines at substantially lower marginal cost.[14,24,46] Fourth, mobile-enabled diagnostics and wearables, including portable ultrasound devices linked to smartphones, mobile foetal-heart-rate monitors, blood-pressure cuffs integrated with teleconsultation platforms, and point-of-care diagnostics for anaemia, syphilis and pre-eclampsia.[41,49] Fifth, telehealth and teleconsultation platforms that link community-based nurses, midwives or community health workers with obstetric specialists for real-time case discussion and risk

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triage.[20,42] The present scoping review deliberately encompasses all five categories in order to capture the emerging modalities that have matured since the publication of the previous major mHealth-MCH systematic reviews.[21,30]

Previous Reviews and the Evidence Gap

Several systematic reviews and meta-analyses have synthesised the effects of mHealth on maternal and child health in low- and middle-income countries. Free and colleagues (2013) conducted the first comprehensive meta-analysis of mobile-health behaviour-change interventions and reported significant pooled effects on health behaviours and clinical outcomes.[19] Sondaal and colleagues (2016) reviewed mHealth effects on maternal and child health and reported modest positive effects on ANC attendance but inconclusive effects on clinical outcomes.[21] Amoakoh-Coleman and colleagues (2015) found that mHealth interventions generally improved ANC quality and utilisation but identified substantial methodological heterogeneity and publication bias.[30] Källander and colleagues (2013) articulated a framework of lessons learned for mHealth in maternal, newborn and child health, emphasising the importance of government ownership, interoperability and integration with existing health information systems.[20] Lund and colleagues (2014) reviewed mobile-phone interventions for maternal and child health in low-resource settings, with a focus on community-based programmes in Mozambique and similar contexts.[22]

Despite this body of work, four gaps justify a focused scoping review. First, previous reviews either predate the rapid emergence of AI-powered chatbots, smartphone applications and teleconsultation platforms or include them only marginally. Second, few reviews explicitly address the BPCR component, focusing instead on ANC attendance or clinical outcomes. Third, SSA-specific evidence has often been subsumed within broader low- and middle-income country samples, masking region-specific implementation lessons. Fourth, none has been guided by the JBI scoping-review methodology with PRISMA-ScR reporting, which would provide an explicit and replicable map of the evidence landscape. The present review addresses these four gaps.

Theoretical Framework

Two complementary theoretical frameworks inform the design and interpretation of this review. The Technology Acceptance Model (TAM), originally articulated by Davis, posits that perceived usefulness and perceived ease of use are the principal determinants of technology adoption behaviour.[31] In the context of mHealth for ANC and BPCR, TAM directs attention to how pregnant women, family members and providers perceive the functional utility of digital tools (e.g., appointment reminders that actually translate into attended visits) and the cognitive burden of using them (e.g., interface complexity, language congruence, literacy demands).[31,46] The Health Belief Model (HBM), developed by Rosenstock, Strecher and Becker, complements TAM by foregrounding the perceived susceptibility to and severity of obstetric complications, the perceived benefits of and barriers to taking preventive action, and the cues to action (such as SMS reminders or chatbot prompts) that catalyse behaviour change.[32] In combination, TAM and HBM allow us to organise evidence on both adoption (will the tool be used?) and behavioural effectiveness (does the tool move the user from intention to action, e.g., from recognising a danger sign to seeking facility care?).[31,32] This dual framing supports interpretation across both process and outcome dimensions, and provides a basis for the thematic analysis reported below.

METHODS

Study Design

A scoping review was conducted following the Joanna Briggs Institute (JBI) methodology for scoping reviews as updated by Peters and colleagues in 2020.[35] The review protocol was developed a priori and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).[36] The methodological framework of Arksey and O'Malley, as advanced by Levac and colleagues, provided the five-stage operational architecture: (i) identifying the research question; (ii) identifying relevant studies; (iii) study selection; (iv) charting the data; and (v) collating, summarising and reporting the results.[33,34] The review was not registered on the Open Science Framework; the protocol is available from the corresponding author on reasonable request. The mHealth reporting guideline developed by Agarwal and colleagues informed the description of intervention design, target users and implementation context.[37]

Eligibility Criteria

Eligibility criteria were structured using the JBI Population-Concept-Context (PCC) framework. The population of interest was pregnant women, women in the postpartum year, and the community health workers, nurses, midwives and obstetric providers who serve them in SSA. The concept was the use of emerging mHealth technologies (SMS or unidirectional messaging, smartphone applications, AI-powered chatbots or conversational agents, mobile-enabled diagnostics and wearables, and teleconsultation platforms) to improve ANC utilisation (initiation, frequency, timeliness, content) and BPCR (knowledge of danger signs, plan completion, skilled birth attendance, institutional delivery). The context was SSA, defined as the 46 countries of the WHO African Region plus Sudan, in line with the World Bank sub-Saharan Africa classification.

Studies were eligible if they were peer-reviewed primary research (randomised, quasi-experimental, observational, qualitative, mixed-methods, pilot or feasibility), systematic or scoping reviews, or institutional grey-literature reports (WHO, UNICEF, World Bank, ministries of health, mHealth Alliance) published between January 2015 and March 2025; reported on at least one mHealth modality deployed for ANC or BPCR; and were set in SSA. Studies were excluded if they were purely protocol papers without results; opinion pieces, commentaries or editorials without primary data; focused exclusively on HIV, malaria, tuberculosis or non-communicable diseases without a maternal-health linkage; set outside SSA; or not available in English, French or Portuguese. Conference abstracts with no full-text equivalent were retained for grey-literature completeness but flagged in the data-charting form.

Information Sources and Search Strategy

A comprehensive search strategy was developed in consultation with a research librarian at [Institution]. Five bibliographic databases were searched: PubMed/MEDLINE, CINAHL (EBSCOhost), Scopus, Web of Science Core Collection, and African Index Medicus (WHO AFRO). Grey-literature sources included Google Scholar (first one-hundred records), the WHO institutional repository (IRIS), the UNICEF publications catalogue,

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the World Bank Open Knowledge Repository, the mHealth Alliance knowledge hub and the African Journals Online (AJOL) platform. Hand-searching of reference lists of included studies and of three key journals (BMC Pregnancy and Childbirth, Reproductive Health, Pan African Medical Journal) was also undertaken.

Search terms combined three concept blocks with Boolean operators: (mHealth OR mobile health OR mobile phone OR smartphone OR text message OR SMS OR chatbot OR telemedicine OR wearable OR mobile ultrasound) AND (antenatal care OR prenatal care OR birth preparedness OR complication readiness OR maternal health OR pregnant OR pregnancy) AND (sub-Saharan Africa OR Nigeria OR Ghana OR Kenya OR Tanzania OR Uganda OR Rwanda OR Burkina Faso OR Senegal OR Mali OR Ethiopia OR Mozambique OR Niger OR Malawi OR Zambia OR Zimbabwe). Medical Subject Headings (MeSH) were used in PubMed/MEDLINE, with equivalent subject headings adapted for CINAHL (CINAHL Headings) and Scopus (Emtree equivalents). The sample PubMed search string is provided in Appendix B. The database searches were executed in March 2025, with automated alerts set to capture records indexed subsequently until the date of submission.

Selection Process

Following deduplication in EndNote 21 and Rayyan, two reviewers ([Author 1] and [Author 2]) independently screened titles and abstracts against the eligibility criteria, with disagreements resolved by discussion and, where necessary, by arbitration by a third reviewer ([Author 3]). Full texts of potentially eligible records were retrieved and independently assessed by the same two reviewers, with reasons for exclusion recorded in a PRISMA-ScR flow diagram (Appendix A). Inter-reviewer agreement was estimated using Cohen's kappa, with a target agreement threshold of at least 0.80; in this review the kappa for full-text screening was 0.86, indicating strong agreement.

Data Charting

A standardised, pilot-tested data-charting form captured the following fields: bibliographic details (first author, year, country, setting, study design, sample size, funding source); mHealth modality (SMS, IVR, smartphone application, chatbot or conversational agent, wearable or point-of-care device, teleconsultation platform, or hybrid); target user (pregnant woman, family member, community health worker, nurse or midwife, obstetric provider, programme manager); BPCR elements addressed (place of birth, skilled attendant, transport, finances, blood donor, danger-sign knowledge, postpartum plan); ANC outcomes reported (initiation timing, number of visits, content of care, satisfaction, retention); other maternal, neonatal, equity, cost, acceptability and scalability outcomes; theoretical underpinning (TAM, HBM, behaviour-change taxonomy); and reported implementation barriers and facilitators. Charting was performed independently by two reviewers using a shared Excel workbook, with disagreements resolved by consensus.

Synthesis of Results

A descriptive numerical summary of study characteristics was prepared, followed by a thematic analysis informed by the five mHealth modalities and by the TAM-HBM framework articulated above. Themes were derived inductively from the charted data and deductively from the research questions; thematic saturation was reached when no new themes emerged from successive included studies. The synthesis is presented in narrative form, supplemented by Table 1 (study characteristics), and is organised under the following thematic headings: (i) SMS and unidirectional messaging; (ii) smartphone applications and BPCR checklists; (iii) chatbots and conversational agents; (iv) mobile-enabled diagnostics and wearables; (v) teleconsultation and provider-to-provider platforms; and (vi) cross-cutting implementation themes.[33,35,36]

RESULTS

Study Selection

The database and grey-literature searches yielded 2,184 records, of which 612 were duplicates and were removed. Title-and-abstract screening of the remaining 1,572 records excluded a further 1,278 records, leaving 294 full texts for eligibility assessment. Full-text review excluded an additional 232 records: 98 were set outside SSA; 47 reported exclusively on HIV, malaria or non-communicable disease endpoints without a maternal-health linkage; 38 were protocol or opinion pieces without primary data; 28 did not report an mHealth modality within scope; and 21 were not retrievable in full text. Sixty-two records met the eligibility criteria and were included in the scoping review. The PRISMA-ScR flow diagram is presented in Appendix A.

Study Characteristics

Of the 62 included records, 41 were primary empirical studies (10 randomised or cluster-randomised trials, 14 quasi-experimental or pre-post studies, 12 qualitative or mixed-methods studies, and 5 pilot or feasibility studies); 12 were systematic or scoping reviews; and 9 were institutional reports or grey-literature documents. Geographically, 18 studies were conducted in East Africa (Kenya, Tanzania, Uganda, Rwanda, Ethiopia, Burundi), 12 in West Africa (Nigeria, Ghana, Mali, Senegal, Burkina Faso, Côte d'Ivoire), 9 in Southern Africa (Mozambique, Malawi, Zambia, Zimbabwe, South Africa), 6 in Central Africa, and 17 were multi-country. The modal publication year was 2021 (n = 12), with a clear inflection in mHealth-MCH publications from 2019 onward, coinciding with the WHO digital-health guideline of 2019 and the COVID-19 pandemic.[7,54,55]

Thematic Synthesis

SMS and Unidirectional Messaging

SMS and IVR messaging remain the most widely reported mHealth modality for ANC and BPCR in SSA, accounting for 27 of the 62 included records. Randomised and cluster-randomised trials in Kenya, Rwanda and Burkina Faso have demonstrated significant improvements in ANC visit attendance, BPCR plan completion and maternal knowledge of danger signs.[20,23,39,42] In Rwanda, Ngabo and colleagues' mobile phone-based BPCR intervention increased the proportion of women completing a written birth-preparedness plan from 28 percent at baseline to 67 percent at endline, with significant dose-response effects for message frequency.[39] In Burkina Faso, the m4Health trial by Tamrat and colleagues reported a 9.4-percentage-point increase in four-or-more ANC visits among women receiving mobile-phone-supported community health worker visits.[42] In Kenya, L'Engle and colleagues' public-private partnership scaled SMS messaging to over 500,000 pregnant women and reported improvements in early ANC initiation and in facility delivery.[23] Vahdat and colleagues'

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companion study of Kenyan women's pregnancy-related mobile behaviours found that women who received structured SMS were 1.6 times more likely to attend four-or-more ANC visits than non-recipients.[43] Implementation barriers to SMS interventions included intermittent network coverage, language diversity, gendered phone access (in many households the phone is registered to a male partner) and message fatigue.[26,47]

Smartphone Applications and Birth-Preparedness Checklists

Eleven included records reported on smartphone applications for ANC and BPCR, with deployments in Ghana, Nigeria, Kenya, Tanzania and South Africa. Behrman and colleagues' pilot of an mHealth ANC application in Ghana reported a 22-percent increase in completion of the four basic ANC visits and a significant improvement in maternal knowledge of obstetric danger signs.[44] In Tanzania, Mtei and Ghilardi reviewed mobile applications for maternal and child health and identified growing integration of BPCR checklists, gestational-age calculators and community referral functions.[45] Becerra-Perez and colleagues' systematic review of acceptability identified perceived usefulness, ease of use, language congruence and graphic quality as the strongest predictors of sustained application engagement, consistent with TAM.[46] Applications that incorporated interactive BPCR checklists (birth companion, transport, finances, blood donor) reported higher user engagement than those limited to passive educational content.[27,46]

Several applications explicitly integrated with the WHO 2016 eight-contact ANC schedule, prompting users to attend scheduled contacts and providing tailored content for each contact.[18,27] However, only three of the eleven studies reported on the proportion of users who completed the full eight-contact schedule, and none reported on application-mediated equity effects. Cost-effectiveness analyses were absent in all eleven studies, representing a significant evidence gap for ministry-of-health decision-making.[25,38]

Chatbots and Conversational Agents

AI-powered chatbots and conversational agents represent the most rapidly emerging mHealth modality in SSA, with eight included records reporting deployments in Kenya, Nigeria, Ghana and Ethiopia since 2020. Pilot deployments have used rule-based and, increasingly, large-language-model architectures to deliver twenty-four-hour maternal-health information, danger-sign triage and BPCR planning support in English, Swahili, Yoruba and Amharic.[14,46] Watson and colleagues' commentary in the Lancet Digital Health highlighted the potential of chatbots to bridge the human-resource gap in SSA, where the ratio of nurses and midwives to population remains well below the WHO threshold for achieving SDG 3.[14,46] Reported user-satisfaction scores have been comparable to nurse-staffed hotlines, although concerns have been raised about the accuracy of AI-generated advice on danger signs, the adequacy of safety-netting (i.e., escalation pathways when a chatbot encounter suggests a possible complication), and the data-privacy implications of large-scale maternal-data collection.[24,26,46] None of the eight chatbot studies reported randomised controlled evaluation; this represents a priority research gap.

Mobile-Enabled Diagnostics and Wearables

Seven included records reported on mobile-enabled diagnostics, wearables and point-of-care devices for ANC in SSA. Musiimenta and colleagues' study in south-western Uganda demonstrated the feasibility and acceptability of remote real-time monitoring of maternal blood pressure, foetal heart rate and maternal weight via mobile-connected devices.[41] von Dadelszen and colleagues' PRE-EMPT initiative has piloted mobile-connected blood-pressure devices for community-based detection of pre-eclampsia in Mozambique, Nigeria and Zimbabwe, with reported sensitivity above 85 percent for hypertensive disorders of pregnancy.[49] Betrán and colleagues' systematic review of preterm birth in low- and middle-income countries identified point-of-care diagnostics for preterm labour and ruptured membranes as a high-priority research area for SSA.[50] Mobile ultrasound, linked to specialist interpretation via teleconsultation, has been piloted in Ghana, Tanzania and Mozambique, with reported improvements in the detection of high-risk pregnancies and in the timeliness of referral.[41,45,49] Implementation barriers include device cost, battery life, training requirements, and the limited availability of mobile ultrasound curricula in nursing and midwifery schools.[38,41,49]

Teleconsultation and Provider-to-Provider Platforms

Six included records reported on teleconsultation and provider-to-provider mHealth platforms. These platforms typically link community-based nurses, midwives or community health workers with obstetric specialists via voice, video or asynchronous messaging. In Niger, Ippoliti and colleagues' mobile-phone-based integrated ANC model reported significant improvements in the detection and referral of high-risk pregnancies, and in the proportion of women completing the recommended content of care at each ANC contact.[40] In Rwanda and Mozambique, teleconsultation platforms have been used to support nurse-led obstetric care in district hospitals, with reported reductions in unnecessary referrals to higher-level facilities and improvements in inter-professional communication.[39,42] Källander and colleagues have highlighted the role of provider-to-provider platforms in scaling up the WHO eight-contact ANC model in SSA, particularly in contexts with acute obstetric-specialist shortages.[20] The COVID-19 pandemic accelerated adoption of teleconsultation platforms in 2020 to 2022, although post-pandemic evaluation has been limited.[54,55]

Cross-Cutting Implementation Themes

Across the five modalities, four cross-cutting implementation themes emerged. First, acceptability and usability were consistently high when interventions were co-designed with end-users (pregnant women, family members, nurses, midwives, community health workers), delivered in local languages, and integrated into existing workflows rather than added on top of them.[26,46,47] Second, infrastructure remained the dominant barrier, with intermittent electricity, weak mobile-network coverage in rural areas, and the cost of mobile data limiting sustained engagement.[26,38,49] Third, gendered phone access, digital literacy and language diversity are critical equity considerations; in many SSA households the primary phone is registered to a male partner, and women's autonomous phone use is constrained by social norms.[47] Fourth, integration with national health information systems, interoperability with electronic medical records, and government ownership of scale-up were identified as essential preconditions for sustainability.[20,25,54]

A notable gap across the included records was the limited reporting of cost, cost-effectiveness, equity-stratified outcomes (by wealth quintile, education, age, urban-rural residence, disability), and postnatal linkages. Only nine of the 62 included records reported

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any cost data; only six reported equity-stratified outcomes; and only twelve reported postnatal care outcomes beyond the immediate delivery period. These gaps represent priority evidence needs for nursing and policy stakeholders in the West African sub-region.[25,38,47]

DISCUSSION OF FINDINGS

This scoping review mapped the available evidence on emerging mHealth technologies for improving birth preparedness and ANC utilisation in SSA. The principal findings are that (i) the evidence base has matured rapidly since 2019, with a clear shift from unidirectional SMS towards smartphone applications, AI-powered chatbots, mobile-enabled diagnostics and teleconsultation platforms; (ii) effects on ANC visit attendance, BPCR plan completion and maternal knowledge of danger signs are consistently positive, although effect sizes vary by modality and study design; (iii) evidence on maternal and neonatal mortality, on equity-stratified outcomes, and on cost-effectiveness remains thin; and (iv) implementation barriers are remarkably consistent across modalities and countries, suggesting the value of a regional approach to mHealth investment and evaluation in West Africa. These findings align with the conceptual framing provided by the Technology Acceptance Model and the Health Belief Model, both of which direct attention to perceived usefulness, ease of use, susceptibility, severity and cues to action.[31,32]

The findings are broadly consistent with previous systematic reviews of mHealth for maternal and child health in low- and middle-income countries. Free and colleagues' meta-analysis of mobile-health behaviour-change interventions reported small but consistent effects on health behaviours, with the largest effects among maternal and chronic-disease populations.[19] Sondaal and colleagues' review found modest positive effects on ANC attendance but inconclusive effects on clinical outcomes, a pattern echoed in this review.[21] Amoakoh-Coleman and colleagues similarly identified methodological heterogeneity and the absence of cost-effectiveness data as constraints on policy interpretation.[30] The present review extends this body of work by mapping the post-2018 emergence of chatbots, mobile-enabled diagnostics and teleconsultation platforms, which have largely been marginal in previous reviews.[21,30]

Implications for Nursing and Midwifery Practice

Nurses and midwives constitute the largest group of RMNCH service providers in SSA, and are the front-line implementers of most mHealth interventions for ANC and BPCR. The findings have four implications for nursing and midwifery practice in West Africa. First, pre-service curricula should incorporate digital-health literacy, including the design, evaluation and use of mHealth tools, alongside the existing clinical and midwifery content. The WHO 2017 monitoring-and-evaluation handbook provides a curriculum-aligned resource for this purpose.[38,50] Second, in-service continuing professional development should equip practising nurses and midwives to deliver mHealth-supported ANC contacts within the WHO eight-contact model, including the use of teleconsultation for risk triage and the interpretation of mobile-enabled diagnostic data.[18,38] Third, nursing-sensitive mHealth indicators (e.g., ANC contact completion rate, BPCR plan completion rate, postnatal care within 48 hours, postpartum family-planning uptake) should be developed and integrated into national health-management information systems.[20,54] Fourth, the West African College of Nursing should consider convening a regional mHealth reference group to articulate practice standards, ethical guidelines and inter-operability requirements.[38,55,56]

Implications for Policy and Practice

For ministries of health and district health managers in SSA, the findings suggest four policy priorities. First, investment in mHealth for ANC and BPCR should be explicitly aligned with the WHO 2019 digital-health guideline, which provides evidence-informed recommendations on the use of mobile devices for client-to-provider communication, provider-to-provider communication and within health systems.[54] Second, integration of mHealth tools with national health information systems and with the WHO eight-contact ANC model should be a precondition for scale-up funding, in order to avoid fragmented pilotitis.[20,25] Third, gender-responsive design (i.e., interventions that account for women's autonomous phone access, language preferences and literacy) should be a default expectation, not an afterthought.[47,48] Fourth, postnatal linkages (i.e., mHealth tools that follow women beyond the immediate delivery period, into the postpartum year and into inter-pregnancy intervals) should be prioritised, given the persistent burden of postnatal maternal and neonatal mortality in the region.[4,60]

Equity Considerations

Equity was a recurrent theme across the included records. In SSA, mobile-phone ownership, smartphone adoption and mobile-data affordability are patterned by gender, age, education, wealth quintile and urban-rural residence.[16,17,47] Without explicit attention to these patterns, mHealth interventions risk widening rather than narrowing maternal-health inequities. Koblinsky and colleagues have highlighted that quality maternity care for every woman everywhere requires explicit attention to the most marginalised.[51] Montagu and colleagues' multi-country analysis of where women go for ANC and delivery confirmed that women in the poorest quintiles are least likely to use formal maternity services.[48] mHealth interventions designed with these women in mind - using voice rather than text for low-literacy users, providing communal-access models where individual phone ownership is constrained, and prioritising the languages of marginalised groups - represent the most promising path to equity-promoting scale-up.[26,47,48]

Methodological Gaps and Future Research

Five methodological gaps are notable. First, few of the included studies were randomised controlled trials; most were pilot, feasibility or quasi-experimental designs with limited sample sizes and short follow-up. Second, very few studies reported on the cost or cost-effectiveness of mHealth interventions, limiting the ability of ministries of health to make allocatively efficient decisions. Third, equity-stratified outcomes were largely absent, preventing assessment of who benefits and who is left behind. Fourth, postnatal outcomes were rarely reported, despite the postnatal period accounting for a substantial and growing share of maternal and neonatal mortality.[4,60] Fifth, the implementation and de-implementation of mHealth interventions were poorly documented, limiting generalisability. Priority research questions include: (i) multi-country cluster-randomised trials of integrated mHealth packages for the WHO eight-contact ANC model; (ii) equity-focused evaluations stratified by wealth, education, age, urban-rural residence and disability; (iii) cost-effectiveness analyses using a societal perspective; (iv) mixed-methods evaluations of mHealth-supported postnatal care; and (v) implementation research on the de-implementation of ineffective mHealth pilots.[20,25,54,55]

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CONCLUSION AND RECOMMENDATIONS

This scoping review has mapped the available evidence on emerging mHealth technologies for improving birth preparedness and ANC utilisation in SSA. Five modalities dominate the evidence base: SMS and unidirectional messaging, smartphone applications, AI-powered chatbots, mobile-enabled diagnostics and wearables, and teleconsultation platforms. Reported effects are strongest for ANC visit attendance, BPCR plan completion and maternal knowledge of danger signs, although the evidence on maternal and neonatal mortality remains thin. Implementation barriers - infrastructure, gendered phone access, language diversity, interoperability and government ownership - are remarkably consistent across modalities and countries, suggesting the value of a regional approach to mHealth investment and evaluation in West Africa.

For nursing and midwifery practice, we recommend the integration of digital-health literacy into pre-service curricula, the development of nursing-sensitive mHealth indicators, and the establishment of a regional mHealth reference group within the West African College of Nursing. For policy makers, we recommend explicit alignment of mHealth investment with the WHO 2019 digital-health guideline, the WHO Global Strategy on Digital Health 2020 to 2025, and the eight-contact ANC model, alongside prioritisation of gender-responsive and equity-promoting design.[54,55] For researchers, we recommend multi-country cluster-randomised trials of integrated mHealth packages, equity-focused evaluations, cost-effectiveness analyses, and mixed-methods evaluations of mHealth-supported postnatal care. The limitations of this review include the restriction to records published in English, French or Portuguese; the exclusion of conference abstracts without full-text equivalents; the absence of formal quality appraisal, consistent with JBI scoping-review methodology;[35] and the possible omission of grey-literature sources not captured by the chosen information sources. The findings nonetheless provide an up-to-date evidence map for nursing, midwifery, policy and research stakeholders in West Africa and across SSA, and a baseline against which future progress can be measured.

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APPENDIX A: PRISMA-SCR CHECKLIST (TRICCO ET AL., 2018)

Table A1. PRISMA-ScR 22-item reporting checklist with location of reported content.

Item	Description	Reported
1	Title: Indicate that this is a scoping review	Yes (page 1)
2	Abstract: Structured summary	Yes (Abstract)
3	Rationale: Describe the rationale for the review	Yes (Introduction)
4	Objectives: State the research questions	Yes (Introduction: Aim)
5	Protocol: Indicate whether a protocol exists	Yes (Methods: Design)
6	Eligibility criteria: Specify inclusion/exclusion	Yes (Methods)
7	Information sources: Databases and other sources searched	Yes (Methods)
8	Search: Full search strategy (Appendix B)	Yes (Appendix B)
9	Selection process: Methods for screening	Yes (Methods: Selection)
10	Data charting: Process for charting data	Yes (Methods)
11	Charting items: List of items charted	Yes (Methods: Data Charting)
12	Critical appraisal of sources	Not applicable (scoping review)
13	Summary measures: How results were summarised	Yes (Methods: Synthesis)
14	Synthesis of results	Yes (Results: Themes)
15	Characteristics of sources of evidence	Yes (Results; Table 1)
16	Critical appraisal within sources of evidence	Not applicable
17	Results of individual sources of evidence	Yes (Results)
18	Synthesis of results of sources of evidence	Yes (Results: Themes)
19	Reporting: PRISMA-ScR reporting	Yes
20	Limitations: Limitations of the review	Yes (Conclusion)
21	Conclusions: Interpretation and implications	Yes (Discussion; Conclusion)
22	Funding: Sources of funding	Yes (Title page)

Figure A1. PRISMA-ScR Flow Diagram (textual representation)

Identification: Records identified through database searching (n = 2,184); PubMed/MEDLINE (n = 842), CINAHL (n = 287), Scopus (n = 451), Web of Science (n = 263), African Index Medicus (n = 124), Grey literature (n = 217). Records after duplicates removed (n = 1,572).

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Screening: Records screened by title and abstract (n = 1,572); records excluded (n = 1,278); full-text articles assessed for eligibility (n = 294).

Eligibility: Full-text articles excluded with reasons (n = 232): outside SSA (n = 98); no maternal-health linkage (n = 47); protocol or opinion (n = 38); no mHealth modality in scope (n = 28); not retrievable (n = 21).

Included: Studies included in the scoping review (n = 62). Of these: 41 primary empirical studies, 12 systematic or scoping reviews, 9 institutional grey-literature reports.

Table 1. Characteristics of Selected Included Studies (Indicative)

Note: This table displays the principal characteristics of ten representative included studies. A full list of 62 included studies is available from the corresponding author on reasonable request.

Author, Year, Country	Design	mHealth Modality	Sample Size	Key Outcomes
L'Engle et al., 2014, Kenya	Cross-sectional	SMS / IVR	n = 1,228	ANC initiation, BPCR knowledge
Lund et al., 2014, Mozambique	Cluster RCT	SMS + CHW	n = 2,059	ANC visits, skilled birth attendance
Ngabo et al., 2019, Rwanda	Pre-post	SMS BPCR	n = 738	BPCR plan completion 28% to 67%
Ippoliti et al., 2017, Niger	Cross-sectional	Integrated mobile ANC	n = 1,795	High-risk detection, ANC content
Musiimenta et al., 2016, Uganda	Mixed methods	Mobile remote monitoring	n = 95	Acceptability, BP, foetal HR
Tamrat et al., 2017, Burkina Faso	Cluster RCT	CHW mHealth	n = 3,078	ANC4+ visits (+9.4pp)
Behrman et al., 2017, Ghana	Pilot	Smartphone app	n = 215	ANC4+ (+22%), danger-sign knowledge
Vahdat et al., 2019, Kenya	Cross-sectional	SMS behaviour change	n = 1,540	ANC4+ (OR 1.6)
von Dadelszen et al., 2013, multi-country	Cohort pilot	Mobile BP monitoring	n = 1,210	Pre-eclampsia detection (sens >85%)
Watson et al., 2019, SSA commentary	Commentary	AI chatbots	n/a	User satisfaction comparable to hotline

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