IMPLEMENTING DIGITAL HEALTH FOR MATERNAL HEALTH IN NIGERIA: A LITERATURE REVIEW

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Implementing digital health for maternal health in Nigeria: a literature review

A thesis submitted in partial fulfillment of the requirement for the degree of Master of Science in Public Health

By

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Where other people's work has been used (from either a printed source, internet or any other source), this has been carefully acknowledged and referenced in accordance with departmental requirements.
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Abbreviations

AIDS – Acquired Immunodeficiency Virus

ANC – Antenatal Care

BMC – BioMed Central

CHW – Community Health Worker

CPR – Contraceptive Prevalence Rate

eHealth – Electronic Health

EmONC – Emergency Obstetric and Newborn Care

FMoH – Federal Ministry of Health

GGE – General Government Expenditure

HIV – Human Immunodeficiency Virus

HRH – Human Resources for Health

HW – Health Worker

ICT – Information and Communications Technology

IMNCH – Integrated Maternal, Newborn and Child Health

IVR – Interactive Voice Response

LMICs – Low and Middle Income Countries

mHealth – Mobile Health

MNCH – Maternal Newborn and Child Health

NBS – National Bureau of Statistics

NDHS – Nigerian Demographic Health Survey

NPC – National Population Commission

PDA – Personal Digital Assistant

PHC – Primary Health Care

PMTCT – Prevention of Mother to Child Transmission

PNC – Post Natal Care

SBA – Skilled Birth Attendance

SMS – Short Message Service

SSA – Sub Saharan Africa

TBA – Traditional Birth Attendant

UHC – Universal Health Care

UCL – University College London

VU – Vrije Universiteit

WBG – World Bank Group

WHO – World Health Organization

Key terms

Access: defined as the opportunity for people to seek, reach or use health services in proportion to their needs (Levesque J., Harris M. & Russell G., 2013)

Digital health: "a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas, such as the use of advanced computing sciences in 'big data', genomics and artificial intelligence" (WHO, 2019a, p. ix)

Digital health application: the software and technology systems used for health (WHO, 2019a, p. 91)

Digital health intervention: "a discrete function of a digital technology to achieve health sector objectives" (WHO, 2019a, p. 91)

eHealth: "the use of information and communications technology in support of health and health-related fields" (WHO, 2019a, p. ix)

Enabling environment: "attitudes, actions, policies and practices that stimulate and support the effective and efficient functioning of organizations, individuals and programmes or projects" (WHO, 2019a, p. 91)

mHealth: "the use of mobile wireless technologies for health" (WHO, 2019a, p. ix)

Scale-up: the expansion of interventions from pilot stage to fully operational projects (Kenny G. et al. 2017)

Telemedicine: remote consultation or delivery of health services at a distance (WHO, 2019a)

Utilization: defined as realized access – the extent to which individuals actually use health services or their health service needs are fulfilled (Levesque J., Harris M. & Russell G., 2013).

Abstract

Background: High maternal mortality is a major public health problem in Nigeria. The use of digital technology to address health system barriers is a growing area that has shown positive developments and potential for improving health outcomes including maternal health. Many interventions, however, fail to develop past the pilot stage which limits their ability to effectively impact health system outcomes. Understanding the implementation process and underlying factors can help address slow adoption and increase expansion of innovations.

Methodology: A literature review was done by searching PubMed, Science Direct and Scopus databases. The four-phase model of program implementation and the components of the eHealth enabling environment were used as a framework to structure and analyze the findings.

Results: Key findings revealed a predominance of mHealth interventions. Emphasis of most studies was on the early phases of implementation, with limited evidence addressing sustainability. Enabling factors of implementation include community engagement and health worker support, technology adaptation to local context, service integration and health system support. Challenges were mainly infrastructure related such as power supply, network connectivity and mobile phone access.

Conclusion: The applications of technology in maternal health are diverse and the benefits wide-ranging. Adoption and implementation can be improved by leveraging on and prioritizing the roles of the target community and health workers as well as the existing health system. Providing comprehensive services through integration and a combination of approaches is important for intervention success. Further research is needed for evidence to inform sustainability and scalability of interventions.

Key words: maternal health; mHealth; eHealth; Nigeria; Africa

Word count: 12,971

Introduction

Nigeria has one of the highest number of maternal deaths in the world with an estimated maternal mortality ratio of over 900 deaths per 100,000 live births in 2017 (WHO, 2019b). Many cases of maternal mortality are a result of poor access to quality maternal health services. In recent years, digital technology has been used to address some of the many barriers to access.

This topic was inspired by my long term interest in maternal health issues in public health. Pregnancy and childbirth are life-changing and memorable experiences for many women and naturally as a woman, this critical period and its attendant problems and interventions are of interest and importance to me.

Digital health is a growing field of practice in health that refers to the use of digital technologies specifically in support of health and health-related issues. According to the World Health Organization (WHO), the term digital health refers to "eHealth (which includes mHealth), and emerging areas, such as the use of computing sciences in the field of artificial intelligence, big data and genomics" (WHO, 2019a, p. 91). It includes eHealth i.e. the application of information and communications technology (ICT) in health, of which mHealth (mobile wireless technologies for health) is also a subset (WHO, 2019a).

The rapid proliferation of technology, especially mobile technology has inspired the application of digital health in alleviating health service and system challenges in different areas including maternal health (WHO, 2019a). This innovative approach to healthcare is largely driven by the ubiquitous nature of the technology, its relatively low cost and accessibility in low-resource settings (WHO, 2019a), with many low and middle income countries (LMICs) achieving over 90% of mobile penetration (UCL, cited in Feroz, A. et al. 2017). Many mobile applications have been shown to increase access to health services and information, improve health care quality & coverage and promote behavior change for disease prevention (WHO, 2018). They help facilitate timely referrals of pregnant women, increase utilization of antenatal care (ANC) services and skilled birth attendance (SBA) and improve health worker knowledge and skills in basic obstetric care (Amoakoh-Coleman M. et al. 2016).

In Nigeria, technological application in maternal health is only slowly gaining ground. In spite of the positive developments and increased interest, very few mobile technology solutions move beyond small-scale pilots to become fully operational (FMoH, 2014; Wallis et al. 2017). It is hoped that by exploring the process and underlying factors of implementation of digital health interventions for maternal health, this review can contribute to the evidence required for improved adoption and expansion of technology solutions for maternal health in Nigeria

Chapter 1: Background of Nigeria

1.1 Geography, Demography and Population Overview

Nigeria is a country located in the west coast of Africa, along the Gulf of Guinea on the Atlantic ocean in the south, extending to the Sahara Desert in the north. It is bordered by the republics of Niger and Chad in the north, the Republic of Cameroon to the east and the Republic of Benin to the west (see fig. 1).

Fig. 1: Map of Nigeria

Source: NPC and ICF (2019) Nigeria Demographic and Health Survey 2018

It is made up of 36 states and a Federal Capital Territory. The states are grouped into six geopolitical zones: North Central, North East, North West, South East, South South and South

West (NPC and ICF, 2014). According to the World Bank Group (WBG), Nigeria has an estimated population of 202 million people, making up about 50% of West Africa's population (WBG, 2019). Its population structure is young with persons aged 15 years and under constituting 45%. Women of reproductive age make up 22% of the population (NBS, 2018).

1.2 Socio-cultural, Educational and Socio-economic Context

Nigeria is an ethnically and culturally diverse country, with over 370 ethnic groups, of which the Hausa, Yoruba and Igbos make up the major groups (NPC and ICF, 2014). Although progress has been made in terms of socio-economic development in recent years, large segments of the country's population still live in poverty and lack access to basic services (WBG, 2019). A survey by the National Bureau of Statistics (NBS) in 2019 showed that 40.1% of the total population are considered poor as they live below the national poverty line. Poverty levels are reported to be significantly higher in rural areas (52.1%) compared to urban ones (18%) (NBS, 2019). The instability due to insurgency in the country in recent years, particularly in the North East, contributes to the regional inequality and limited access to economic opportunities (WBG, 2019).

Education, a key factor strongly associated with income level, shows variation according to gender, as men are overall better educated compared to women. According to the Nigerian Demographic Health Survey (NDHS), 35% of women have no education compared to 22% of men, while 23% of women have completed secondary education compared to 32% of men (NPC and ICF, 2019). Other gender disparities include variations in employment level (86% of men employed compared to 65% of women) and in mobile phone ownership (80.6% for males and 55.3% for females) (NPC and ICF, 2019). Gender issues are heavily influenced by patriarchal society norms as reflected by women's participation in household decision-making - 37% of married women reportedly do not participate in decisions concerning household purchases, healthcare or family visits (NPC and ICF, 2019).

1.3 Healthcare System and Health Situation Overview

The Nigerian healthcare system consists of public and private sector health services along with traditional health providers. The government is responsible for public health sector services within its three tiered system – local governments provide primary care, state governments provide secondary care, while the federal government is responsible for tertiary care. The private sector plays a significant role in healthcare delivery as it provides around 60% of healthcare services (FMoH, 2018). The country's healthcare system in general is fraught with many challenges including poor infrastructure, inadequate funding, inequitable distribution of health resources, lack of skilled health workforce and limited access to health services (FMoH, 2018). Government funding for health is low with only 4.6% of total general government expenditure (GGE) spent on health in 2017 (WHO, 2017). Reliance on out-of-pocket spending is thus high at 77.2% (WHO, 2017).

The country also struggles with a high burden of communicable diseases such as malaria and HIV/AIDS, which constitute the leading cause of morbidity, as well as the threat of increasing non-communicable diseases (FMoH, 2018). Health facilities and resources are overburdened by the rapidly growing population. This, in addition to weak governance and coordination mechanisms, result in poor national key health indicators (FMoH, 2018). For instance, from the 2018 NDHS, under-five mortality rate and infant mortality rate were 132 deaths per 1,000 live births and 67 deaths per 1,000 live births respectively (NPC and ICF, 2019).

1.3.1 Overview of Maternal Healthcare

Maternal mortality in Nigeria is significantly high and constitutes a major public health concern in the country. According to the NDHS 2018, Nigeria has an estimated maternal mortality ratio of 512 maternal deaths per 100,000 live births (NPC and ICF, 2019). However, the reliance on the sisterhood survey method as a source of data by the NDHS (NPC and ICF, 2019) and the lack of well-functioning civil registration systems (WHO, 2019b), pose the continuous challenge of data accuracy and availability (FMoH, 2018). According to 2017 WHO estimates, maternal mortality in Nigeria is much higher, at around 917 per 100, 000 live births (WHO, 2019b).

The low level of facility deliveries and skilled birth attendance (SBA) are contributory factors to Nigeria's high maternal mortality, as only 39% of live births took place in a facility in 2018, while less than half of deliveries (43%) were assisted by a skilled provider (NPC and ICF, 2019). High fertility and low contraceptive uptake are also associated with maternal mortality in the country. The total fertility rate is 5.3 children per woman. In 2018, the NDHS reported contraceptive prevalence rate (CPR), which is the percentage of women using any contraceptive method, as 17% among currently married women age 15-49, 12% of whom use a modern method (NPC and ICF, 2019). This falls short of the Federal Ministry of Health (FMoH) 2020 target of 27%. Unmet need for family planning i.e. proportion of women who are not pregnant and want to postpone or stop childbearing, but are not using contraceptives, is 19% (among currently married women age 15-49) (NPC and ICF, 2019).

Chapter 2: Problem statement, justification for the research, objectives and methodology

2.1 Problem statement and justification for the research

Maternal mortality is a major public health problem the world over, with almost 300,000 women dying from causes related to pregnancy and childbirth in 2017 (WHO, 2019c). LMICs are disproportionately affected as 94% of all maternal deaths occur there (WHO, 2019c). In 2017, according to the WHO, Nigeria alone accounted for 23% of all global maternal deaths and recorded one of the highest estimated national numbers of maternal deaths in the world with approximately 67,000 deaths (WHO, 2019b). Many of these women die due to complications such as severe bleeding during pregnancy and childbirth, arising from delay in access to quality services (WHO, 2019c).

A major contributing factor to high maternal mortality is inequality in access to quality health services which is largely a manifestation of the gap between the rich and the poor (WHO, 2019c). Other barriers preventing access are distance to facilities, lack of information and insufficient skilled health personnel (Al Dahdah M. et al. 2015; WHO, 2019c).
The wide-ranging effects and consequences, from health to socio-economic outcomes, explain the prioritization of maternal health in many developing countries. The absence of a mother due to illness or death can set in motion a spiral of poverty and limited opportunities for her children and family as a whole, as many women contribute significantly to household revenue and are the primary care-givers (WHO, 2014).

To reduce maternal morbidity and mortality, the barriers limiting access to quality healthcare in pregnancy and during and after childbirth need to be addressed. It is important that vital services such as ANC, SBA, and emergency obstetric care are provided to improve maternal health. Preventing unwanted pregnancies by increasing access to contraception is also key in avoiding maternal deaths (WHO, 2019c).

Rapid development of technology has led to the growing field of digital health, which entails the application of technology for the purpose of healthcare. Digital technology has the ability to improve healthcare access and coverage by overcoming existing systemic challenges (WHO, 2019a). According to the WHO, digital technology includes the use of ICT (eHealth) as well as mobile technology (mHealth) (WHO, 2019a). Telemedicine provides medical consultation across long distances, patient data can be monitored and tracked using digitized wearable devices, while the use of electronic medical records has greatly improved health information management (Lupton D., 2014). Widespread access and use of mobile phones, particularly in developing countries, has encouraged more investment and development of mobile health innovations for implementation of digital health (WHO, 2019a). Mobile applications have demonstrated the potential to improve health service delivery by improving data collection, information and time management and enhancing clinical decision-making (Kenny G. et al. 2017; Labrique A.B. et al. 2013). Health system barriers like limited access to training and effective supervision for health workers have been surmounted using mobile technology (Otu A. et al. 2016).

In maternal health, there is growing acknowledgement of the potential of digital health technologies to address maternal mortality, especially in developing countries (Ag Ahmed M.A. et al. 2017). A systematic review of technology-enabled interventions in maternal health revealed that they can be used not only to provide information, but for patient reminders, emergency response and monitoring, thus addressing the issues of access to information and inadequate human resource (Sondaal S.F.V. et al. 2016). Several other

reviews also show increased utilization of maternal health services associated with mobile technology interventions, including uptake of ANC and SBA (Al Dahdah M. et al. 2015; Lee S.H. et al. 2016; Obasola O.I. et al. 2015). Digital health interventions, when integrated with existing, non-technological interventions, have also shown positive results. A systematic review showed that health system and capacity improvements in health workers have been achieved through application of free mobile communication network between clients and providers in combination with health system strengthening, training and community support groups (Sondaal S.F.V. et al. 2016).

However, reviews show that large-scale implementation of technology interventions remains low in developing countries, with many projects unable to move past the pilot stage (Luna D. et al. 2014; Tomlinson M. et al. 2013; Wallis L. et al. 2017). This is attributed to the shortage of evidence necessary to establish the impact of digital health interventions on health system outcomes (Chib A. et al. 2014; Labrique A.B. et al. 2013). Systematic reviews of studies in developing countries, including sub Saharan Africa (SSA), reveal a lack of data supporting effectiveness of interventions (Blaya J., Fraser H. & Holt B., 2010; Tomlinson M. et al. 2013), as well as details of implementation mechanisms and pathways (Ag Ahmed M. A. et al. 2017; Lee S.H., 2016). The inconsistency of study results as indicated in several reviews, highlights the need for more rigorous research (Chib A. et al. 2014; Lee S.H. et al. 2016; Sondaal S.F.V., et al. 2016; Tomlinson M. et al. 2013). Low adoption and sustainable implementation of interventions have also been attributed to infrastructural issues, poor user perception of technology, low digital literacy, usability and acceptability (Kenny G. et al. 2017; Kruse S. C. et al. 2016; Wallis L. 2017).

In Nigeria, mobile phone penetration has increased rapidly, almost doubling in under a decade, making it a potentially effective tool for reaching a large segment of the population (GSMA, 2014). The growing interest in digital health globally, has given rise to several initiatives in the country – current efforts are however fragmented and short-lived (FMoH, 2014; Ohuruogu V., Flores P. & Foh K., 2015) as well as uncoordinated with duplication of activities resulting in inefficient use of resources (FMoH, 2016). With the country's high number of maternal deaths, and in light of the positive applications of digital technology in health, Nigeria cannot afford to ignore the potential benefit from effective implementation of technology dedicated to the improvement of maternal health outcomes. With the rapid developments and innovations in ICT, failure to effectively explore, implement and integrate the digital health option in the health system will result in a missed opportunity to significantly accelerate current efforts aimed at reducing high maternal mortality in the country (Tamrat T. & Kachnowski S., 2012).

In order to improve the development and implementation of digital health for maternal health in Nigeria, it is necessary to understand the successes, challenges and lessons learned in similar contexts. It is also important to have evidence to inform sustainable implementation and scale-up of interventions (Ag Ahmed M. A. et al. 2017; Tomlinson M. et al. 2013). Policy-makers, funders and planners need robust and convincing evidence to make informed choices with regards to digital technology interventions (Chib A. et al. 2014; Lee S. et al. 2016). They need credible information to determine the value of digital health in terms of health outcomes in comparison with other essential health interventions; if they can serve as a replacement or supplement to non-digital interventions (Labrique A.B. et al. 2013). It is thus important to summarize the available information on the implementation and feasibility of digital health for maternal health in similar contexts to contribute to improving knowledge for efficient and sustainable implementation in Nigeria.

The outcome of interest for this review is behaviour change which includes increased ANC attendance, facility deliveries or SBA and post natal care (PNC) attendance, uptake of contraceptives and utilization of emergency obstetric care, as they are essential health services crucial for maternal survival.

2.2 Objectives of the thesis

The overall objective of this paper is to synthesize and review evidence on implementation and feasibility of digital health interventions for maternal health in SSA, in order to provide recommendations for improved implementation, sustainability and scale-up in Nigeria.

Specific objectives:

I. To assess the implementation of digital health interventions for maternal health in SSA including Nigeria
II. To explore the factors influencing implementation of digital health interventions for maternal health in SSA including Nigeria
III. To make recommendations to policy makers, innovators and implementers for improved implementation, scale-up and sustainability of digital health interventions for maternal health in Nigeria.

2.3 Methodology

A review of literature on digital health interventions for maternal health in SSA countries, including Nigeria, was done. Electronic searches were carried out using PubMed, Science Direct and Scopus databases. The Vrije Universiteit (VU) Library was also searched, which allowed access to bibliographic databases such as BMJ Journals and BioMed Central (BMC), through which articles were accessed. Reference lists of selected articles were also screened for other relevant articles for inclusion. Search terms focused on digital health, maternal health and sub Saharan Africa (detailed combination of search terms are provided in appendix I). The WHO and Ministry of Health (MoH) of Nigeria websites were searched for relevant policy and strategy documents.

2.3.1 Inclusion criteria:

- Studies evaluating digital technology (ICT such as telemedicine and mobile wireless applications) interventions primarily targeted at increasing ANC attendance, SBA/facility deliveries, emergency obstetric care, PNC attendance (i.e. 42 days after delivery) and/or uptake of family planning
- Studies that focus primarily on the end-user (i.e. women of reproductive age, pregnant women and new mothers) and the interaction between the end-user and health workers
- Studies implemented in SSA. The review focused on studies conducted in SSA as they are more comparable and similar in context to Nigeria. However, focusing on countries in SSA alone excludes the possibility of learning from relevant experiences outside the region.
- Studies that include measurement of behaviour change (improvement in care-seeking behaviour in pregnant women and new mothers)
- Peer-reviewed articles. The search was limited to peer reviewed literature so as to obtain conclusions and recommendations that are based on reliable and well-researched information. However, adopting this strategy means relevant studies in grey-literature may have been missed.
- Studies available in English

- Studies published between 2009 and 2019.

2.3.2 Exclusion criteria:

- Studies that evaluate maternal health outcomes other than as described above (such as HIV/AIDS, malaria in pregnancy and Prevention of Mother to Child Transmission - PMTCT)
- Studies that include measures other than behaviour change/service utilization (such as health worker capacity and cost-effectiveness of intervention)
- Studies that only evaluated willingness of participants to use digital health interventions, without implementation
- Studies with abstracts only or protocols yet to be implemented.

2.3.3 Study Selection

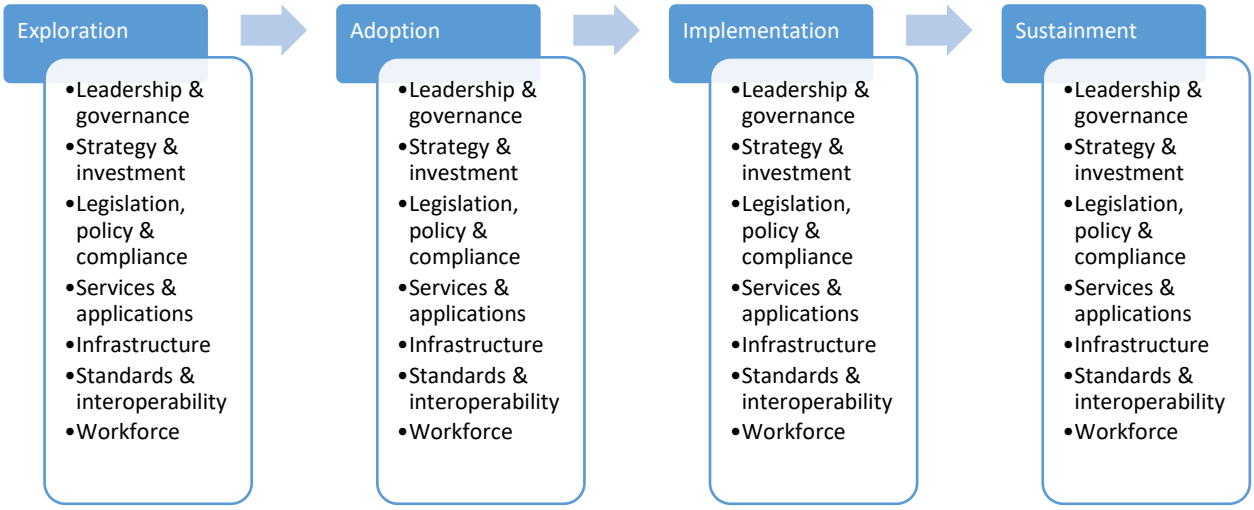
Studies were first screened by title, then abstract and finally by full text to determine those meeting the inclusion criteria. After screening by title, 108 were selected which were subsequently screened by abstract, leaving 21 which were then screened by full text. Five additional studies were identified by screening reference lists of selected studies. A total of 16 studies were finally selected for the purpose of this review. The flow diagram in appendix II illustrates the selection process.

2.4 Analytical framework

The four-phase model of program implementation was selected for the analysis of evidence in this review. This concept, as described by Aarons G.A. et al. (2011), divides the implementation process of an intervention into four key stages namely exploration, adoption/preparation, implementation and sustainment/sustainability. It was selected because it responds to the main focus of this review which is to assess the implementation process of interventions as well as identify underlying factors. The framework was however adapted for the purpose of this review by replacing the themes and sub-themes outlined under each phase with factors more appropriate and better suited to implementation in ICT settings. The themes in the original framework (see appendix III) which include socio-political context, organizational characteristics, etc., were developed for projects implemented in publicly funded settings and are applicable to public sector services in general (Aarons G.A. et al. 2011).

The adapted framework contains the seven components of the eHealth enabling environment as identified by WHO, listed under each phase (see fig.2). These components are the major areas that contribute to digital health implementation. They include leadership and governance, strategy and investment, legislation, services and applications, infrastructure, standards and interoperability and workforce (WHO, 2012).

Fig. 2: Four-phase model of program implementation and components of digital health implementation



Source: Adapted from Aarons G.A. et al (2011) Advancing a conceptual model of evidence-based practice in implementation in public mental health and child welfare systems and WHO (2012) National eHealth Strategy Toolkit.

Using this model, major issues influencing implementation were identified so that associations could be made and analyzed in the discussion section. The selected studies were synthesized and described under the four phases of the program implementation process. Each stage was further discussed using the seven eHealth components. Common constraints and enablers were highlighted in the evidence and connections made with the implementation process. The table in appendix IV provides a brief description of each of the four phases and the seven components.

Before selecting this analytical framework, other frameworks were considered – the mHealth and ICT framework (Labrique A.B. et al. 2013) which describes 12 common mHealth and ICT applications for maternal and child health and the 5C conceptual framework by Drury P. (2005), which addresses five key areas in ehealth development in developing countries. However, the mHealth and ICT framework was found to be too broad for this paper, as only three of the 12 groups (client education and behaviour change, sensors and point-of-care diagnostics and electronic decision-support) are relevant in this review. On the other hand, the 5C framework is limited in scope, as it only describes 5 criteria- context, content, capacity, community and connectivity. This would not allow for a sufficient analysis of the implementation process of the interventions.

Chapter 3: Maternal Health in Nigeria

Maternal health encompasses the health of women during pregnancy, delivery and post-delivery. It refers to the measures taken to ensure women experience each stage positively and in a state of well-being, preventing and reducing injury and death as much as possible (WHO, 2020). Maternal death is defined as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from unintentional or incidental causes" (WHO, 2019c, p. 8). In Nigeria, most maternal deaths are as a result of preventable causes such as post-partum hemorrhage, sepsis and prolonged obstructed labour (FMoH, 2017). Evidence-based, high impact interventions such as ANC, SBA, emergency obstetric care, PNC & family planning are proven, cost-effective measures for preventing and managing life-threatening maternal complications. Increasing access to these services across the antenatal, intrapartum & postpartum stages is essential for maternal survival and well-being (Campbell O. & Graham W., 2006; NPC and ICF, 2019; WHO, 2019b).

3.1 Current approach

The Integrated Maternal, Newborn and Child Health (IMNCH) strategy of the FMoH emphasizes the increased access to essential and cost-effective healthcare interventions. The strategy recognizes and focuses on ANC, SBA, comprehensive and basic Emergency Obstetric and Newborn care (EmONC) and family planning as important interventions as well as the integration of these services for improved maternal health outcomes (FMoH, 2017). Current government efforts include the provision of free contraceptives to improve access and uptake, the midwife service scheme to improve skilled attendance at delivery in rural communities, free maternal and child health services and upgrading primary health care facilities to provide EmONC (FMoH, 2018).

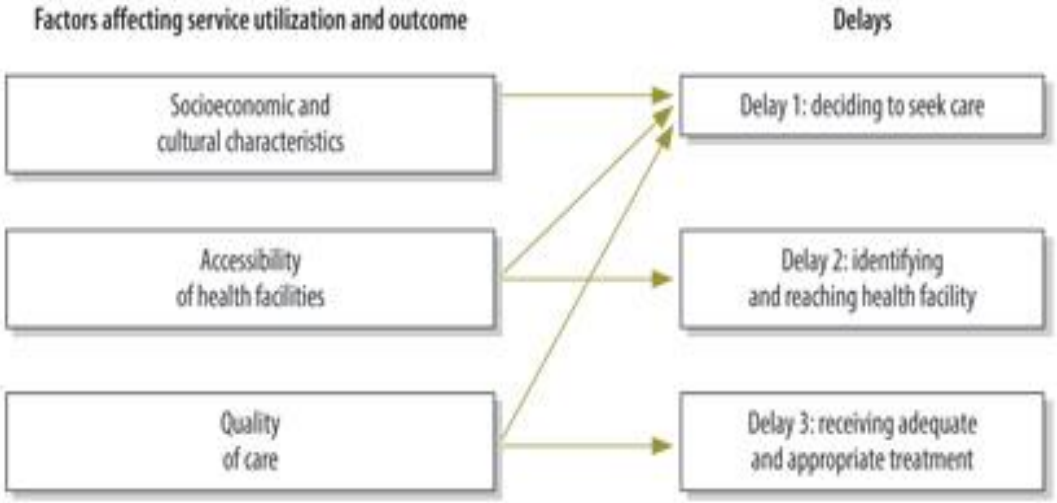
While some progress has been made, for instance with ANC coverage and SBA increasing from 58% and 39% in 2008 to 67% and 43% in 2018 respectively (NPC and ICF 2019), implementation and coverage is still limited in many areas. Emergency obstetric care is available in only less than 20% of health facilities nationwide and there are still wide regional disparities in access to basic maternal health services, with the northern region and rural areas disproportionately affected (FMoH, 2018).

3.2 Barriers to accessing maternal health services and factors influencing maternal mortality

Maternal health access and utilization are important in reduction of maternal deaths. However, several studies have shown that various barriers determine the use of maternal health services (Jat T.R. et al. 2011; McNamee P. et al. 2009; Sumankuuro J. et al. 2018). Demand-side constraints, as described by Ensor and Cooper (2004), consist of barriers that determine an individual's ability and willingness to seek care including income and education level and travel costs/distance of facilities. Other factors such as socio-economic and cultural factors including norms, practices and the household decision-making status of the woman are contributory (McNamee P. et al. 2009). Supply-side barriers such as availability and distribution of health personnel and resources and level of acceptability of services are important (Peters D.H. et al. 2008). Others are funding for healthcare systems and quality of care (McNamee P. et al. 2009). Socio-economic factors and service delivery constraints are two determinants commonly and consistently recognized across many contexts (Jat T.R. et al. 2011; McNamee P. et al. 2009).

The three-delay model (fig. 3) by Thaddeus and Maine (cited in Pacagnella R.C. et al. 2014; Thorsen C. et al. 2012) is a widely accepted framework in maternal health that examines the common barriers to obtaining obstetric care in developing countries

Fig. 3: The three-delay model



Source: Calvello E.J. et al (2015) Applying the lessons of maternal mortality reduction to global emergency health.

The model focuses on the key factors associated with maternal mortality from the perspective of delays preventing timely access to effective care, the most important being cost, facility distance and quality of care (McNamee P. et al. 2009), which are some of the key determinants identified as supply and demand-side barriers. The delays are firstly, the delay to seek care, secondly, the delay in reaching the health facility and the final delay is the delay in receiving adequate and appropriate care (Thaddeus S. and Maine D., 1994).

3.2.1 Supply side barriers

Availability & distribution of skilled human resources for health (HRH)

In Nigeria, less than 50% of deliveries are attended by a skilled professional, which includes nurses, midwives, auxiliary nurses/midwives and doctors (NPC and ICF 2019). A significant proportion (42%) of women still receive assistance during delivery from untrained providers such as traditional birth attendants (TBAs) and relatives/friends, while 11% do not receive assistance at all (NPC and ICF 2019).

A woman's chances of receiving quality healthcare or dying during childbirth depend on where she lives in Nigeria. Rural dwellers and women from northern Nigeria are at higher risk of maternal morbidity and mortality than their urban counterparts and those from the south (FMoH, 2017). This is largely due to regional disparities in distribution of skilled health workforce. Health workers are mostly concentrated in urban areas and in the southern part of the country due to availability of infrastructure, resulting in severe shortages in the rural areas and the northern region (FMoH, 2018). In 2018, the Northwest region had the lowest rate of facility deliveries at 16% compared to the national average of 39% (NPC and ICF 2019). In the same year, 61% of deliveries in urban areas took place in a health facility, compared with 26% of births in rural areas (NPC and ICF 2019).

Availability & distribution of healthcare resources & financing

This refers to availability of essential health commodities including drugs, as well as medical equipment. It also refers to availability of funding for healthcare (Sumankuuro J. et al. 2018). Nigeria's healthcare system is poorly funded with limited financial protection for majority of the population (FMoH, 2018). Over 70% of healthcare financing is comprised of out-of-pocket payments (MoH, 2017; WHO, 2017). Funding is, thus, a major barrier to accessing healthcare, particularly for those at the lowest quintile who are most at risk of catastrophic medical expenditure (MoH, 2017). The country's poorly coordinated health system along with inadequate funding results in inequities in distribution of health commodities and resources (FMoH, 2018).

Quality of care/service delivery

Availability of appropriate and adequate maternal care including emergency obstetric care and referral services is important for maternal well-being and survival (Sumankuuro J. et al. 2018). Over 80% of health facilities in the country are unable to offer emergency obstetric care (FMoH, 2018). Referral systems in the country are largely weak with poor linkage between community-based primary health facilities and secondary and tertiary-level facilities providing advanced care (FMoH, 2018).

3.2.2 Demand side barriers

Socio-economic factors (income, education)

A positive association exists between socio-economic status and the use of maternal health services including ANC and facility delivery. A woman's educational status and socio-economic level are the most associated with utilization of ANC and skilled attendance at birth (Jat T.R. et al. 2011). Women of low socio-economic status living in remote areas, especially in the SSA region, are most often unlikely to receive adequate health care (WHO, 2019b). In Nigeria, the NDHS in 2018 showed that 93% of women in the highest quintile are most likely to receive ANC from skilled providers compared with 41% in the lowest quintile (NPC and ICF 2019). Also, women without education had less access to ANC at 45% compared with those with at least a secondary education at 97% (NPC and ICF 2019). Similarly, with facility deliveries, better educated women are more likely to have facility births (88%) than women without education (14%) (NPC and ICF 2019).

Physical factors

Physical factors refer to the physical accessibility of health services which is mainly influenced by the distance to the facility. It also includes availability and cost of transportation and condition of the roads (Thaddeus S. & Maine D., 1994). Rural areas in Nigeria are disproportionately affected by physical accessibility. Many major health facilities are situated far away from rural communities, usually in bigger towns. This situation is further worsened by the bad condition of the road network and in some cases limited transportation (NPC and ICF, 2019).

Socio-cultural factors

Utilization of maternal health services is closely associated with women's empowerment and household decision-making ability (NPC and ICF 2019). In some parts of the country, women

need permission from their husbands before they can seek care (FMoH, 2018). According to NDHS, only 34% of married women reported participating in decisions regarding their own healthcare (NPC and ICF, 2019). Rates were shown to be higher amongst women who were employed and those living in urban areas (NPC and ICF, 2019). Cultural beliefs and practices also influence the demand for some health services. In a society supportive of big families, contraceptive use in some communities in Nigeria is frowned upon and seen as a taboo. This leads to a reduced demand for family planning services (FMoH, 2017).

It is important to note that the above factors influencing maternal health access are closely associated and have inter-relationships which contribute to and shape utilization of maternal health services (Thaddeus S. & Maine D., 1994). In Nigeria, high maternal mortality is a result of a complex combination of health system inadequacies, socio-economic factors and cultural practices (NPC and ICF 2019).

Nigeria's fertility rate remains high at 5.3 (NPC and ICF 2019) due to cultural practices such as preference for large families, early marriage, misconceptions about contraceptives and limited access to family planning services (FMoH, 2017). Many of such cultural practices are more prevalent amongst poorly educated, rural communities with low socio-economic status where access to quality healthcare is limited. Early marriage and/or first pregnancy increases the risk of obstetric complications including prolonged obstructed labour which leads to vesico-vaginal fistula (FMoH, 2017). Most women affected are low-income with reduced agency and therefore unable to access timely obstetric care (FMoH, 2017).

Chapter 4: Overview of Digital Health in SSA

4.1 The role of technology in healthcare

The use of digital technology for improving healthcare and health systems is a rapidly developing field, particularly in SSA where systemic gaps provide wide ranging opportunities for their application (Holst C. et al. 2020). Shortage of medical supplies is addressed using drones for distribution, disease outbreaks are monitored and analyzed with data and artificial intelligence, while vital registration systems, patient registries and health information management are strengthened through electronic health records and various other applications (Holst C. et al. 2020; WHO, 2012). Digital health solutions present a unique opportunity to expand and improve health services, thus contributing to the goal of universal health coverage (UHC) (WHO, 2019a). Facilitating client education through targeted communication, stimulates demand for services while decision-support systems, increased access to clinical protocols and tele-consultations for health workers improve quality and coverage of health services (WHO, 2019a).

Mobile phones have a significant presence in the SSA region and are especially relevant due to their relative ease of use and wide reach. 70% of mobile phone subscriptions are in LMICs alone (WHO, 2018). Evidence shows a predominance of mobile technology in digital health (Tomlinson M. et al. 2013; WHO, 2019a). Aside from its broad reach, the potential to overcome travel constraints, particularly to hard-to-reach communities in LMICs is a key factor (Tomlinson M. et al. 2013). Mobile phones have been used for improved communication, health promotion, combating the counterfeit drug problem and improving access to health financing through mobile money platforms (Holst C. et al. 2020; Tamrat T. & Kachnowski S., 2012). They have also been useful in improving health worker capacity by facilitating trainings and consultations, collecting data and allowing for remote access to health facilities (Amoakoh-Coleman M. et al. 2016; Lupton D., 2014; Tamrat T. & Kachnowski S., 2012).

4.2 Digital health interventions for maternal health - types of applications and benefits

Reviews of studies reveal a predominance of mobile health application in maternal health, which includes the use of personal digital assistants (PDAs), tablets and patient monitoring and hand-held devices in addition to mobile phones (Al Dahdah M. et al. 2015; Feroz A. et al. 2017; Obasola O.I. et al. 2015). It is estimated that one out of five mHealth interventions in developing countries is targeted at maternal health (Al Dahdah M. et al. 2015). The high penetration of mobile phones in SSA, ease of use of and cost-effectiveness of mobile technology explains this trend (Ag Ahmed M. A. et al. 2017; Al Dahdah M. et al. 2015). They commonly employ mobile functions such as short message service (SMS), voice and interactive voice response (IVR) in their applications (Al Dahdah M. et al. 2015; Labrique A.B. et al. 2013). Common applications in maternal health include client education and behaviour change communication, which is reportedly the most common, registries and vital events tracking, data collection and reporting, electronic health records, and provider-to-provider communication (Feroz A. et al. 2017). Many interventions consist of two or more of these applications for addressing a specific health constraint or accomplishing a particular health goal (Feroz A. et al. 2017).

Many studies have been able to show improvement in maternal health outcomes following implementation of interventions. Several studies have demonstrated increase in ANC, PNC utilization and SBA, particularly through the use of SMS (Kebede A. et al. 2019; Lund et al. 2012; Lund et al. 2014; Omole O. et al. 2017; Ruton H. et al. 2018; Shiferaw S. et al. 2016). SMS reminders for clinic attendance and educational text messages were most common in

this regard (Feroz A. et al. 2017; Lee S.H. et al. 2016). Prompt referrals and reduced delay in management of emergencies are a direct benefit of mobile-enabled two-way communication between health providers and clients (Lee S.H. et al. 2016; Oyeyemi S. & Wynn R., 2014; Tamrat T. & Kachnowski S., 2012). Evidence also shows that mobile applications help the enhancement of data collection and reporting processes as well as strengthening of health information management through electronic health records (Amoah B. et al. 2016; Battle J. et al. 2015; Feroz A. et al. 2017; Lee S.H. et al. 2016; Oyeyemi S. & Wynn R., 2014; Ruton H. et al. 2018; Tamrat T. & Kachnowski S., 2012).

4.3 Challenges, limitations and risks of digital health

4.3.1 Challenges

In order for digital health interventions to function optimally and efficiently, delivering the desired impact on health outcomes, they require an enabling environment. This consists of mechanisms concerning leadership & governance, strategy & investment, legislation, policy & compliance, infrastructure, services & applications, standards & interoperability and workforce (WHO, 2019a; WHO, 2012). The degree of availability of the various components varies in different contexts and determines the level of adoption within a setting (WHO, 2019a).

Digital health implementation in SSA is faced with barriers that affect access to interventions. For instance, the disparities in access to mobile devices between urban and rural dwellers as well as the different genders is a major issue i.e. urban-rural and gender digital divide (Al Dahdah M. et al. 2015; Holst C. et al. 2020). In Nigeria, mobile phone ownership is significantly higher for men (80.6%) than women (55.3%) (NPC and ICF, 2019). The high costs, to both consumers and providers, of expanding services in the country to remote areas contributes to the digital divide between rural and urban areas (FMoH, 2014).

Limited internet access and electricity supply are other issues common in the SSA region that influence access. Lack of infrastructure and appropriate technology have been identified as the most prevalent barriers in the region (Kruse C. et al. 2019). These infrastructural limitations may differ from country to country, but ultimately influence intervention implementation (Kenny G. et al. 2017; Luna D. et al, 2014). Other contextual barriers that affect uptake are low digital literacy, availability of digital content in the local language and access to smart phone devices (Holst C. et al. 2020) as well as acceptability and ease of use of the technology (Kruse S. C. et al. 2016).

The fragmented implementation, short-lived nature and lack of sustainability of digital health interventions in SSA limits their level of impact on health outcomes (FMoH, 2014; FMoH, 2016). Studies have shown that many implemented projects remain at the pilot phase of implementation (Cockcroft A. et al. 2018; Kenny G. et al. 2017; Labrique A.B. et al, 2013). In 2015, more than 400 mHealth programs were initiated in Africa alone, however, very few achieved large-scale implementation (GSMA, 2016). A major indication for limited project scale-up is the shortage of evidence to support their value, performance and impact on health system targets (Labrique A.B. et al. 2013; Ohuruogu V., Flores P. and Foh K., 2015). In spite of over 500 mHealth studies documented by the World Bank, there

is limited documentation on uptake, engagement and effectiveness after project completion (Tomlinson M. et al, 2013). A lack of documented information on the underlying factors of implementation is another reason interventions fail to move past the pilot phase (Ag Ahmed M. A. et al. 2017). Pathways to intended outcomes and mechanism of implementation are not fully explained (Lee S.H. et al. 2016).

Other possible reasons for poor project expansion and adoption beyond pilots include negative end-user disposition and perceptions of the technology (Kenny G. et al. 2017). Incompatibility of technology applications with existing digital health initiatives is another challenge of interventions. As many innovations are developed in silos, a lack of coordination and adherence to standards reduces their efficiency (van Heerden A. et al. 2012; Wallis L. et al. 2017).

4.3.2 Limitations and risks

In spite of its growing potential and positive outcomes, digital health does have its limitations and risks and is not a universal solution to healthcare challenges (Holst C. et al. 2020; WHO, 2019a). The rapid development and drive for digital health in recent years has led to the implementation of short-lived projects with limited understanding of their health impact (WHO, 2019a). Issues of privacy and confidentiality regarding patient data are some of the risks of digital technology. Access to the use, transfer and storage of patient data by technology platforms raises questions of data safety, security and credibility of stakeholders (Al Dahdah M. et al. 2015). Ethical considerations about the use of patient data for commercial gain, the potential for monopoly by certain groups leading to inequitable access, particularly in low-resource settings, are some of the main concerns (Al Dahdah M. et al. 2015; Busreo F. & Tanner M., 2020; Mariano B., 2020).

These concerns brought about the development of the WHO guidelines on digital interventions. The enthusiasm for innovation necessitates the establishment of international standards (WHO, 2019a). Such standards and regulations ensure that digital solutions remain people-focused, allowing for inclusivity of all groups, especially the vulnerable and underserved (Busreo F. & Tanner M., 2020; Mariano B., 2020). They also help to serve as a reminder of the role of digital health, which is to be complementary and not a replacement for functional health systems, which remain a key requirement for healthcare delivery (WHO, 2019a).

To protect patient data and storage, the WHO guidelines recommend the establishment of clear protocols for ensuring patient consent and verifying provider credentials (WHO, 2019a). Where possible, with regards to health issues with sensitive data, such as sexual, reproductive and maternal, newborn and child health, digital targeted client communication is advised (WHO, 2019a). Development & implementation of national digital health strategies and multi-sectoral collaboration, are other strategies that can lead to increased accountability, transparency and implementation of ethical digital health solutions (Busreo F. & Tanner M., 2020; Mariano B., 2020).

4.4 Digital health in Nigeria

The country's ICT and telecommunications sector has progressed steadily over the years. Over 60% of the population has access to mobile phones, and broadband subscriptions, though low, are increasing as services become more affordable. Availability of network coverage in rural areas is also on the rise (FMoH, 2014).

Application of technology in healthcare in Nigeria ranges from electronic health records, to disease surveillance tools and devices for patient monitoring and care (FMoH, 2014). Like many other parts of SSA, most applications in Nigeria are delivered via mobile technology (SMS based) and are focused on maternal and child health. Majority are donor funded with players ranging from small start-ups and large multi-nationals to local and international development organizations (NASEM, 2017).

However, implementation is fragmented and uncoordinated and poorly aligned with national health system goals (FMoH, 2014; NASEM, 2017). As a result, the Nigerian government has developed a National Health ICT Strategic Framework (2015-2020) in a bid to harmonize the application of technology for health purposes, in order to allow for strategic and sustainable interventions (FMoH, 2016). The overall objective of the national strategy is to leverage digital health in the achievement of UHC by providing a framework and appropriate guidance and governance structures for implementation of technology interventions (NASEM, 2017). However, proper regulation is still lacking, with digital health efforts receiving minimal government support and limited investment (Muanya C., 2019; Witchalls C., 2020). Lack of investment has been attributed to lack of evidence of effectiveness of digital health, reluctance in adopting digital health technology and implementation costs (Ohuruogu V., Flores P. and Foh K., 2015).

Chapter 5: Results – summary and analysis of evidence from across SSA including Nigeria

5.1 Overall summary of results

This review identified and examined 16 articles, comprising 15 studies on digital health interventions for maternal health. The studies were conducted in 8 countries and territories – Nigeria (3), Ethiopia (3), Zanzibar (3), Kenya (2), Ghana (2), Rwanda (1), Tanzania (1) and Uganda (1). All the studies involved mHealth interventions which were either SMS-based or a combination of SMS and other functions such as voice communication, IVR and/or apps, however, two of them (Amoah B. et al. 2016; Abejirinde I.O. et al. 2018) consisted of interventions where mobile phone technology was combined with other digital health devices (portable ultrasound and non-invasive diagnostic devices). Most were pilot studies, with only two indicated as otherwise; one was an ongoing nationwide intervention (Ruton H. et al. 2018) and the other a scale-up of a previous pilot (Battle J. et al. 2015).

13 of the articles comprised of technology applications focused on client education and behaviour change (Atnafu A. et al. 2017, Babalola S. et al. 2019; Battle J. et al. 2015; Hackett K. et al. 2018; Johnson D. et al. 2016; Kebede A. et al. 2019; Lund S. et al. 2012; Lund S. et al. 2014; Mangwi A. et al. 2016; Omole O. et al. 2017: Ruton H. et al. 2018; Shiferaw S. et al. 2016; Unger J. et al. 2018). Five articles featured interventions with electronic decision-support along with data collection and reporting functions for health workers (Amoah B. et al. 2016: Atnafu A. et al. 2017; Battle J. et al. 2015; Hackett K. et al. 2018; Shiferaw S. et al. 2016).

With regards to the study results, all of the studies reported increase in the outcomes measured (i.e. ANC utilization, SBA/facility deliveries, PNC & contraceptive use) except four, two of which showed no impact on contraceptive use (Atnafu A. et al. 2017; Johnson D. et al. 2016), another had no effect on uptake of facility delivery (Unger J. et al. 2018), while one study result was inconclusive (Abejirinde I.O. et al. 2018). The key findings from the selected articles were summarized in a table for easy comparison (see appendix III for detailed summary table). The four-phase model of implementation was used to organize and describe the evidence. Under each phase, the key components of digital health implementation are discussed using the information from the selected studies.

5.2 Exploration phase

In the first phase of implementation, evidence was found on three of the seven ICT components-leadership and governance, strategy and investment and infrastructure. For leadership and governance, the articles emphasized the aspects of stakeholder engagement and community needs assessment. Six articles (Abejirinde I. et al. 2018; Amoah B. et al. 2016; Battle J. et al. 2015; Johnson D. et al. 2016; Omole O. et al. 2017; Unger J. et al. 2018) discussed stakeholder engagement by highlighting the importance of community awareness campaigns to sensitize participants and stakeholders prior to project implementation, to reduce cultural barriers and increase acceptance of the intervention (Battle J. et al. 2015). Effective and continuous engagement of project beneficiaries helped to overcome initial fear and reluctance towards the device at the point-of-use (Abejirinde I. et al. 2018).

Five articles (Amoah B. et al. 2016; Atnafu A., Otto K. & Herbst C.H., 2017; Johnson D. et al. 2016; Omole O. et al. 2017; Oyeyemi S. & Wynn R., 2014) reported the use of baseline data to inform the project design and development. Collecting demographic data in particular was deemed important in understanding community needs which helped with intervention compliance (Johnson D. et al. 2016). It also allowed for priority needs of the community to be addressed (Amoah B. et al. 2016).

For strategy & investment, only one article (Mangwi A. R. et al. 2016) described the strategy of integration of the intervention with the community's health system at the design stage. Infrastructural issues were captured by three articles (Kebede A.S. et al. 2019; Mangwi A. R. et al. 2016; Omole O. et al. 2017), all of which highlighted the significant high mobile phone network coverage in the target communities prior to implementation. This, in addition to the ease of use of mobile technology, enabled successful implementation of the intervention (Lund S. et al. 2012).

5.3 Adoption/preparation phase

In the second phase of implementation, the articles provided evidence for three of the seven eHealth components – services & applications, infrastructure and workforce. In this phase, the articles approached the themes of services & applications as well as infrastructure from the perspective of adaptation and modification of the content and applications to the local context.

Six articles (Babalola S. et al. 2019; Hackett K. et al. 2018; Kebede A.S. et al. 2019; Lund S. et al. 2012; Omole O. et al. 2017; Unger J. et al. 2018) indicated the adaptation of intervention content to local context by translating from English to the local language. Providing content in the local language was important for overcoming the barrier of illiteracy and addressing the varied literacy levels of participants (Hackett K. et al. 2018; Lund S. et al. 2012). A key aspect of content adaptation was pre-testing amongst study participants and incorporation of the feedback into the content before implementation (Babalola S. et al. 2019; Kebede A.S. et al. 2019; Johnson D. et al. 2016). Developing content with input from beneficiaries and end-users was identified as an important part of the implementation process (Babalola S. et al. 2019; Unger J. et al. 2018).

For infrastructure, three articles (Atnafu A., Otto K. and Herbst C.H., 2017; Lund S. et al. 2014; Shiferaw S. et al. 2016) described modifications made to the technology in preparation for intervention implementation. Software applications were locally developed and adapted to the context and needs of the end-users (Atnafu A., Otto K. and Herbst C.H., 2017; Shiferaw

S. et al. 2016). Using locally designed software helped increase participation and engagement as it was more responsive to the end-users' needs (Shiferaw S. et al. 2016).

Nine articles (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Babalola S. et al. 2019; Battle J. et al. 2015; Hackett K. et al. 2018; Kebede A.S. et al. 2019; Lund S. et al. 2012; Mangwi A. R. et al. 2016; Shiferaw S. et al. 2016) described in detail the training and technical support provided for the workforce for the intervention, most of whom consisted of local facility staff and in some cases, community volunteers. Training provided comprised not only of utilization of the technology but also healthcare skills (Battle J. et al. 2015; Hackett K. et al. 2018; Mangwi A. R. et al. 2016). This was the case in studies where the technology intervention was integrated with other health services, necessitating workforce training to take on a broader approach. It was, thus, used as an opportunity to upgrade health worker skills in essential maternal health services. This strategy helped in providing a more comprehensive set of services, which was cited as a facilitator of improved health outcomes and success of the intervention (Abejirinde I.O. et al. 2018; Battle J. et al. 2015; Hackett K. et al. 2018; Ruton H. et al. 2018).

The importance of training in communication and negotiation skills for health workers was indicated as a means of ensuring acceptance of the intervention among beneficiaries (Abejirinde I.O. et al. 2018). Health workers ability to engage the women and involve them actively in the process of using the intervention fostered acceptance particularly among rural dwellers with low literacy levels (Abejirinde I.O. et al. 2018; Mangwi A. R. et al. 2016). Using health worker cadres close to the grassroot/household level i.e. CHWs, increased communication with beneficiaries which contributed to successful implementation (Atnafu A., Otto K. and Herbst C.H., 2017). Improved client-health worker interaction increased client satisfaction with the care delivered (Abejirinde I.O. et al. 2018).

5.4 Implementation phase

The third phase of implementation was the most documented in all the articles. The evidence provided information on four of the seven ICT components - leadership & governance, services & application, infrastructure and workforce.

For leadership & governance, four articles (Amoah B. et al. 2016; Battle J. et al. 2015; Lund S. et al. 2012; Unger J. et al. 2018) reported supportive supervision & quality assurance checks during the implementation phase.

The services & application component was well-described in all the articles with specific details of how the intervention was delivered and platforms used. Ten articles (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Atnafu A., Otto K. and Herbst C.H., 2017; Battle J. et al. 2015; Hackett K. et al. 2018; Lund S. et al. 2012; Lund S. et al. 2014; Mangwi et al. 2016; Ruton H. et al. 2018; Shiferaw S. et al. 2016) reported implementing interventions with health workers serving as intermediaries in the SMS component. Text messages with appointment reminders and educational messages were sent through the health workers instead of directly to the client. This way, the interaction between health workers and clients was leveraged in the behaviour change communication process. This approach was significant in the successful implementation of the technology, as it eliminated the need for mobile phone ownership by the clients, which was a barrier in rural settings (Hackett K. et al. 2018; Mangwi et al. 2016). Communication was more effective with health workers as go-betweens, where they relayed the SMS content to clients through voice-calls. This overcame the barrier of illiteracy (Mangwi et al. 2016; Shiferaw S. et al. 2016). Health workers, as intermediaries, were able to allay client fears and mistrust of the technology which led to increased compliance (Abejirinde I.O. et al. 2018).

Service integration and combination of approaches was also deemed a significant facilitator of implementation. Integrating the technology intervention with other support services such as home visits, counselling, education, supervision and health system support in the form of essential health commodities and equipment, contributed to the increase in health outcomes observed in eight articles (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Battle J. et al. 2015; Hackett K. et al. 2018; Lund S. et al. 2012; Mangwi A. R. et al. 2016; Oyeyemi S. & Wynn R. 2014; Ruton H. et al. 2018). One study revealed that implementation of the mobile intervention alone was insufficient to meet the expected outcomes (i.e. increased ANC, PNC & SBA), however, the reverse was the case when integrated with a more comprehensive set of interventions including training, supervision & necessary medical equipment (Ruton H. et al. 2018). The use of a combination of mobile technology approaches e.g. SMS communication, decision-support, data reporting and storage and voice calls, along with health worker support was reported as beneficial (Battle J. et al. 2015). Improved detection of pregnancy danger signs leading to appropriate obstetric care was attributed to the integration of remote ultrasound imaging in the intervention (Amoah B. et al. 2016). However, it was observed that the cost implications of providing portable ultrasound machines on a large scale will be a challenge for scale-up (Amoah B. et al. 2016).

In integrated programmes, health worker support (i.e. counselling, home visits, general support in referrals, etc.) was an important influence in clients' decision to seek care (Battle J. et al. 2015). Providing health system support in the form of essential medical equipment and medicines enabled the facilities to function optimally and ensured quality delivery of care which allowed for successful implementation of the project (Amoah B. et al. 2016; Lund S. et al. 2012).

Four articles (Amoah B. et al. 2016; Kebede A.S. et al. 2019; Omole O. et al. 2017; Unger J. et al. 2018) provided information on infrastructure in the implementation phase with descriptions of the software and technical systems employed. Notable constraints to implementation highlighted were the issue of limited power supply and technical problems with the mobile technology & network (Atnafu A., Otto K. and Herbst C.H., 2017; Babalola S. et al. 2019; Mangwi A. R. et al. 2016; Oyeyemi O. & Wynn R., 2014). Mobile phone ownership, particularly in rural areas, was identified as a constraint and potential barrier to scale-up (Babalola S. et al. 2019; Kebede A.S. et al. 2019; Omole O. et al. 2017). However, in recognition of this challenge, two articles (Lund S. et al. 2012; Lund S. et al. 2014) required only a registered phone number in the intervention as opposed to actual phone ownership for participation, as mobile sharing is quite common in low-resource settings (Babalola S. et al. 2019).

For the workforce component, one article identified active health worker participation as an important factor that helped ensure community ownership & contribute to successful outcomes (Shiferaw S. et al. 2016) Use of the local health workforce as research assistants was also a positive influence due to their personal local knowledge of clients (Lund et al. 2012; Lund S. et al. 2014). However, health worker attrition due to trainings, transfers & leave of absence, was indicated as an important challenge which could affect continuity of the project (Mangwi A. et al. 2016).

5.5 Sustainment/Sustainability

For the final phase of implementation, the evidence did not provide information related to sustainability of interventions. However, perceived contributing factors and barriers to feasibility and continuity of the projects were identified. Integration of the intervention with the health system was highlighted as a contributing factor to feasibility (Mangwi A.R. et al. 2016). This is in line with the earlier mentioned point of combination of services in the implementation phase as an enabling factor. Possible barriers to sustainability were raised

with the issues of prior mobile phone ownership and provision of phone vouchers (Lund S. et al. 2012; Omole O. et al. 2017). This is a valid concern as significant funding will be needed to make provision for mobile phones and phone vouchers for all participants when implementing on a large-scale. However, as shown in the evidence, engaging health workers as intermediaries and furnishing them with mobile phones can serve as a more cost-effective alternative (Hackett K. et al. 2018; Mangwi A. R. et al. 2016).

The role of health workers is once again emphasized in the final phase, as their receptivity and disposition to the technology is revealed as a contributor to continuity (Battle J. et al. 2015; Shiferaw S. et al. 2016). This shows their importance in the pathway of implementation to sustainability as they help to continuously link the intervention to the beneficiaries.

5.6 Cross-cutting themes

There were some additional issues, although outside of the framework, that intersected with and also influenced the implementation process. They include gender, geographic location/residence, health systems and equity.

5.6.1 Gender

Three articles (Amoah B. et al. 2016; Babalola S. et al. 2019; Kebede A.S. et al. 2019) highlighted the role of gender in the implementation process. Compliance with the intervention and uptake of provided services, i.e. ANC, contraceptive use & PNC, was influenced by the woman's ability to make decisions. Where women enjoyed relative autonomy, utilization of services was reportedly higher (Kebede A.S. et al. 2019). Spousal disapproval and negative pressure from male partners were cited as barriers to participation for some women (Amoah B. et al. 2016; Babalola S. et al. 2019). This is important, as in many African communities, including Nigeria, women still require permission from their husbands before they can engage in certain activities outside of the home. Patriarchal norms and socio-cultural practices influence women's decision-making ability including the ability to seek care. This significantly influences their ability to participate and access the essential maternal health services available, which affects the implementation and success of the intervention.

5.6.2 Geographic location/ Place of residence

Three articles reported that distance to the facility was a strong predictor of utilization of services such as facility deliveries and ANC attendance (Amoah B. et al. 2016; Hackett K. et al. 2018; Oyeyemi S. & Wynn R., 2014) The positive impact on facility deliveries was therefore equally attributable to the geographical access of the health facility and not just the mobile intervention. Uptake of services following sensitization, counselling and education via SMS, voice calls and/ or IVR was possible when the health facility was within reach of the participants (Amoah B. et al. 2016; Hackett K. et al. 2018; Oyeyemi S. & Wynn R., 2014). One study reported geographical distance as a barrier to the home visit component of the integrated service with mobile technology (Mangwi A. et al. 2016).

Disparity in access to infrastructure in urban and rural areas also influenced the implementation of technology interventions. As shown in the evidence, implementation of the mobile phone technology for SBA was more successful in women in urban areas compared to their rural counterparts. This was attributed to challenges in rural areas which serve as barriers to accessing the digital health intervention such as limited power supply and mobile phone access (Atnafu A., Otto K. and Herbst C.H., 2017; Babalola S. et al. 2019; Lund S. et al. 2012).

5.6.3 Health systems

From the evidence, mobile technology intervention had the added advantage of strengthening healthcare delivery particularly at the primary level. In five studies, it was discovered that better communication through mobile technology improved PHC linkages with secondary facilities, and increased referrals & quality of care. It also allowed local PHC workers to receive prompt support & feedback from experts on referred cases, resulting in improved maternal health outcomes (Abejirinde I.O. et al. 2018; Battle J. et al. 2015; Lund S. et al. 2012; Lund S. et al. 2014; Oyeyemi S. & Wynn R., 2014). As a result, client confidence in the health system increased leading to increased demand & overall utilization of maternal health services at the primary level (Abejirinde I.O.et al. 2018; Mangwi A. et al. 2016; Oyeyemi S. & Wynn R., 2014). This reduced the burden on the secondary and referral facilities, freeing up resources for management of more complicated cases (Oyeyemi S. & Wynn R., 2014).

As revealed in the Rwandan study, digital health interventions require health system contexts with the capacity to support them for successful implementation (Ruton H. et al. 2018). This was also highlighted in the Kenyan study, which pointed out the need for good health systems for successful delivery of digital health interventions that focus on engagement & utilization (Unger J et al. 2018).

As illustrated earlier with facility distance, communities still require accessible health facilities for positive health outcomes. Ensuring that the facilities function optimally by providing essential commodities, equipment & infrastructure during implementation, improved the chances of intervention success (Amoah B. et al. 2016; Lund S. et al. 2012).

On the other hand, it was shown that digital interventions are a potential health systems strengthening tool, which enhance the implementation of non-technological, evidence-based high impact interventions such as ANC & SBA (Hackett K. et al. 2018). Therefore, implementing them as an integrated set of programs enhances service delivery and increases impact while strengthening the health system at the same time. In the same vein, the evidence showed that non-alignment/poor integration with the existing health care delivery system at the time of implementation reduces the impact of the project outcomes (Atnafu A., Otto K. & Herbst C., 2017; Unger J. et al. 2018).

5.6.4 Equity

From the evidence, it appears urban communities may be inadvertently targeted when implementing digital health interventions as they benefit more significantly compared to their rural counterparts (Johnson D. et al. 2016; Lund S. et al. 2012). This may be as result of availability of infrastructure and a more enabling environment in urban areas. However, equitable access to services was addressed in aspects of implementation in the evidence. Women without mobile phones and literacy skills were able to participate where a registered mobile number was the only requirement & health workers served as intermediaries (Lund S. et al. 2012; Lund S. et al. 2014; Hackett K. et al. 2018; Mangwi et al. 2016).

The use of IVR made the project content available to a wide range of participants regardless of literacy level and mobile phone type (basic or smartphone) (Babalola S. et al. 2019). The use of voice SMS was suggested in order to further cater to illiterate communities (Lund S. et al. 2014). Also, to allow effective communication and uptake of services, mobile phone vouchers were provided to participants (Lund S. et al. 2012; Lund S. et al. 2014). However, cost concerns were raised in terms of feasibility for large-scale implementation (Lund S. et

al. 2012; Lund S. et al. 2014). Although two-way communication via SMS had its benefits (improved efficiency in engaging clients), the approach created added costs which need to be considered for scale-up (Unger J. et al. 2018).

5.7 Quality of the Evidence

With regards to the quality of the evidence, ten articles (Atnafu A., Otto K. & Herbst C., 2017; Babalola S. et al. 2019; Hackett K. et al. 2018; Johnson D. et al. 2016; Kebede A. et al. 2019; Lund S. et al. 2012; Lund S. et al. 2014; Mangwi A. et al. 2016; Omole O. et al. 2017; Unger J. et al. 2018) were randomized control trials, one article (Oyeyemi O. & Wynn R., 2014) was a case-control study, and the others (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Battle J. et al. 2015; Ruton H. et al. 2018; Shiferaw S. et al. 2016) had quasi-experimental non randomized designs.

In three articles, the groups were not similar at the start of the trial, which could affect the interpretation of the results (Lund S. et al. 2012; Lund S. et al. 2014; Mangwi A. et al. 2016). Outcomes measured could have been confounded by health worker knowledge and influence (Lund S. et al. 2012; Lund S. et al. 2014). In one study (Oyeyemi O. & Wynn R., 2014), there was no baseline data available from both groups, so the results cannot be fully ascribed to the intervention.

For two studies (Amoah B. et al. 2016; Ruton H. et al. 2018), the results cannot be attributed to the mobile technology alone, but could have been due to the other components integrated in the intervention such as portable ultrasound and additional health system support. Three studies (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Babalola S. et al. 2019) had a small sample size, so results are not generalizable. The low response rate in one other study (Johnson D. et al. 2016) could affect the interpretation of the result, whether it actually reflects a true effect. In three studies (Abejirinde I.O. et al. 2018; Johnson D. et al. 2016; Unger J. et al. 2018), results were based on self-reported data, leading to possible bias (recall bias). Three studies (Abejirinde I.O. et al. 2018; Amoah B. et al. 2016; Battle J. et al. 2015) had no control group which limits the certainty of their results.

Chapter 6: Discussion, Conclusion and Recommendations

6.1 Principal findings

The number and nature of studies in this review confirm the growing interest in digital health in the SSA region and the popularity of mobile technology interventions in maternal health. The ubiquity and relative ease of use of mobile phones and the technology contribute to the widespread application in maternal health projects in the region.

The findings from the results showed an emphasis on some aspects of the implementation process and eHealth components compared to others. The result of this emphasis is an imbalance in the availability of information and gaps in the understanding of how digital health interventions for maternal health are implemented.

The second and third phases of implementation were the areas most documented in the selected articles. The evidence addressed activities related to the adoption/preparation and implementation of the interventions, compared with the first and fourth phases, i.e. the exploration and sustainment phases. As a result, influencing factors of implementation identified were mostly related to the intervention development and execution. There was limited evidence on the sustainment phase of implementation, which is expected as the interventions were mostly pilots.

With regards to the eHealth components, the evidence focused on issues surrounding services & applications, workforce and infrastructure. The studies did not provide much information on the leadership & governance, strategy & investment, interoperability as well as legislation & policy components, even though they are necessary aspects of an enabling environment for digital health projects. For some studies, this may be due in part to the space limitation of peer-reviewed journals. Also, it is my opinion that since many of these projects were pilot interventions, the focus of the implementers was on the application of the technology, its impact on maternal health outcomes and the need to prove its effectiveness. As such, they were implemented in silos with little emphasis on issues related to long-term deployment such as the effect and implication of the wider policy environment, compliance with standards and compatibility with other digital health systems. However, many studies still provided relevant information and perspectives applicable to intervention feasibility and sustainability that are useful to practitioners in the field of digital health. In order to reap the full benefits of digital health interventions for maternal health, activities geared towards sustained impact on maternal health outcomes need to be developed.

The main enabling factors identified in this body of research were community engagement and needs assessment, adaptation of technology to local context, health worker engagement & support, service integration and a combined approach to technology implementation. Ensuring that project beneficiaries were adequately sensitized and engaged prior to implementation of the intervention, allowed for increased user acceptance and easy adoption. Also, this way, the actual needs of the community can be addressed and not those as perceived by the project implementers, which is important for intervention impact. It also fosters ownership of the intervention which would increase the possibility of continuity of the project. Identifying with the local context by customizing the technology and content specifically to the local needs, particularly language, featured prominently in the evidence. Providing content in the local language is especially significant in Nigeria, where low level of education (especially for women) is still a challenge. Beneficiaries' ability to access maternal health information in the local dialect increases trust and acceptance of the technology and improves compliance.

Health workers played a significant role in the implementation process. Health worker support and involvement featured prominently in the articles reviewed. As intermediaries, they helped

to overcome the barriers of poor literacy, mistrust and negative perceptions of technology which contributed to acceptance and compliance. This shows that they are an important part of the behaviour change process necessary for the increased utilization of maternal health services. Their motivation and active participation was a positive contributor to implementation success. Health workers, particularly at the community level, are therefore, well-positioned to support the delivery and implementation of technology interventions since they interact directly with patients and are an important link between the community and health facilities. In Nigeria, where availability and distribution of skilled human resources for health is a significant barrier to maternal health access, targeting the health worker component at community level should be an important strategy in the implementation process to fully harness the benefits of digital technology for maternal health. As shown in the evidence, the digital health intervention can be used as an opportunity to improve availability of skilled workforce in the country, through comprehensive health worker training both in the use of the digital technology and in essential maternal healthcare.

Strengthening health worker capacity aligns with the approach of providing health system support as part of the intervention implementation in several studies. This was identified as a key contributing factor to the implementation process. Additional health system support integrated with technology applications, contributed to the increased maternal health outcomes observed. The inclusion of home visits, education, counselling and provision of essential medical equipment at the facilities, increased the utilization of ANC, SBA/facility deliveries & PNC. This approach recognizes the importance of supporting and aligning with the existing health system by integrating services to provide a more comprehensive maternal health package. It is, therefore, important that implementation of technology interventions adopt a more holistic approach to addressing health system constraints in order to ensure increased impact. In Nigeria, where poor availability and distribution of essential medical commodities is a barrier to maternal health access, using this approach can lead to better distribution of resources, particularly in under-served areas, and ultimately, improved maternal healthcare delivery and maternal survival.

It is interesting to note that while digital health interventions are developed with the aim of overcoming specific health system challenges, they still require a well-functioning health system to support their effective implementation. For instance, improving care-seeking behaviour in pregnant women and new mothers by providing information and education via SMS, will not result in increased utilization of ANC & SBA where health facilities are still out of reach and basic medical equipment and skilled personnel are unavailable. This point reiterates the role of digital health as complementary to and not a replacement for the necessary components a health system needs to function optimally.

Although not a primary outcome of the digital interventions in the selected studies, the ability of the technology to strengthen health systems by improving referral linkages, is significant. Through improved provider-to-provider communication using voice calls and two-way SMS, referrals and quality of obstetric care improved. This is especially important in Nigeria, where the linkages between PHCs and higher level health facilities are poor and the referral system is weak, resulting in reduced maternal survival. Adopting similar interventions in the country can thus improve maternal health service delivery.

The challenges identified in the evidence were mainly related to infrastructure and they include power supply, technical problems with mobile technology and network as well as mobile phone ownership/mobile sharing. This is in line with barriers discussed earlier that contribute to limited access to technology interventions and poor project expansion in SSA. The urban-rural and gender digital divide mentioned earlier, comes to play here, where disparities in mobile access and network coverage still exist in spite of the growing popularity of mobile technology. This inequality is further reinforced by high levels of poverty in the rural areas. Like many countries in the SSA region, Nigeria also struggles with widespread poverty

and limited access to basic amenities such as power supply, especially in the rural areas. Mobile phone ownership is also significantly lower among women compared to men, reducing their ability to benefit from maternal health interventions provided via mobile devices. It is important that these gaps are addressed for improved implementation, effectiveness and impact of digital technology interventions in maternal health.

6.2 Quality of the Evidence

Overall, the quality of evidence is high as most of the studies were randomized control trials. A few of them lacked control groups and a randomized design and had small study groups, which may limit the certainty of the results. However, this is not so important as the focus of this review is on the implementation process and not on the results of the interventions. The quality of the research was affected by underreporting for several ICT themes, including leadership & governance, strategy & investment, interoperability and policy. This resulted in gaps in the evidence. In the case of studies were the technology intervention was integrated with other approaches e.g. health worker components, health system support, etc., successful implementation cannot be entirely attributed to the technology component alone. It is thus difficult to ascertain which component was most relevant and necessary in the process.

6.3 Observations on usefulness of the framework

The framework helped me to organize the evidence and summarize the findings using themes and concepts relevant to the implementation of digital health interventions. It allowed me to identify commonalities in the studies and relate them to key issues influencing implementation and feasibility of interventions. However, using the four phase model of implementation came with the challenge of delineating the various phases in each study, as the implementation process is a continuum and the studies did not distinguish one phase from the other. The articles had varied approaches in describing & reporting the technology interventions, with different authors emphasizing different aspects of the implementation process. In practice, implementation is an iterative process, with considerable overlap between activities in the different phases and the results from each phase feeding back into the previous ones.

The framework only allowed for analysis of supply-side issues, mainly the enabling environment, with little consideration for user-side related themes such as digital literacy, gender, access to technology, acceptability, location/place of residence, privacy and confidentiality, even though some appeared as cross-cutting themes, showing their relevance in the implementation process. In future, the framework can be adapted to include these issues as an additional component under each phase.

6.4 Limitations and strengths of the research

The strength of the review is that studies selected and analyzed are all from SSA countries which are similar in context to the Nigerian setting and as such are relatively comparable. However, the studies were implemented in predominantly rural settings, thus the interpretations and recommendations may not be valid for the whole population or in different contexts.
The main limitation of this study was that most of the selected articles were pilot projects/ small-scale interventions. This resulted in underreporting of some aspects of the implementation process, particularly the sustainment/sustainability phase. As such, influencing factors identified and subsequent recommendations are limited to the

development, adoption and execution aspects of the process. The research results lacked information for improving sustainability, which was one of the objectives of the research.

6.5 Conclusion and Recommendations

6.5.1 Conclusion

This review shows there is a growing body of evidence of digital health interventions for maternal health in SSA. Mobile health initiatives are especially popular owing to the high penetration of mobile phones, wide network coverage and the ease of use of the technology. Interventions have the potential to overcome health system constraints and barriers to maternal health access by improving communication, client education and health worker capacity. This has led to increased utilization of maternal health services, improved referrals and enhanced data collection and reporting. However, the short-lived nature of most interventions limits their level of impact on maternal health outcomes. The full benefit of digital solutions are not being harnessed as most projects fail to move past the pilot phase.

Analysis of selected evidence revealed an emphasis on technology development, adoption and execution with limited focus on the sustainability of the interventions. Information on key eHealth components including interoperability, leadership, legislation and funding, was limited. Identified factors associated with the implementation process were limited to the context of technology adoption and implementation. They include effective community and health worker engagement, adaptation of technology to local context, service integration and health system support. Challenges to implementation are largely infrastructural, including issues with power supply, network connectivity and disparities in mobile phone access.

Implementation strategies should focus on the role of the community and health workforce to increase acceptability and adoption. Using an integrated approach to services increases chances of successful implementation. There is a need to identify factors related to sustainability and scale-up of interventions to improve their expansion on a larger scale and ultimately increase their impact on maternal health outcomes. Better documentation of studies is required to provide detailed evidence to inform sustainable implementation.

6.5.2 Recommendations

Based on the review of the evidence in SSA, recommendations for improving implementation and feasibility of digital health for maternal health interventions in Nigeria are as follows:
Recommendations for policy makers/ policy recommendations:

- Address sustainability by providing supportive legislative, financial and leadership frameworks and improving ICT infrastructure-power supply, mobile network connectivity & coverage. This can be done by:
    - Reviewing the current national eHealth strategy and establishing plans for enhanced implementation
    - Determining the minimum ICT infrastructural requirements at local government level and establish a support package

- Strengthen existing health system by providing basic essential resources, to support successful implementation of technology interventions. This can be achieved by prioritizing the funding and upgrading of primary health healthcare facilities.

- Engage stakeholders (private sector, innovators, implementers) to align digital health efforts with national health sector strategies by providing regular fora for meeting, exchange of ideas and plans and for collaboration.

Recommendations for digital health innovators & implementers/ intervention recommendations:

- Ensure adequate community participation and health worker support at community level to foster acceptance and ownership of the technology intervention & ensure continuity. This can be done by:
    - Targeting health workers at the design and development stage to obtain their input and support
    - Providing training and technological support that is in alignment with their current work processes and job needs
    - Involving intervention beneficiaries in the design, testing and implementation
    - Ensuring engagement is continuous throughout the implementation process

- Integrate technology intervention with existing health system services to provide a comprehensive package of services that increases impact on maternal health outcomes. To achieve this, implementers should engage the government at the design stage of the intervention to determine what applications would best suit the health delivery system and align with national health goals.

- Prioritize activities geared towards continuity and sustainment of interventions by establishing linkages with existing digital systems, adopting a more collaborative approach to implementation as opposed to working in silos.

Research recommendations:

- Further research is required to determine actions necessary for scale-up & improved sustainability. Future research should include more interventions implemented on a large-scale in order to better identify the process and factors that influence sustainability and scale-up in low-resource settings

- Improved reporting to address information gaps:–studies should aim to provide more detailed descriptions of the implementation process. Studies on cost-effectiveness & feasibility of interventions are also needed to decide which combination of interventions (digital & non-digital) should be implemented.

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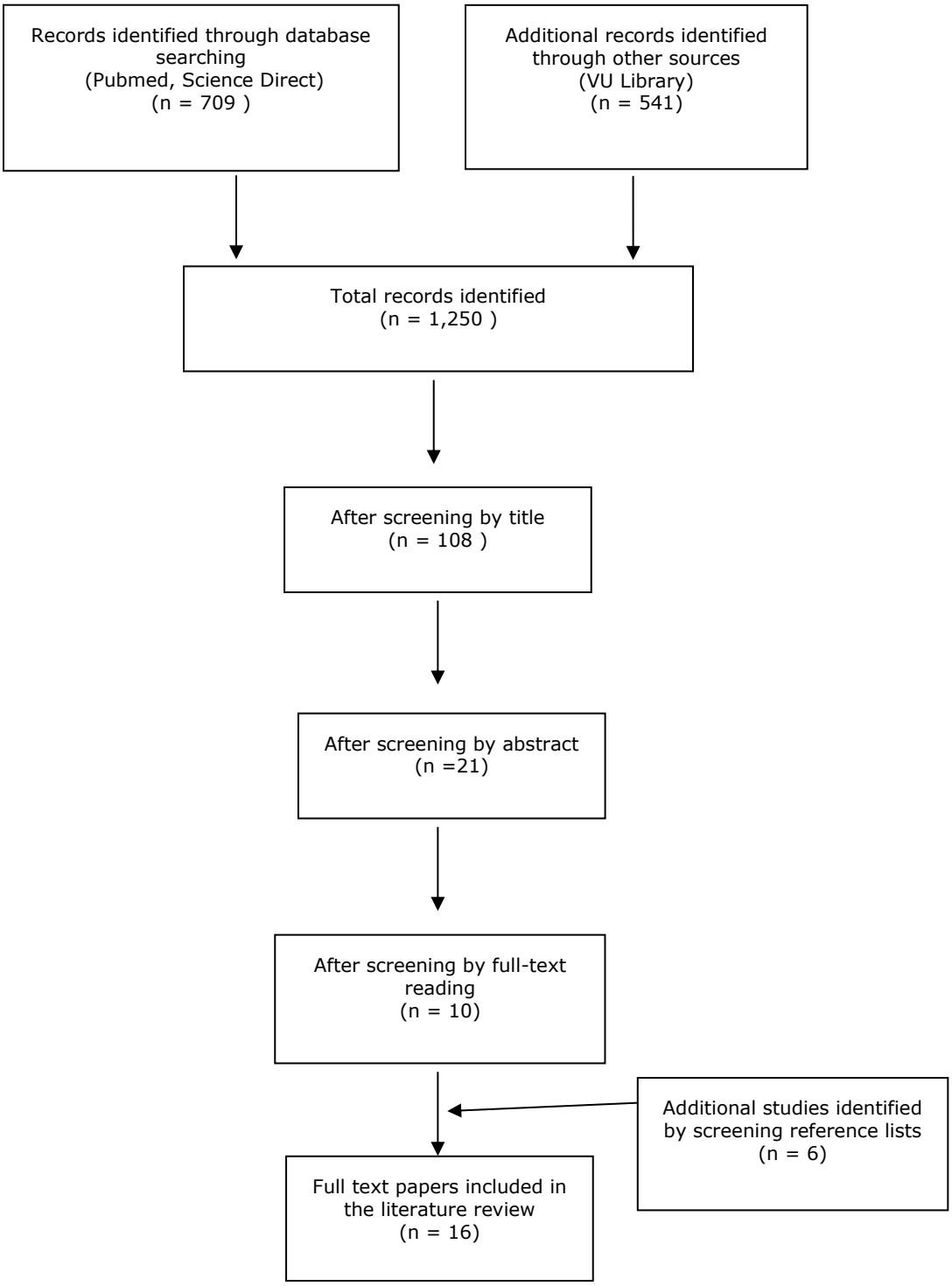
APPENDICES

Appendix I: Search strategy

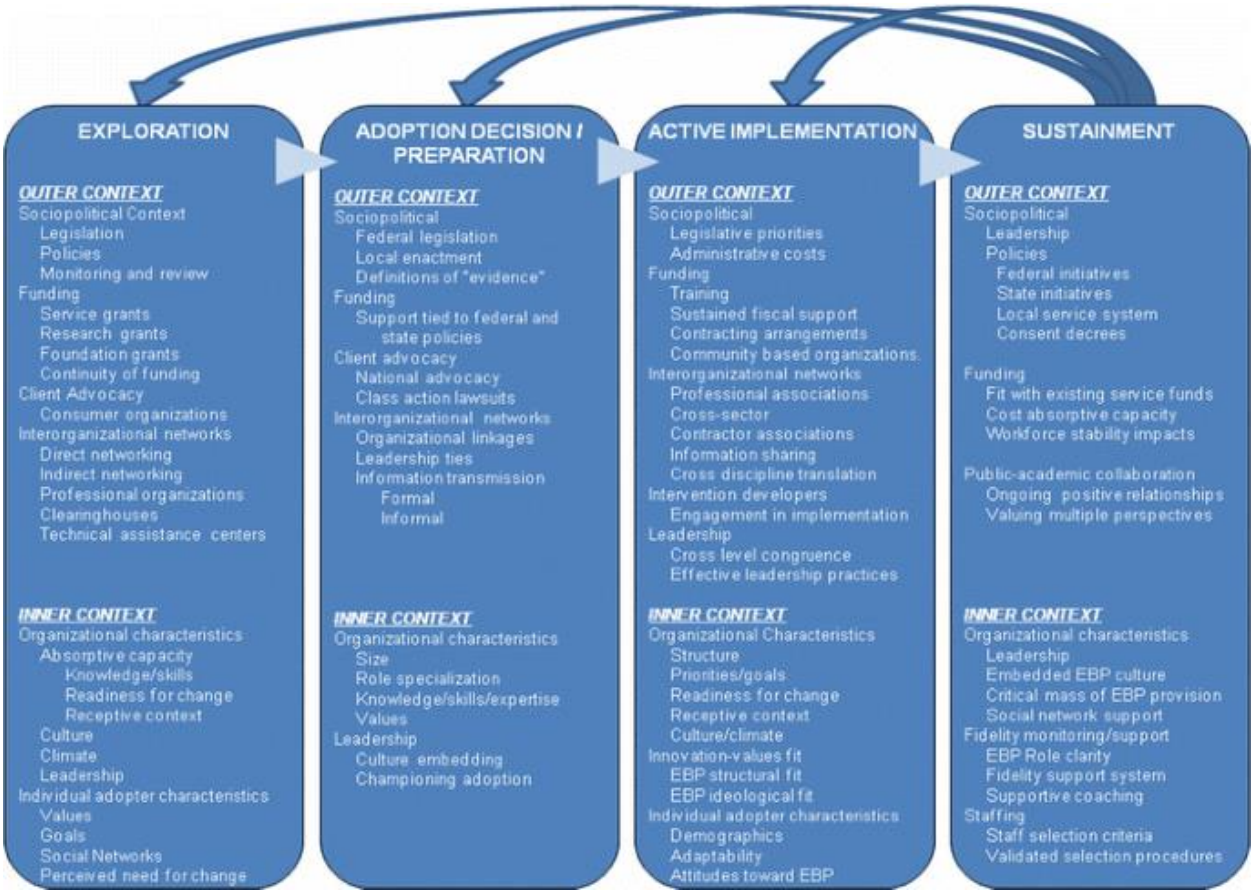
CATEGORY	SEARCH TERMS
#1 - Intervention	digital health OR digital technology OR digital applications OR digital health interventions OR mHealth OR mobile health OR eHealth OR eHealth interventions OR mobile technology OR mobile applications OR mHealth interventions AND
#2 - Outcome	maternal health OR maternal health outcomes OR antenatal care services OR ANC OR postnatal care OR PNC OR skilled birth attendance OR facility delivery OR emergency obstetric care OR family planning OR contraceptive use AND
#3 – Setting	sub Saharan Africa OR Africa OR African region OR Nigeria OR West Africa OR East Africa AND
#4 – Others	evaluation OR impact OR health access OR utilization OR assessment OR limitations OR scale-up OR behavior change

Appendix II: Flow Diagram of Study Selection Process



Source: Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement.

Appendix III: Four-phase model of implementation phases and factors affecting implementation in public service sectors



Source: Aarons G.A. et al. (2011) Advancing a conceptual model of evidence-based practice in implementation in public mental health and child welfare systems.

Appendix IV: Description of Implementation Phases & eHealth Components

	Exploration phase: Includes needs & infrastructure assessment, stakeholder engagement	**Adoption Phase:** Involves modification of intervention to suit local context	**Implementation phase:** Involves program execution & activities to ensure fidelity	**Sustainment phase:** Includes measures taken to ensure long-term impact
eHealth Components	**ACTIVITIES**			
Leadership & governance: Overall coordination & alignment with project goals	Public awareness & consultation	Continued stakeholder engagement & consultation	Oversight of program execution, plans for monitoring	Assessment of monitoring data; linkages of outcomes to feasibility & continuity
Strategy & investment: Financial & planning activities	Strategic planning, funding & financial management	Provide support, resources & motivation	Provide support, resources & motivation	Cost analysis
Legislation, policy & compliance: Legal framework & policy environment	Strategies for compliance & data security	Relevant regulatory guidance or oversight	Relevant regulatory guidance or oversight	Relevant regulatory guidance or oversight
Services & applications: Solutions for specific health challenges	Identification of application & linkage with expected outcome of interest	Adaptations to content & delivery platforms	Mode of delivery of intervention, platforms used & frequency	Mode of delivery of intervention, platforms used & frequency
Infrastructure: Physical & software infrastructure & services	Assessment of infrastructure availability	Modifications to existing infrastructure	Details of infrastructure used in the implementation process	Minimum infrastructure support for sustainment
Standards & interoperability: Minimum standards for information exchange	Define terminologies, messaging structures, quality & data security	Integration of intervention into national health information system	Establish linkages to facilitate data exchange	Intervention algorithms to support replicability
Workforce: manpower, knowledge & skill	Training, supervision & support	Technical support, tools developed	Additional training during intervention, if required	Additional training during intervention, if required

Sources: (Aarons G.A. et al. 2011; Agarwal S. et al. 2016; Valente T.W. et al. 2015; WHO, 2019a; WHO 2012)

Appendix V: Summary table

	Article description	Intervention description	Country	Duration	Study type	Study population	Scale of project	Outcomes measured	Results	Implementation challenges, enablers & opportunities
#1	Abejirinde I.O.et al (2018) Pregnant women's experiences with an integrated diagnostic and decision support device for antenatal care in Ghana.	mHealth & non-invasive diagnostic devices (integrated diagnostic & clinical decision support linked to android tablets)	Ghana (rural)	12 months	Proof-of-concept study	Pregnant women & health workers in selected facilities	Pilot project	ANC utilization	Effect of intervention on ANC utilization inconclusive	**Enabling/ success factors:** -Client engagement & trust in health worker ability -Health workers (HWs) served as intermediaries -Additional HW training in communication skills **Challenges/ potential barriers:** -Longer consultation/ patient waiting time -Possible over-reliance on technology
#2	Amoah B. et al (2016)Boosting antenatal care attendance and number of hospital deliveries among pregnant women in rural communities: a community initiative in Ghana based on mobile phones applications and portable ultrasound scans.	mHealth intervention implemented along with use of portable ultrasound scans	Ghana (rural)	11 months	Community trial	Pregnant women in the selected community	Pilot study	ANC attendance & facility deliveries	Increase in ANC attendance & facility deliveries	**Enabling/ success factors:** -Health worker engagement pre-implementation -Combination of mobile devices & portable ultrasound -Additional health system support -Proximity to health facility -Health workers served as intermediaries **Challenge & potential barriers:** -Male partner pressure against participation -Portable ultrasound machines capital intensive for scale-up
#3	Atnafu A., Otto K. & Herbst C. (2017) The role of mHealth intervention on maternal and child health service delivery: findings from a randomized controlled field trial in rural Ethiopia.	mHealth (appointment reminders via SMS reminder; voice calls used for communication)	Ethiopia (rural)	13 months	Randomized control trial	Pregnant women & new mothers in selected communities	Pilot project	ANC, SBA, PNC & contraceptive prevalence	Increased ANC, SBA & PNC; no impact on contraceptive prevalence	**Enabling/ success factors:** -Health workers served as intermediaries -Engagement of HW cadres close to the grassroots/ household level **Challenges/ potential barriers:** -Network failure and irregular power supply -Periodic shortages of project mobile phones for HWs -Non-alignment/ integration with existing health care delivery system
#4	Babalola S. et al (2019) Efficacy of a Digital Health Tool on Contraceptive Ideation and Use in Nigeria: Results of a Cluster-Randomized Control Trial.	mHealth (educational content via IVR calls)	Nigeria (urban)	3 months	Randomized control trial	Women aged 18 – 35 with access to a mobile phone	Pilot project	Contraceptive use	Increase in contraceptive use	**Enabling/ success factors:** -Use of IVR made the content available to wide range of participants -Content was adapted to the local language -Pre-testing & incorporation of feedback before roll-out **Challenges/ potential barriers:** -High attrition rate of participants -Technical issues with the technology such as network problems -Mobile sharing & lack of electricity -Spousal disapproval
#5	Battle J. et al (2015) mHealth for Safer Deliveries: A mixed methods evaluation of the effect of an integrated mobile health intervention on maternal care utilization.	mHealth (mobile app for client tracking, data & report generation, with decision-support feature; SMS or voice calls for referrals) integrated with home visits for education and counselling by HWs	Zanzibar (rural & urban)	24 months	Mixed methods evaluation	Pregnant women & HWs in selected facilities	Scale-up of a previous initial pilot	Facility deliveries & PNC attendance	Increase in facility deliveries & PNC attendance	**Enabling/ success factors:** -Community awareness, engagement & sensitization -Integrated program approach -Use of combination of mHealth applications

#6	Hackett K. et al (2018) Impact of smartphone-assisted prenatal home visits on women's use of facility delivery: Results from a cluster-randomized trial in rural Tanzania.	mHealth (appointment reminders via SMS; point-of-care, decision-support system) combined with household counselling visits by CHWs	Tanzania (rural)	10 months	Randomized cluster trial	Women aged 16 – 49 who were pregnant & women who had a live birth during the intervention period as well as CHWs	Implemented as part of a larger 3-year MNCH project	Facility deliveries	Increased facility delivery	**Enabling/ success factors:** -Combining the mobile technology intervention with home visits -Health workers as intermediaries -Integrated program approach **Challenges/ potential barriers:** -Novelty effect of using the technology not sustainable
#7	Johnson D. et al (2016) A randomized controlled trial of the impact of a family planning mHealth service on knowledge and use of contraception.	mHealth (educational content via SMS)	Kenya (urban)	8 months	Randomized control trial	Not indicated	Pilot project	Knowledge and use of contraceptives	Increase in knowledge of contraception, but no effect on contraceptive use	**Enabling/ success factors:** -Baseline data collection **Challenges/ potential barriers** - "Pull' service approach - Public awareness and sensitization focused on urban areas
#8	Kebede A. et al (2019) Effect of enhanced reminders on postnatal clinic attendance in Addis Ababa, Ethiopia: a cluster randomized controlled trial.	mHealth (SMS reminders, voice calls)	Ethiopia (urban)	3 months	Randomized control trial	Women who had live births at selected facilities within the study period and had mobile phone access	Pilot project	PNC attendance	Increased PNC attendance	**Enabling/ success factors:** -Content adapted to local language -Previous ANC attendance **Challenges/ potential barriers:** -Mobile phone ownership or access a requirement
#9	Lund S. et al (2014) Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial.	mHealth (appointment reminders & educational content via SMS)	Zanzibar (urban & rural)	12 months	Randomized controlled trial	Pregnant women attending ANC clinic at the selected facilities	Pilot project	ANC attendance	Increase in the proportion of women receiving the recommended 4 ANC visits during pregnancy	**Enabling/ success factors:** -Additional health system support -Mobile phone ownership not a requirement for participation requirement for participation -Provision of mobile phone vouchers -Health workers served as intermediaries -Literacy was not a requirement for participants -Urban residence of the participants -High mobile phone penetration and ease of use -Engagement of local health workforce as project support staff **Challenges & potential barriers:** **-**Provision of mobile phone vouchers as not feasible if intervention is implemented on a large scale
#10	Lund S. et al (2012) Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: a cluster-randomised controlled trial.	mHealth (appointment reminders & educational content via SMS)	Zanzibar (urban & rural)	12 months	Randomized controlled trial	Pregnant women attending ANC clinic at the selected facilities	Pilot project	Skilled birth attendance (SBA)	Increase in skilled delivery attendance	**Enabling/ success factors:** -Additional health system support -Mobile phone ownership not a requirement for participation requirement for participation -Provision of mobile phone vouchers -Health workers served as intermediaries -Literacy was not a requirement for participants -Urban residence of the participants

										-High mobile phone penetration and ease of use -Engagement of local health workforce as project support staff **Challenges & potential barriers:** **-**Provision of mobile phone vouchers as not feasible if intervention is implemented on a large scale
#11	Mangwi A. et al (2016) Effect of Village Health Team Home Visits and Mobile Phone Consultations on Maternal and Newborn Care Practices in Masindi and Kiryandongo, Uganda: A Community-Intervention Trial	mHealth (educational content via SMS & voice calls btw HWs for clinical support & referrals) combined with home visit for education & counselling	Uganda (rural)	18 months	Randomized control community intervention trial	Pregnant women from selected villages	Not indicated	Health facility delivery, ANC attendance	Increase in utilization of facility delivery, no statistically significant association with ANC consultation	**Enabling/ success factors:** -Health workers served as intermediaries **Challenges/ potential barriers:** -Health worker attrition -Geographical distance -Mobile network interruptions
#12	Omole O. et al (2017) The effect of mobile phone short message service on maternal health in south-west Nigeria.	mHealth (appointment reminders & educational content via SMS)	Nigeria (urban & rural)	Not indicated	Randomized control study design	Pregnant women attending ANC clinics in selected facilities	Pilot study	ANC attendance & facility deliveries	Increase in facility deliveries	**Enabling/success factors:** -High level of mobile phone penetration & coverage -Public launch & sensitization prior to implementation -Baseline data collection -Content adapted to local context (translation, etc) **Challenges & potential barriers:** -Mobile phone & credit voucher ownership may be a challenge for large-scale implementation -Literacy requirement for end-users
#13	Oyeyemi O. & Wynn R. (2014) Giving cell phones to pregnant women and improving services may increase primary health facility utilization: a case–control study of a Nigerian project.	mHealth (free mobile phone access for enhanced communication between clients & health workers)	Nigeria (mostly rural communities)	Not indicated	Case-control study	Pregnant women at selected health facilities	Pilot project	Facility delivery	Increase in facility utilization	**Enabling/ success factor:** -Proximity of health facility **Challenges/potential barriers** -High demand for free mobile phones resulted in periodic shortages -Mobile phone network issues & irregular power supply for charging phones
#14	Ruton H. et al (2018) The impact of an mHealth monitoring system on health care utilization by mothers and children: an evaluation using routine health information in Rwanda.	mHealth (appointment reminders via SMS & data reporting component) in addition to health system support (equipment, medical training & supervision)	Rwanda (urban & rural)	Not indicated	Interrupted time series analysis	Pregnant women and mothers at selected health facility	Large-scale (nationwide)	ANC, PNC utilization, facility delivery	Increase in facility deliveries and PNC visits but limited impact on ANC visits	**Enabling/ success factors:** -Additional health system support -Integrated program approach

#15	Shiferaw S. et al (2016) The Effects of a Locally Developed mHealth Intervention on Delivery and Postnatal Care Utilization; A Prospective Controlled Evaluation among Health Centres in Ethiopia.	mHealth (appointment reminders & educational content via SMS; included a decision-support component)	Ethiopia (urban & rural)	12 months	Non-randomized controlled study	Pregnant women visiting selected health facilities	Not indicated	Facility deliveries, ANC & PNC attendance	Increased facility deliveries (by 15%) & PNC attendance (by 20%)	**Enabling/success factors:** -Intervention had features of decision-support for health workers -Health workers served as intermediaries -High mobile penetration, as indicated by the authors -The use of a locally designed application - Active HW participation
#16	Unger J. et al (2018) SMS communication improves exclusive breastfeeding and early postpartum contraception in a low to middle income country setting: a randomized trial.	mHealth (educational content via SMS)	Kenya	Not indicated	Randomized control trial	Pregnant women attending the selected clinic	Pilot project	Facility delivery and contraceptive use	Early post-partum contraceptive use increased, no effect on uptake of facility delivery	**Enabling/ success factors:** -Input from users (HWs) & beneficiaries (pregnant women) incorporated before implementation -Use of 2-way SMS **Challenges/ potential barriers:** -Non-alignment/ integration with existing healthcare delivery system -The 2-way approach had added costs