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Maternal Healthcare Access and Maternal Electronic Service Delivery in Resource-Constrained Environments: A Systematic Literature Review on Frameworks, Approaches, and Insights

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Background and Purpose: Ensuring the well-being of mothers and newborns is contingent upon guaranteeing access to maternal health services. However, marginalized communities in Developing Countries (DCs) often face obstacles in accessing these critical services, primarily due to limitations in the strategies and methods used to deliver maternal healthcare. These barriers encompass various challenges, such as geographical remoteness, inadequate infrastructure, and socio-economic disparities. Additionally, the limited availability of trained healthcare professionals and insufficient medical facilities exacerbate the situation. Overcoming these challenges necessitates a comprehensive review of the existing literature to find the best practices for integrating sensitive interventions, community engagement, and innovative technological solutions for the subject under investigation. This study was motivated by the imperative to investigate the integration of maternal healthcare services with e-services and assess the effectiveness and efficiency of existing approaches for accessing maternal e-services. This was driven by a sustained objective of enhancing maternal health service delivery using technologically supported platforms.

Methods: This study sought to answer the research question: "What are the strengths and weaknesses of existing frameworks for delivering and supporting maternal e-services?" A systematic literature review was conducted to address this, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model. This rigorous approach ensured inclusive coverage and transparency in selecting and analyzing relevant studies. The methodology involved systematically searching multiple online databases using a keyword-based search technique to identify studies focused on maternal healthcare services and delivering maternal e-services.

Results: The study highlighted numerous potential e-services for improving maternal healthcare, yet their implementation appears uncertain due to the limited effectiveness of existing approaches, which predominantly rely on traditional methods. While several e-service frameworks exist to guide maternal healthcare delivery, they predominantly focus on textual and voice-based maternal education, with limited attention to multimedia capabilities. The study developed a conceptual framework delineating the current state of maternal e-service delivery, emphasizing key domains as services supported by existing maternal e-service delivery frameworks and weighing a desired future state that integrates potential e-services to improve maternal healthcare and women's health.

Conclusion: The study emphasizes the urgency of exploring how technology-driven frameworks, especially those centered on mobile platforms, can integrate potential e-services to enhance maternal healthcare delivery. Bridging this gap holds the promise of revolutionizing maternal healthcare through effective maternal e-service delivery, making it more accessible and effective for women in need worldwide.

Keywords: Maternal e-services, maternal healthcare, health informatics, mobile health.

1 Introduction

Maternal health encompasses the well-being and healthcare of women and infants, which can be broadly categorized into three stages. The first stage is during pregnancy, commonly known as antenatal care (ANC)

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[1], [2]. During this stage, healthcare services are provided to monitor the pregnant woman's health and ensure the well-being of the developing fetus. The second stage is childbirth, often referred to as birth care [3]. This stage focuses on providing appropriate medical support and assistance during pregnancy, labor, and birth to ensure a safe and healthy birth. The final stage is the postnatal or postpartum care (PNC) period, which involves healthcare services and support for the mother and newborns in the weeks following childbirth [4]–[6]. This stage aims to address any potential complications, provide guidance on breastfeeding, and promote the physical and emotional recovery of the mother while ensuring the optimal health and development of the newborns [7]–[9].

Maternal health presents a vital component of population health that encompasses various dimensions of healthcare, including family planning, preconception care, prenatal care, and postnatal care, all of which are essential for the well-being of mothers and babies [10], [11]. It is closely linked to other aspects of women's health, such as reproductive health and general well-being, underscoring its importance in comprehensive healthcare [10], [11]. Therefore, it is essential to prioritize women's health and provide adequate maternal healthcare services to safeguard the lives of both mothers and newborns to support sustainable and unhindered population growth [12]–[14]. Maternal health services are essential for mothers' and infants' overall health and well-being [15]–[17]. The proper utilization of mainstream maternal health services plays a vital role in reducing mortality and morbidity [18]. This is possible through early detection of danger signs and management of potential complications associated with pregnancy and childbirth, as discussed earlier [19]. Several studies have indicated that if proper maternal care services are provided to mothers, fewer complications during pregnancy are anticipated with safe and successful delivery [20], [21].

Despite the discussed benefits of maternal care services, the actual utilization of these services remains low in many communities [22]. This is especially evident in low-resource settings, such as various Sub-Saharan African countries, including Uganda, Kenya, Tanzania, Nigeria, and Ethiopia, where healthcare delivery systems face numerous challenges [23], [24]. Key obstacles include a shortage of healthcare providers, long distances to healthcare facilities, financial limitations, limited awareness of the importance of maternal care, and compromised or substandard quality of care [25]. These challenges are compounded by traditional approaches to accessing maternal healthcare, primarily through antenatal care visits at health facilities and home visits by trained healthcare workers [26], [27]. Studies have underscored the importance of adequate maternal healthcare provision, revealing a multitude of risks that may compromise the well-being of both mothers and newborns if not addressed. These risks span a range of complications associated with pregnancy and childbirth, including preterm birth, low birth weight, and elevated maternal mortality rates, each carrying significant health impacts [28]–[30]. Maternal mortality compromises the population and lives of pregnant women and their newborns [31]. Statistics show that the global maternal mortality rate declined from 2000 to 2017 by 38%, derived from 342 to 211 deaths per 100,000 live births respective of the year range, giving the average annual reduction rate at 2.9%. Following the UN Sustainable Development Goal 3 - "Good Health and Well-being" projections show that by 2030, an annual rate of 6.4 % %is needed to achieve the global goal of 70 maternal deaths per 100,000 live births [8], [32], [41], [33]–[40]. Further studies showed that of the approximately 295,000 global maternal deaths, 94% occurred in countries with low resource settings, such as developing countries, especially in sub-Saharan Africa and Southern Asia [42], [43].

Despite the existing challenges in the delivery of maternal health services, it is a fact that many maternal care services can be enhanced and facilitated through technological innovations [27], [44], [45]. Therefore, it is crucial to embrace emerging technological trends and incorporate tech-related innovations in the provision and support of maternal care services. These innovative approaches, often referred to as maternal e-services, have the potential to overcome barriers and limitations in delivering adequate maternal healthcare [18]. By leveraging technology, such as mobile applications, telemedicine, and digital platforms, access to maternal care services can be improved, addressing the constraints and challenges that exist in traditional service delivery models. The paper is structured as follows: Section 2 outlines the methodology adopted in the study, followed by the presentation of results in Section 3. Section 4 provides a discussion of the findings, while Section 5 highlights the study's limitations. Finally, the conclusion is presented in Section 6.

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2 Materials and methods

The study utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Figure 1) to conduct a review of the literature concerning maternal healthcare and the provision of maternal e-services. This process began with the development of the research questions to direct the study's focus: "**What are the strengths and weaknesses of existing frameworks for delivering and supporting maternal e-services?**" In line with this question, the study contributes to knowledge in two key aspects. Firstly, it assesses the status of maternal e-service delivery by uncovering the current available maternal e-services and suggesting ways to enhance access to maternal healthcare through their expansion. Secondly, it synthesizes academic literature to analyze existing approaches in the delivery of maternal e-services, with a particular focus on how technology-based frameworks have facilitated and influenced the provision and support of these services. The PRISMA (Figure 1), an established model in literature reviews, facilitated the sourcing of numerous studies from scientifically recognized electronic databases. This model serves as a comprehensive guideline for conducting literature reviews, ensuring transparency and rigor in the review process. Subsequently, the review activity unfolded sequentially as follows:

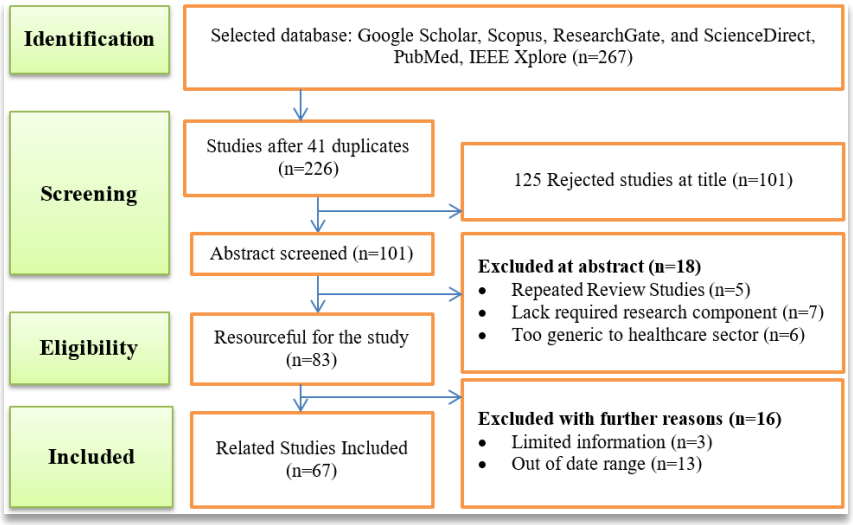

Figure 1. Flow diagram for the selection of related studies. **Source:** Author's synthesis(s) (2024)

The process of identifying and identifying relevant publications for the study involved the following steps:

- **Identification**: Studies were retrieved from scholarly databases, including Google Scholar, Scopus, ResearchGate, PubMed, IEEE Xplore, and ScienceDirect, following a systematic keyword search technique. The keywords used included but were not limited to maternal health AND maternal electronic health OR maternal electronic services, mobile health services AND mobile health, pregnancy OR prenatal care AND postnatal care, childbirth AND electronic intervention, electronic delivery AND digital intervention, AND digital health. In some instances, these keywords were used in combination to ensure a comprehensive search and retrieval of closely related studies. This strategy ensured that a broad spectrum of studies related to maternal e-services and maternal healthcare access at large was considered. As a result of this thorough search, a total of 267 articles were initially identified. However, upon closer examination, it was found that 41 of these articles were duplicates, which were subsequently removed from the pool, leaving a refined selection of unique studies for further review and analysis.
- **Publication screening**: The screening phase involved reviewing the titles and abstracts of the identified studies to assess their relevance to the research topic. Studies that are deemed irrelevant or do not meet the inclusion criteria are excluded at this stage. Out of the 226 studies after removing duplicates, 125 were excluded at the title screening stage (n=101), and 18 were excluded based on the abstract screening (n=83). Reasons for exclusion at the abstract screening phase include repeated review studies (n=5), lack of required research component, i.e., not focused on maternal healthcare

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access (n=7), and being too generic to the healthcare sector (n=6). The screening of the relevant details about the publications was accomplished by using advanced features of Microsoft Excel 2019, such as sorting and filtering, if and if else function, among others.

- **Eligibility of the publication**: Studies that passed the screening phase were further assessed for eligibility based on predefined criteria. A total of 83 studies were considered resourceful for the study after the screening phase. Out of these 83 studies, 16 were excluded for reasons including limited information as required by the researchers (n=3) and being out of date range (n=13) because the study focused on research published from 2015 onwards to ensure the inclusion of the most current and relevant data.
- **Publication inclusion**: Studies that meet all the inclusion criteria were considered relevant for the review and are included in the final review. In this case, 67 studies were included for further analysis

2.1 Some Common attributes of the selected publications

2.1.1 The exclusion and inclusion criteria

Numerous inclusion and exclusion criteria have been used because the publication selection procedure is important for adding scientific value to the literature reviews. Therefore, we decided to concentrate on research on maternal healthcare access and maternal electronic service delivery, particularly focusing on potential electronic services to maternal healthcare, potential insights on maternal electronic services to maternal healthcare, electronic service frameworks for maternal healthcare, and related works to maternal healthcare and developing solutions to the same. The modified inclusion and exclusion criteria are displayed in Table 1. The publications that were not published in the English language or ones that were still in publication at the time of selection were disqualified. The goal of our work was to examine maternal healthcare access and maternal electronic service delivery: strategies in resource-constrained environments; hence, we also incorporated quantitative, qualitative, and case study analyses. Additionally, a variety of epistemological stances were also adopted to emphasize the topic's multidisciplinary aspect.

Table 1. Inclusion and exclusion criteria of publications

Inclusion criteria	Exclusion criteria
Books, empirical studies, editorials, fields of social science, information science, economic science, humanities, English language articles, articles in academic journals, case studies, quantitative and qualitative analyses, and epistemological approaches	Summaries of conferences, convention lawsuits, book reviews, field of agriculture science, interviews, technical as well as health science, summaries of meetings, editorial letters; non-academic texts, and non-English papers, papers that were still in publication

Source: Synthesized by the Author(s) (2024)

2.1.2 Inclusion and exclusion criteria of frameworks for maternal e-services

The study emphasized analyzing existing frameworks for maternal e-services, adopting a different approach to identify, include, and exclude frameworks that have been studied to support access to these services. While some frameworks were identified based on the criteria outlined in Figure 1, others were not found. To source relevant frameworks, a comprehensive keyword search was conducted across online scholarly databases, as illustrated in Figure 1. The search specifically targeted practical electronic frameworks for maternal e-services rather than purely conceptual models. Key search terms included "maternal e-services frameworks," "approaches to maternal healthcare access," "digital frameworks for maternal health," "e-health interventions in maternal care," "mHealth solutions for maternal services," "electronic systems for maternal healthcare," and "maternal health digital access models."

Table 2. Inclusion and exclusion criteria of frameworks for maternal e-services

Inclusion Criteria	Exclusion Criteria
Practical Implementation: Frameworks that have been practically implemented and tested in real-	Conceptual Frameworks/Models: Frameworks that are purely theoretical or conceptual without practical implementation or testing.

world settings, as opposed to purely theoretical or conceptual models.	
Relevance to Maternal Health: Frameworks specifically designed to address maternal healthcare, focusing on improving access, quality of care, and health outcomes for mothers.	Non-Specific to Maternal Health: Frameworks addressing general healthcare or other areas not specifically focused on maternal health
Digital Solutions: Frameworks incorporating digital or electronic solutions, including mobile health (mHealth) applications, electronic health (eHealth) systems, and other technological interventions	Non-Digital Solutions: Frameworks that do not incorporate digital or electronic components.
Evidence-Based: Frameworks supported by empirical evidence demonstrating their effectiveness and impact on maternal health outcomes.	Lack of Empirical Evidence: Frameworks without supporting evidence or data on their effectiveness and impact.

Source: Synthesized by the Author(s) (2024)

2.1.3 Distribution of articles by publication year

The only publications released between 2015 and 2024 were chosen. To benefit from a period in which the associated theme, in addition to a viable dynamic, has found considerable resonance, publications on the topic should be as current as feasible. The review concentrated on reports written for maternal healthcare access and maternal electronic service delivery. Amongst the reviewed papers, 8 were published in 2019, 16 in 2020, 15 in 2021, 8 in 2022, and 10 in 2023; the years with the fewest publications were 2015, 2016,2017,2018, and 2024. Indicating the present interest in this area of study, the majority of the papers were published between 2018 and 2023 (Figure 2).

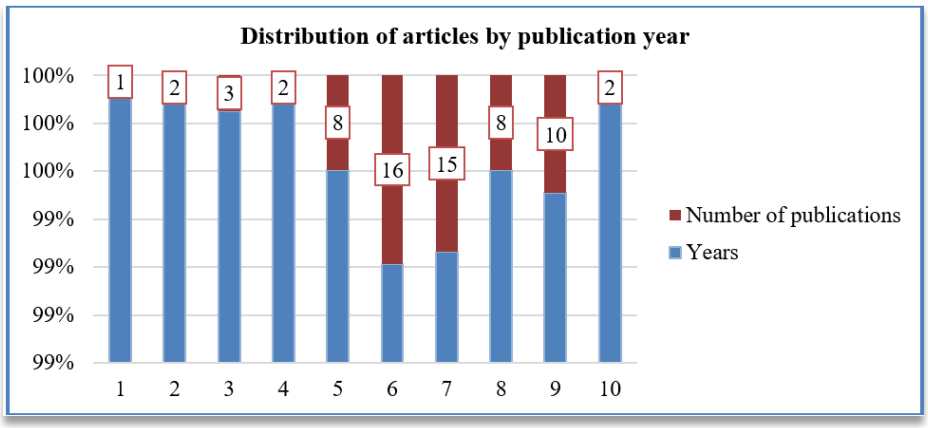

Figure 2. Distribution of articles by publication year.
Source: Synthesized by the Author(s) (2024)

2.1.4 Distribution of articles by database

Figure 3 shows the distribution of publications across various databases, with a focus on those related to the topic being studied. PubMed has the highest number of publications, with a total of 19, followed by Google Scholar and Scopus, with 17. ResearchGate and IEEE Xplore are also a significant source, contributing 6 publications, while Science Direct has the fewest in this selection, with 2 publications. Although other databases exist, such as CINAHL, Web of Science, and Embase, their publications were already included in the counts from the considered sources. In line with this study, the distribution indicates that PubMed is the most prominent source for publications relevant to the topic of this study, followed by Google Scholar and Scopus, suggesting these databases are particularly valuable for researchers in terms of maternal healthcare access.

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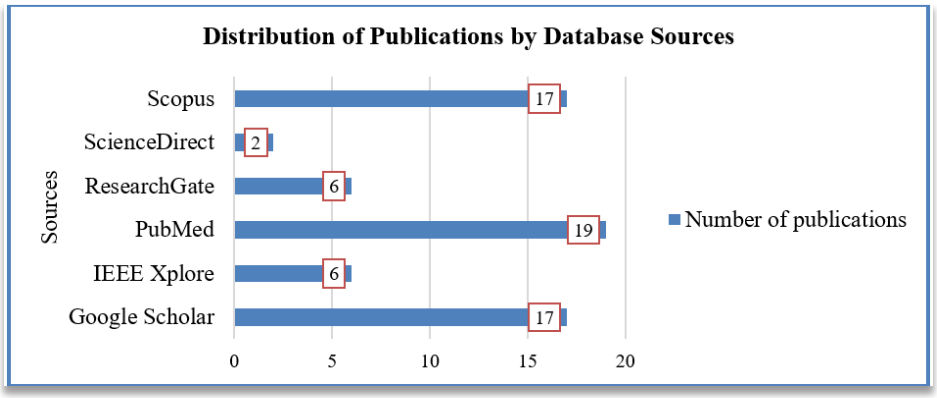

Figure 3: Distribution of publications by database Sources
Source: Synthesized by the Author(s) (2024)

3 Results

The results of this review study are presented in four sections: (3.1) the nature of maternal e-services, which discusses the state-of-the-art maternal electronic services identified in the literature review, followed by potential electronic services that could enhance access to maternal healthcare access and improve women's health; (3.2) traditional approaches to accessing maternal healthcare, which provides state-of-the-art insights into both maternal electronic services and traditional access methods found in the literature; (3.3) frameworks for maternal e-services, which details the state-of-the-art frameworks for electronic maternal healthcare services found in the literature review; and (3.4) related studies, presenting the state-of-the-art insights, challenges, and barriers toward accessing maternal healthcare as found in the literature review.

3.1 The nature of maternal e-services and potential maternal e-services

The nature of maternal e-services centers on the involvement of electronic technologies, such as the Internet and mobile phones, to deliver maternal healthcare services. These services can include online resources for pregnancy and childbirth education, telemedicine consultations with healthcare providers, and access to remote monitoring and support from healthcare professionals [46], [47]. The goal of maternal e-services is to improve access to healthcare and support for pregnant women and new mothers, particularly in areas where access to in-person healthcare may be limited, as well as in emergency-based situations [30], [48]. These services can be particularly useful for women who live in rural or remote areas or who have mobility issues that make it difficult to access in-person care [49]. The study identified the following as the potential e-services that can be considered to improve access to maternal healthcare.

a) **Maternal health education:** At each phase of maternal health, mothers are entitled to access information required for the management of conditions and complications specific to that particular stage [50], [51]. The necessity lies in obtaining this information from credible, accredited, and qualified healthcare professionals. This clarifies the reason behind the advice for mothers to regularly seek antenatal care from authorized healthcare service providers such as hospitals. This activity is termed the Antenatal Care Visits (ACV) [52], [53]. Moreover, after giving birth, new mothers are supposed to purposely acquire information to ensure the healthy living of both the mother and newborn baby. It is worth noting that the information provided after childbirth varies based on the mode of delivery, that is, vaginal delivery or cesarean section (c-section) [54]–[56]. Electronic delivery of information often prioritizes text-based formats like SMS and voice notes. However, it's crucial to acknowledge the potential of multimedia composition and delivery for digital content. This includes infographics, images, videos, animations, and text-based formats [57], [58]. Multimedia content delivery enhances comprehension and retention by leveraging visual elements, which are known to facilitate better recognition and understanding,

b) **Emergence support services**: Maternal life is fraught with various levels of risk, posing challenges and potential dangers to both mothers and infants [59], [60]. Complications can arise at any time, putting the lives of mothers and infants at risk [61], [62]. This imperative extends to new mothers, especially those

who undergo cesarean section deliveries, as they face a myriad of medical risks and complications that can adversely impact both their health and the well-being of their newborns [63], [64]. Following this situation, it's pivotal for research studies to investigate the potential of technology-based solutions to facilitate responses to emergencies linked with maternal health, thereby ensuring the protection of lives for both mothers and infants,

c) **Expert consultation services**: Pregnant and new mothers must consult health providers to seek health assistance in uncontrollable situations [65], [66]. Traditionally, maternal consultations have required mothers to visit healthcare facilities. However, various challenges, such as geographical distance, financial limitations, and a shortage of healthcare providers, often result in missed consultation appointments [67]. Missing dialogues with experts create potential vulnerability, which could lead to an escalation in maternal risks and complications. This situation places the lives of both mothers and infants in a state of uncertainty and heightened danger [68], [69]. Therefore, it is essential to establish a framework that outlines the integration of technology to assist in remote consultations for better maternal health care and

d) **Medical prescriptions and investigations services**: Similar to other aspects of healthcare, maternal well-being involves the administration of prescribed medications and necessary medical tests/investigations [70]. These interventions are designed to promote health outcomes for both mothers and infants. Urgency intensifies, particularly for mothers who undergo cesarean section, owing to their heightened susceptibility to various health complications and risks [71], [72]. Nevertheless, there are instances where the dosages of these drugs and medications are overlooked, leading to terrible situations in which lives are put at risk [73], [74]. Despite the critical nature of this aspect, the existing frameworks for maternal e-services lack specific guidelines for addressing the management of medications and medical procedures through technological interventions. This emphasizes the necessity for research to investigate how e-service frameworks can guide the management of medical prescriptions to enhance adherence during maternal life.

3.2 Traditional approaches for maternal healthcare access

Scholarly literature highlights a range of e-services that have the potential to enhance access to maternal healthcare. However, their implementation remains limited by the absence of well-established frameworks and approaches, particularly within the digital ecosystem. As a result, traditional methods continue to dominate the delivery and support of maternal healthcare services in resource-constrained countries. While these conventional approaches have facilitated access to some extent, they face several challenges that undermine their effectiveness, as outlined below.

a)In-person visits to health facilities: In-person visits to health facilities, commonly known as antenatal care (ANC) visits, are crucial to accessing maternal services [26]. During these visits, healthcare professionals engage in direct dialogues with pregnant mothers to assess their health, provide specialized care, conduct check-ups, offer health education, and address concerns [46], [75]. ANC visits also allow for necessary medical procedures, immunizations, and mental health monitoring However, there are limitations to ANC visits, including distance and transport costs for mothers and long waiting times due to a limited number of healthcare practitioners [62], [76].

b) Home Visits by healthcare workers: Home visits by trained health workers are a valuable method of accessing maternal services, especially for expectant and new mothers who face barriers to attending ANC visits [77], [78] Health professionals provide personalized care, including health advice, prenatal check-ups, and assessing the mother's living conditions [27]. However, challenges such as long distances and limited healthcare workers restrict the widespread implementation of this method [79]–[81]. Additionally, it may not be suitable during situations where physical meetings are prohibited, such as pandemic and endemic situations.

c) Use of Phone calls for consultation purposes: Mothers commonly use phone calls to access maternal services, allowing them to seek medical advice and receive health education remotely [65], [82]. This method offers convenience and eliminates barriers associated with in-person visits, making it particularly useful during situations like pandemics [25], [66]. However, the effectiveness of this method is limited as it provides fewer services compared to in-person visits and lacks a reference source for shared information. This highlights the need for better approaches that support the diverse sharing of maternal information with attention to multimedia integration.

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3.3 Analysis of frameworks for maternal electronic services access

With the advent of technological advancements, the healthcare sector has witnessed transformative interventions aimed at enhancing service access and improving care quality. Within the realm of maternal health, numerous studies have highlighted the emergence of potential solutions leveraging technology to facilitate the provision of maternal healthcare services, particularly by aiding mothers in accessing critical resources through technology-based platforms. As mobile devices, such as smartphones and tablets, become increasingly integrated into communities, mobile technologies are recognized for their potential to enable access to maternal e-services. This study delved into the examination of existing frameworks guiding the design and development of technology-based applications for maternal e-service access, elucidating prevalent approaches and practices in this domain. Table 2 summarizes these frameworks, reflecting the name of the framework, Strengths/Services Supported, and areas that require Improvement (weakness/loopholes).

a) The mobile health communication framework for postnatal care

Employing a multi-method research approach, as illustrated in the works by Mbuthia et al. [83], [84] yielded the development of a theory-driven framework designed to improve postnatal care in rural Kenya through mobile health communication. This innovative framework was constructed by amalgamating the most robust available evidence on mobile health communication, along with valuable insights gleaned from both users and policymakers. Consequently, Mbuthia's framework sheds light on the pivotal role of mobile communication, particularly through the exchange of mobile messages (SMS), as a critical strategy for fostering the adoption of postnatal care practices in rural Kenya. However, it is crucial to acknowledge that the scope of Mbuthia's framework is circumscribed solely to the domain of postnatal services. While it excels in addressing postnatal care uptake, it leaves out other critical stages of maternal care and overlooks the vast potential of various other maternal e-services.

b) The mHealth Messaging Service Framework (MomConnect)

MomConnect, originating in South Africa, is a noteworthy mobile health framework designed with the primary objective of delivering essential maternal education and information to mothers, with the ultimate aim of enhancing maternal and child health outcomes [85]. This framework guides leveraging Short Message Service (SMS) technology to offer information and support to expectant and new mothers. The practical implementation of this framework materialized through the development of the MomConnect application, which has demonstrated its effort to reach a diverse number of women, including those residing in underserved regions [86]–[88]. MomConnect’s personalized approach, which allows mothers to filter and receive messages tailored to their needs, has notably increased the utilization of maternal health services [14], [88]–[90].

c) The Mobile Alliance for Maternal Action Framework

The Mobile Alliance for Maternal Action (MAMA) framework is a remarkable product of a collaborative effort between the public and private sectors [91], [92]. This initiative centers on the integration of mobile technologies as a means to disseminate critical healthcare information to mothers residing in resource-limited settings, with the ultimate goal of enhancing their health and overall well-being. MAMA was introduced to engage healthcare experts in the practice of mobile health messaging, directing its efforts towards subscribed mothers and imparting essential knowledge on a wide range of topics, including pregnancy, infant care, HIV prevention, infant feeding, and post-partum family planning. The achievements of MAMA are truly commendable, having made a significant impact by reaching approximately 600,000 mothers and their families across nearly 60 countries, fostered through partnerships with over 235 organizations. This has addressed the challenge of providing maternal health education to economically disadvantaged mothers, who often encounter barriers in accessing crucial healthcare information [93].

d) AI Pregnancy companion chatbot framework

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The AI-enabled framework known as the PCC (Pregnancy Care Companion) represents a notable innovation in the realm of maternal education [94], [95]. This framework harnesses modern technology, leveraging Amazon Web Services and Alexa, Amazon's AI-powered virtual assistant, to deliver maternal education through text- and voice-based interaction. PCC addresses the limitations commonly observed in text-based frameworks, such as MomConnect and MAMA Technology, by offering voice-based interactions, enabling pregnant mothers to receive real-time AI-generated responses to their health inquiries [96]. The accuracy and reliability of PCC's implementation have been robustly established through rigorous testing on Amazon Echo Dot devices. PCC's distinguishing feature lies in its interactive voice-based approach, which surpasses traditional text-based platforms in addressing maternal health concerns [97]–[99].

e) AI framework for fetal health status prediction

The Fetal Health Status Prediction Framework (FHSP) is an e-health framework specifically designed to aid in the prediction of fetal health status by harnessing the capabilities of machine learning algorithms [100]. FHSP is distinguished by its utilization of algorithms trained on maternal clinical history data, enabling accurate health predictions. These algorithms include a diverse array of models, such as averaged perceptron, boosted decision tree, Bayes point machine, decision forest, decision jungle, locally deep support vector machine, logistic regression, neural network, and support vector machine. FHSP collects health and clinical history information from pregnant mothers through an assessment form, utilizing these data to generate predictions encompassing medical recommendations, potential risks, and mitigation criteria [101]. As an AI-driven tool, FHSP is a valuable resource for maternal health screening.

f) KIA e-health framework for maternal and child health services

Hayati et al. [102] explain the development of an Android-based application, KIA, designed to modernize the delivery and accessibility of maternal and child health services in Indonesia. This approach was underpinned by the implementation of the KIA E-Health Theoretical Framework, which placed maternal health information provision at its core, encompassing various facets of maternal health, including prenatal and postnatal care and family planning. The framework organized the information domain into user-friendly services, which included immunization information, health-related content, pregnancy calculators, weight tracking for pregnant women, a fertility calculator, and a survey tool. The KIA Framework received favorable acceptance and usability feedback following rigorous testing of the KIA Application. However, it's important to note that while KIA demonstrated strong features and promise in the realm of maternal information delivery, it falls short of being a better framework for maternal services. Its primary focus on the information domain leaves the other vital domains unaddressed.

Table 3. Summary of existing frameworks for maternal e-services

Name of the Framework	Strengths/Services Supported	Weakness / Suggested Areas of improvement
The Mobile Health Communication Framework for Postnatal Care in Rural Kenya (mHCFPC)	Maternal Health Education through Voice based interactions	Lacks Multimedia Capabilities. Only focus on Maternal education leaving other services
The Mobile Health Messaging Service and Helpdesk Framework for South African Mothers (MomConnect)	Maternal Health Education through text-based SMS	Lacks Multimedia Capabilities. Only focus on Maternal education leaving other services
The Mobile Alliance for Maternal Action (MAMA) framework	Maternal Health Education through text-based SMS	Lacks Multimedia Capabilities. Only focus on maternal education leaving other services No filtration of what should be received.

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AI Pregnancy Companion Chatbot (PCC) Framework	Maternal Health education and support through both text and voice-based interactions	Still limited to multimedia capabilities and also the coverage of maternal services is only on maternal education
AI Framework for FHSP	Automated assessment with smart recommendations and maternal education support	Lacks multimedia capabilities and coverage of maternal services is low
KIA E-Health Framework Maternal and Child Health Services in Indonesia	Maternal Health Education through text and Voice-based communications	Lacks Multimedia Capabilities. Only focus on Maternal education leaving other services

Source: Synthesized by the author(s) (2024)

3.4 Studies on insights, challenges towards maternal healthcare access

Pant et al. [25] conducted a study to assess the impact of the emerging COVID-19 pandemic on the provision and accessibility of maternal health services. Employing a narrative review approach, their study sheds light on the myriad challenges introduced by the pandemic that significantly hindered women's ability to access essential healthcare facilities for maternal health needs. These obstacles encompassed a range of factors, including pandemic-related restrictions, transportation difficulties, and heightened concerns about potential exposure to the coronavirus. A critical finding of this study was that a substantial number of women opted to seek hospital-based services, including essential antenatal care visits. The decision is largely driven by the fear of contracting the virus or transmitting it to unborn children. Even for those who managed to reach healthcare facilities, timely care was not consistently provided. This alarming trend has contributed to a significant increase in global maternal mortality rates during the pandemic.

Abejirinde et al. [103] conducted a realistic review to explore the capacity of mobile health technology to enhance the usefulness of maternal healthcare practitioners in low and middle-income nations. The primary motivation behind their research was to uncover the untapped potential of mHealth in improving maternal healthcare provision through healthcare workers. Findings revealed the considerable impact of implementing mobile health solutions on enhancing the proficiency of healthcare workers involved in maternal health.

Indira & Srihari [104] developed a conceptual framework for investigating the efficacy of text messages in the context of maternal healthcare. This study highlights the growing prevalence and user-friendliness of mobile communication, which has paved the way for the adoption of mobile applications to manage diseases and promote healthy behaviors. Beyond the advantages of facilitating health education among patients and reducing waiting times and healthcare expenses, mHealth has emerged as a potent tool for enhancing patient support. It offers a robust platform for swift emergency response and continuous monitoring of patient health status. Consequently, this study illuminates a conceptual framework that elucidates the vast potential of mobile phones in delivering health messages, particularly in providing critical support to mothers throughout their maternal journeys.

The study conducted by Bekyieriya et al. [82] sheds light on the significant potential of mobile health technologies in delivering maternal health services, particularly to expectant mothers in rural areas. The primary objective of their research was to assess the level of awareness among women about Mobile Health (mHealth) technology and identify the challenges faced by these women when attempting to utilize mHealth technology to improve maternal health outcomes in rural areas within the Upper West Region (UWR) of Ghana. To achieve their research goals, the team employed an exploratory design complemented by quantitative data collection tools, most notably semi-structured interviews. Through this approach, they were able to discern that many mothers in remote areas were aware that mHealth is a crucial source of health education information. Information is typically provided by healthcare providers to assist mothers in various aspects of pregnancy activities. However, their study revealed slow adoption of these technologies, primarily attributed to factors such as low female literacy rates within households, financial hardships, deeply ingrained cultural beliefs, network connectivity issues, and other related challenges.

A qualitative study by Mwase et al. [105] explored the implementation and use of toll-free telephone lines (TFL) in four health facilities. These TFLS were established by Save The Mother (STM), aiming to connect vulnerable mothers to healthcare providers, thereby granting them access to maternal and newborn healthcare services, particularly essential information. The findings of this study indicated that the TFL

network played a crucial role in facilitating the delivery of health information to mothers and nurturing relationships between community members and healthcare experts. This was achieved by ensuring prompt responses to inquiries and facilitating timely referrals when necessary. This marked the value of the TFL approach in bridging the gap between healthcare providers and mothers, thereby enhancing maternal and newborn healthcare services.

The study conducted by Bilal et al. [106] , which focused on Africa, aimed to investigate the potential of telemedicine and digital health in improving access to maternal healthcare. Their findings underline the significant challenges faced by women in Africa when it comes to accessing maternal healthcare. As previously discussed, this study reinforced the notion that the delivery of maternal healthcare services remains a critical and fundamental approach to mitigating maternal mortality and morbidity along with their associated devastating consequences. Bilal et al. firmly asserted that the utilization of telemedicine and digital health holds great promise as an alternative means to enhance access to maternal healthcare. This potential lies in the ability of telemedicine and digital health to provide long-distance, real-time services, thereby mitigating various hardships related to geography and economic constraints, including issues such as transport costs, long distances to healthcare facilities, and financial challenges. Bilal et al. believe that with the adoption of these technologies, there is a strong possibility of achieving improved maternal health outcomes in the low-resource settings of African countries.

[108] piloted a quasi-experimental study in various regions of Ghana, with the primary objective of assessing the impact of technological interventions on maternal and child health. Their study involved the recruitment of both mothers and healthcare experts with an interest in T4MCH (Technology for Maternal and Child Health) interventions. The researchers and innovators of this study introduced the concept of T4MCH, which is designed to improve access to maternal healthcare services for expectant mothers and healthcare facilities. This was achieved through the implementation of a mobile-based application called SGS Collect. The application collected personal information from pregnant mothers during their antenatal care (ANC) visits and subsequently delivered SMS and voice-based messages to these mothers within a week. These messages were provided in both English and local languages using a multilingual feature. The key takeaway from this study, which is relevant to the current research, is the demonstration of technology's potential to support the delivery of maternal education. This serves as a reminder that many existing interventions predominantly focus on maternal health education as their core domain. This study highlights the need for a framework that extends beyond education to encompass a wider range of maternal services, ultimately aiming to improve access to and delivery of maternal healthcare services. Table 4 summarizes this related work by reflecting on the source/citation, results of the work, and contribution.

Table 4. Related Studies on Maternal Healthcare and Maternal Electronic Services

Citation/ Method	Results/Key Findings	Contribution/Relevance
Narrative Literature Review [25]	Women opted to forgo hospital-based services, including essential antenatal care visits due to COVID-19	It broadened perspectives on the feasibility of leveraging technology to deliver maternal services in pandemic situations
Realist review study [103]	Revealed the impact of implementing mobile health solutions on enhancing the proficiency of healthcare workers involved in maternal health	Highlights how the conceptualized health framework can improve access to maternal services through the involvement of health workers.
A pilot study at Coimbatore (India) [104]	Pinned the growing prevalence and user-friendliness of mobile communication through mobile apps to promote healthy behaviours	Yields vital insights into the transformative potential of mobile technologies in rendering maternal and health services.
Quantitative data using semi-structured interviews [107]	Many mothers in remote areas are aware of mHealth as a crucial source of health education information with a slow adoption of these technologies' due challenges like financial hardships etc.	Reinforcing the notion that existing health interventions often focus predominantly on maternal health education while side-lining other potential essential services

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Qualitative study [105]	Indicated that the TFL network played a crucial role in facilitating the delivery of health information to mothers and nurturing relationships between community members and healthcare experts	Emphasizes the need for innovative solutions to address and alleviate the limitations of the TFL approach
Literature Review [106]	Emphasized that utilization of telemedicine and digital health holds great promise as an alternative means to enhance access to maternal healthcare	Highlights the relevance and potential of telemedicine in the context of maternal health
Quasi-experimental study [108]	There was improved access to maternal healthcare services for expectant mothers and healthcare facilities through access to antenatal care voice and text messages powered by SGS Collect.	It served as a reminder that many existing interventions predominantly focus on maternal health education as their core domain for maternal e-service delivery

Source: Synthesized by the Author(s) (2024)

Literature has indicated the existence of several e-services that have the potential to alleviate the state of maternal healthcare access in developing communities. This is accompanied by several frameworks that have demonstrated the ability of technology to support maternal health through mHealth innovations and interventions. Numerous studies have concentrated on the potential of mHealth to support maternal education access via mobile messages, which are typically disseminated from healthcare providers to mothers, covering various topics. While there have been some attempts to explore voice interactions, such as in the PCC Framework, these initiatives remain in the minority. Despite their merits, current frameworks exhibit limitations in their concentration on maternal health education using text and voice communication methods. This underlines the necessity for a framework that expands the scope of covered maternal e-services, harnessing multimedia capabilities for content delivery and holistically addressing the needs of maternal care.

4 Discussion

Traditional maternal healthcare approaches, including antenatal care (ANC) visits, home visits, and phone consultations, offer valuable services but face significant limitations. ANC visits provide comprehensive medical care but are constrained by distance, costs, and limited healthcare personnel. Home visits address access barriers with personalized care but are resource-intensive and impractical during crises. Phone consultations offer convenience but lack the depth and scope of in-person interactions. These limitations highlight the emergence of several e-service frameworks that leverage digital technologies to integrate and enhance these approaches, providing better solutions to improve maternal healthcare delivery. Realizing the critical importance of maternal healthcare and women's health, several scholars have studied this area, highlighting the insights, challenges, and barriers to accessing this care. Extended studies developed frameworks that have potentially supported access to this crucial care. The findings of this study underscore the role of existing frameworks in enhancing maternal healthcare through digital means, particularly by providing accessible educational content to mothers. Frameworks like MAMA and MomConnect primarily rely on SMS messaging, which has proven effective in reaching mothers in various circumstances but faces limitations in message size and accessibility. To address these challenges, improved frameworks such as the KIA E-Health Framework and the AI Pregnancy Companion Chatbot (PCC) have introduced voice-based delivery, which is especially beneficial for visually impaired mothers and offers a more intuitive user experience.

However, this study identified a notable gap in current frameworks: the limited use of multimedia elements, such as images, animations, and infographics, which could significantly improve the comprehension and the impact of maternal healthcare information. Moreover, existing frameworks mainly focus on educational services, whereas a broader range of e-services like emergency support, telemedicine,

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and medication tracking could provide a more holistic approach to maternal and women care. As illustrated in Figure 4, this study developed a conceptual framework that serves as a structured model to provide a summative and graphical understanding of the insights, challenges, and barriers identified in maternal healthcare. The conceptualization's independent variables are the features and services provided by the frameworks, with existing ones primarily focusing on maternal education but often lacking support for interactive multimedia content. The dependent variables, which are the outcomes of these services, include improved access to healthcare and the quality of care for expectant and new mothers, ultimately leading to reduced maternal mortality rates. This illustrates how improving the independent variables can positively impact the dependent variables.

The conceptualized framework presents the following domains rooted in the potential services for maternal healthcare: **a) Maternal health education with multimedia support**: The domain goes beyond basic text-based information to incorporate engaging multimedia elements like videos, infographics, and interactive modules. This approach enhances comprehension, knowledge retention, and user engagement. **b) Emergency support: emergency support**: This concerns integrating emergency support services to assist mothers in urgent situations. This can be through real-time response to emergent situations, especially for pregnant mothers and C-section mothers. **c) Medications and Investigations Tracking**: This domain focuses on providing mothers with a secure and convenient platform to track their prescribed medications and test results electronically. This promotes medication adherence and facilitates informed communication with healthcare providers. **d) Remote consultations and appointment management**: This should focus on functionalities for scheduling appointments and conducting consultations with healthcare providers remotely via telemedicine. This purpose is to reduce geographical barriers and improve access to specialist care.

Determinants of the conceptualized framework refer to the expected outcomes of the potential e-services for maternal health that are put in place under a comprehensive framework, typically mobile health-driven, to guide how these services can be implemented and realized in the realm of maternal health. This presents the long-term goals resulting from improved access to maternal healthcare. They include the following: reduced maternal complications and health challenges: improved access to comprehensive health education, emergency support, and remote consultations can empower mothers to make informed decisions and address health concerns effectively, potentially leading to fewer complications and improved overall health. Lower risks of maternal mortality: Timely access to emergency support and improved monitoring of medication adherence can contribute to earlier detection and management of risks, potentially reducing maternal mortality rates. Enhanced care for mothers: E-services offer additional touch points for mothers to receive care and support throughout pregnancy and motherhood. This fosters a more comprehensive and patient-centered approach to healthcare delivery and Improved Emergency Response. The inclusion of a dedicated emergency support system allows for timely intervention in critical situations, potentially saving lives.

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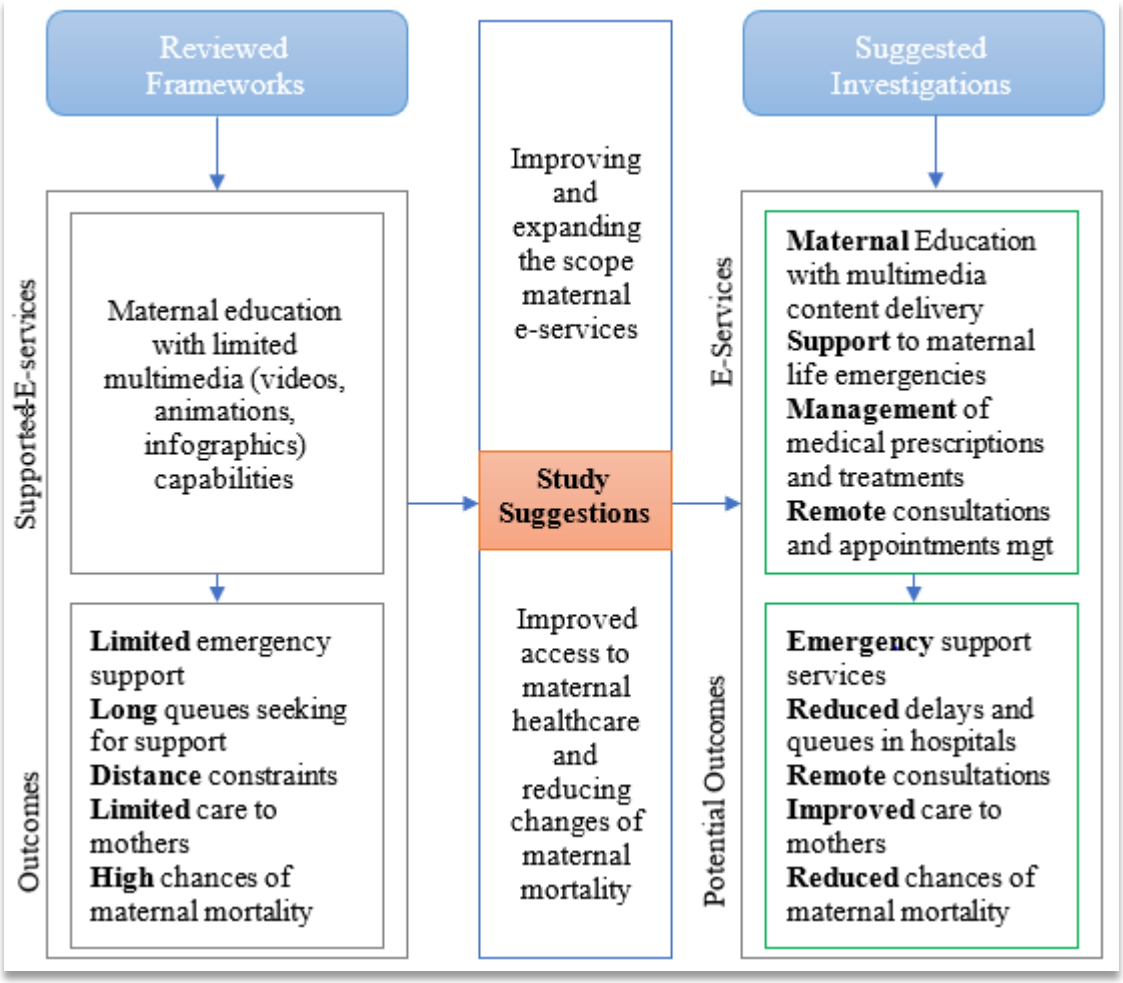

Figure 4. The conceptual framework.
Source: Synthesized by the Author(s) (2024)

5 Limitations

Firstly, the review relied heavily on studies from selected scholarly databases, which may have excluded relevant frameworks or insights not indexed in these sources. The review also did not conduct empirical assessments of the frameworks' effectiveness, relying instead on theoretical analyses of their components and published benefits. Lastly, the study was limited by a lack of region-specific analyses, which could have offered deeper insights into the unique challenges and needs within particular resource-constrained settings, especially in rural and low-literacy populations. These limitations highlight the need for further research that includes a broader range of sources, emerging technology assessments, and empirical validation of framework effectiveness across diverse geographical and demographic contexts.

6 Conclusion and Future Work

This paper highlights the urgent need to utilize technology-based approaches to enhance access to maternal services. The identified challenges in existing approaches, including limited healthcare providers, geographical barriers, financial constraints, lack of awareness, and restricted services, contribute to suboptimal utilization and negative impacts on maternal and infant health outcomes. Integrating technology can address these limitations and improve the quality of healthcare systems in developing countries. Therefore, further studies should prioritize investigating the necessary prerequisites for integrating

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technology platforms in the delivery of maternal services, with a particular focus on addressing the specific needs and limitations faced by marginalized communities with a realization of the identified potential e-services for maternal healthcare improvement. The exploration aims to mitigate the constraints associated with current approaches and enhance the accessibility and effectiveness of maternal healthcare. Future work can also look at including more studies while using other literature review approaches to minimize the potential bias in the selected individual studies.

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