

Assessing the Impact of Digital Health Technologies on Maternal Health Care in Sub-Saharan Africa

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ASSESSING THE IMPACT OF DIGITAL HEALTH TECHNOLOGIES ON MATERNAL
HEALTH CARE IN SUB-SAHARAN AFRICA

by

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A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
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Abstract

Maternal morbidity and mortality are prevalent issues worldwide that profoundly affects low- and middle-income countries (LMICs) in Africa. Estimates vary, but by the end of 2015, at least 300,000 women died in LMICs due to preventable pregnancy and childbirth conditions. Pregnant women die from complications that could be detected and managed if they were able to receive early access to necessary health interventions. Mobile technology is increasingly common across the globe, including LMICs, and incorporating digital health technologies, especially mobile phone (mHealth) programs, can offer a possible solution to morbidity and mortality related to pregnancy.

A literature review analyzing the impact of mHealth programs on maternal health was conducted from various online databases. Nineteen articles that were published in the last ten years and contained technology-based interventions used for maternal health were reviewed. Inclusion criteria included countries listed as low-income and middle-income in the 2017 World Bank list of economies. The studies suggest mHealth programs have the potential to reduce maternal morbidity and mortality by increasing knowledge of safe health practices for pregnant women, community health workers, and traditional birth attendants. Mobile health technology also provides crucial information to providers when complications arise and can improve health facility utilization leading to increased deliveries with skilled birth attendants. This reinforces the need for more mHealth initiatives to be implemented in LMICs, addressing the barriers and community characteristics to positively impact and reduce maternal death in these settings.

Dedication

For my loving family and friends, I could not have done it without the support of you all. And for my home country of Ethiopia, lezelalem tinur.

Acknowledgment

First and foremost, thank you to God. I am so truly blessed and thankful for all the opportunities I have been given. May I never lose sight of what is truly important.

To my loving parents, thank you for all your sacrifices and hard work. Your support and faith in me mean everything.

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Introduction

Low- and middle-income countries (LMICs) in Africa are plagued by high rates of maternal mortality. According to the World Health Organization (WHO), 289,000 women died worldwide in 2013 from pregnancy or childbirth complications, and 62% of those maternal deaths occurred in sub-Saharan Africa (WHO, 2014). The majority of maternal deaths are a result of obstetric complications including postpartum infections, hemorrhage, obstructed labor and other emergencies that can be averted and managed if pregnant women receive early access to necessary health interventions (Amoah, Anto, Osei, Pieterston, & Crimi, 2016).

The United Nations Millennium Declaration was accepted by world leaders in 2000, which established time-specific objectives with a deadline in 2015 (Pagalday-Olivares et al., 2017). These objectives, named Millennium Development Goals (MDGs), aimed to lower rates of extreme poverty and promote peace, human rights, and security. Specifically, MDG five concentrated on reducing the maternal mortality ratio from 400 to 100 maternal deaths per 100,000 live births between 1990 and 2015 (Pagalday-Olivares et al., 2017). To build on and accomplish what MDGs did not achieve, 17 Sustainable Development Goals (SDGs) and 169 targets were initiated to be completed by the year 2030, with maternal health addressed under goal three (WHO, 2015). SDG three focuses on minimizing the global maternal mortality ratio to about 70 per 100,000 live births by 2030 (WHO, n.d.).

Digital health technology has been shown to improve the quality and coverage of care, increase access to health information, services and skills, as well as promote positive changes in health behaviors to prevent the onset of acute and chronic diseases (WHO, 2018). Digital

technology, including the use of electronic health (eHealth) and mobile health technology (mHealth), is a possible solution for pregnant women to receive the necessary care they need and to meet the SDGs by the year 2030.

Background

The use of mobile and wireless devices to support medical and public health practice and research (mHealth) is garnering increased attention as it provides opportunities to swiftly connect people, reducing delay across the chain of health decisions, thus, positively affecting the lives of underserved populations (Ngabo et al., 2012). EHealth (electronic health) is defined as the combined use of electronic communication and information technology in health care (Ngabo et al., 2012). Mobile health (mHealth) is a category of eHealth and is defined as medical and public health practice by mobile devices such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices' through the means of text, video, or call (Entsieh, Emmelin, & Pettersson, 2015). EHealth has the potential to help reduce delays and challenges in maternal health care (MHC) that rural or resource-limited communities are experiencing (Ngabo et al., 2012). Also, eHealth solutions can lower costs for health service delivery, maintenance, and support, making them a viable and affordable way to improve health care in rural communities (Pagalday-Olivares et al., 2017).

While many digital health interventions have succeeded regarding adoption by a considerable number of providers and patients, they have generally failed to gain the level of acceptance required for their integration into national health systems that would promote sustainability and population-wide application (Huang, Blaschke, & Lucas, 2017). Utilizing community health workers (CHWs) is ideal in remote regions for health promotion and illness prevention given the lack of licensed health care providers available in those distant communities (Mangwi Ayiasi, Kolsteren, Batwala, Criel, & Orach, 2016). CHWs are defined as unlicensed volunteers from neighboring areas who serve as health promoters and home-based providers

trained to carry out simple but effective medical tasks (Amoah et al., 2016). With the incorporation of mHealth initiatives, task shifting allows CHWs to serve as intermediaries between higher health institutions and the community (Amoakoh-Coleman et al., 2016). According to a study done by Amoah et al. (2016), younger CHWs grasped the use of the mobile phone application faster than their older peers, demonstrating that age could be a factor included in the selection criteria for CHWs.

Significance

The International Telecommunication Union (ITU) estimates that mobile phone subscribers reached 6.8 billion worldwide, and the global penetration rate attained 89% in LMICs in 2013 (Amoakoh-Coleman et al., 2016). In many such countries, people are more likely to have access to a mobile telephone than to clean water, a bank account or electricity (WHO, 2018). Africa's mobile phone use has increased significantly despite the debatable internet and landline infrastructures (Amoah et al., 2016). More than 500 million users have access to mobile phones, and approximately 50% of all individuals in remote regions in Africa have a mobile phone (Lund et al., 2012), with satisfactory telephone signals already present in even the most distant of communities (Oyeyemi & Wynn, 2014).

There have been multiple mHealth initiatives piloted and implemented in sub-Saharan countries including Uganda, Zambia, Malawi, and Nigeria (Omole et al., 2018). These initiatives have shown potential in the solution of using mobile technology to improve and promote antenatal care (Omole et al., 2018). The predominately used mobile-based method is a short messaging service (SMS) or more commonly known as text messaging (Lund et al., 2012). For example, Uganda established an SMS system by the National Malaria Control Program to support and manage rapid diagnostic tests to combat malaria (Ngabo et al., 2012). Zambia introduced an SMS system to reduce the delay of infant Human Immunodeficiency Virus (HIV) results from the laboratory to remote health facilities. Malawi launched an SMS system to minimize communication errors between health care providers for family and reproductive health in rural regions (Ngabo et al., 2012). Nigeria initiated the “Abiye” (Safe Motherhood) program in 2009 to establish a communication link between pregnant women and health

facilities during emergencies and to improve tracking of women throughout their pregnancy (Omole et al., 2018). These multiple cases demonstrate the potential of mHealth to improve not only maternal health but also, expand to become a solution for various issues in the health field.

A resource-limited country's ability to successfully implement and maintain a health technology network relies on the country's governmental policies and the national health system (Huang et al., 2017). For instance, challenges to Ghana's ability to implement eHealth solutions include the local stakeholders' inability to afford the increased cost (Pagalday-Olivares et al., 2017). Introducing digital technology programs can offer a possible cost-effective method of improving maternal health indicators. Based on a cost analysis of a mHealth intervention in Malawi, it was concluded that cost per user could be decreased by 48% if the service was operated at full scale (Larsen-Cooper, Bancroft, Rajagopal, O'Toole, & Levin, 2016). The service of the study was named *Chipatala cha pa Foni* (CCPF), or "health center by phone" which consisted of a toll-free hotline and a mobile phone-based tips and reminders (T&R) component striving to improve maternal health indicators (Larsen-Cooper et al., 2016, p.318). Results showed that knowledge-based indicators increased by 80% by users compared to nonusers of the CCPF service. The estimated total cost of the service was \$29.33 per user and \$4.33 per successful contact while the average price for each user that experienced a change in maternal health indicators ranged from \$67 to \$355. As CCPF and other mHealth interventions increase utilization and reach full capacity, they are likely to reduce the cost per contact (Larsen-Cooper et al., 2016).

Problem

Numerous disparities and barriers to care contribute to the higher risk of maternal death in sub-Saharan Africa. It was estimated that by the end of 2015, about 300,000 women would have died during and after pregnancy and childbirth and almost all these deaths that could have been prevented occur in LMICs (Omole et al., 2018). Higher maternal education rates have shown been to have a large effect on reducing infant mortality, therefore, research to enhance the knowledge of family planning and fertility might increase access to care and reduce maternal mortality (Roberts, Birgisson, Julia Chang, & Koopman, 2015). A potential tool to address maternal health outcome in LMICs is by the global increase in mobile technology (Amoakoh-Coleman et al., 2016). Mobile platforms, such as phones and tablets, have enormous potential to impact health care delivery and health outcomes (Bull, Thomas, Nyanza, & Ngallaba, 2018). The incorporation of technology-based interventions is a possible solution for reducing maternal mortality in LMICs. Additional research addressing the specific effects of health technology on maternal health outcomes need to be examined.

Purpose

The purpose of the author was to explore: (1) studies that implemented clinical trials using eHealth and mHealth interventions in sub-Saharan Africa; (2) the impact these interventions had on maternal health care; and (3) the factors that impacted the feasibility and ability to integrate the technology into the communities' health infrastructure.

Method

An initial literature review search was done using CINAHL Plus with Full Text, Academic Search Premier, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, MEDLINE, and PsycINFO databases. The results were limited to articles published in the last ten years since research on technology in resource-limited countries is not as current compared to higher-income countries. Search terms included (MH "Telehealth+") OR (MH "Telemedicine+") OR (MH "Telenursing") OR (MH "Remote Consultation") OR (MH "Mobile Applications") OR (MH "Cellular Phone") or mhealth or Telemedicine or telehealth* or "Mobile Application*" or "wireless communication*" or "mobile app*" or "mobile technolog*" or smartphone app* or text*) AND (MH "Africa South of the Sahara+") OR (MH "Africa, Western+") OR "east* Africa" or "west* Africa" or "Sub-Saharan Africa OR Benin OR "Burkina Faso" OR Burundi OR Central African Republic OR Chad OR Comoros OR Congo or Eritrea OR Ethiopia OR Gambia OR Guinea OR Guinea-Bissau OR Liberia OR Madagascar OR Malawi OR Mali OR Mozambique OR Niger OR Rwanda OR Senegal OR Sierra Leone OR Somalia OR South Sudan OR Tanzania OR Togo OR Uganda OR Zimbabwe OR Angola OR Cabo Verde OR Cameroon OR "Côte d'Ivoire" OR Ghana OR Lesotho OR Mauritania OR Nigeria OR "São Tomé" OR Principe or Sudan OR Swaziland OR Zambia) AND (pregnan* or "expect* mother*") AND (outcome* or delivery or complication* or "birth weight" or mortality or morbidity) NOT "decision support" NOT (Botswana OR "Equatorial Guinea" OR Gabon OR Mauritius OR Namibia OR "South Africa"). Inclusion criteria included articles published in the English language and those that contained technology-based interventions used for maternal health in resource-limited countries in sub-Sahara Africa.

The specific countries included were the nations in sub-Saharan Africa, listed as low income or middle income in the 2017 World Bank list of economies (World Bank, 2017), which includes countries by income level and classified by the Gross National Income (GNI) per capita. A detailed explanation of the article selection process can be found in Appendix A Figure 1.

Results

This literature review included nineteen articles, which showed concise findings on the different benefits and barriers of digital health technologies on maternal health care in sub-Saharan Africa. After a comprehensive review of each article, the results are divided into sections based on emerging themes. The sections better unify and discuss the impact of technology on maternal health care: influence of community health workers (CHWs), antenatal and postnatal care, delivery of care, acceptability by pregnant women, barriers to mHealth, and feasibility of integration. Each section illustrates the evidence that shows the impact of mHealth interventions on maternal health care. Refer to Appendix B table of evidence for a concise presentation of the literature.

Influence of Community Health Workers (CHWs)

Several studies (Amoah et al., 2016; Battle et al, 2015; Mushamiri et al., 2015; Ngabo et al., 2012; Mangwi et al., 2016) that used community health workers (CHWs) with an mHealth intervention had a similar criterion for a volunteer to be a CHW. CHWs are literate, unlicensed volunteers that have been selected by community members and have undergone training through the health system (Amoah et al., 2016). Findings from the studies show that CHWs can effectively aid maternal health care with the support of mobile phones. A study by Ngabo et al. (2012) found that CHWs were more pro-active in their duties as a result of reminders that were sent to their mobile phones. Similarly, a study by Mushamiri, Luo, Iiams-Hauser, and Ben Amor, (2015) found that CHWs would forget or not be aware of next appointments for the pregnant women as a result of paper-based methods to record data.

Mobile phones offer a tool for CHWs to monitor pregnant women efficiently and improve timely care-seeking for health facility delivery (Mangwi et al., 2016). CHWs were able to alert health professionals of a referral ahead of time. A study by Battle, Farrow, Tibaijuka, and Mitchell (2015) found that the actual decision to seek care was credited to CHW's counseling messages and the general support they provided over the availability of free transport. The use of mobile phones increased the CHWs' confidence in their ability to correctly refer pregnant women to health facilities and increased their self-efficacy due to a broadening of their knowledge (Battle et al., 2015).

Studies found the use of CHWs helped provide education to the pregnant women and helped increased health professional's preparedness in assisting the pregnant women. Ngabo et al. (2012) found that CHWs helped dispel certain myths about pregnancy and educate pregnant women about attending antenatal care, which in turn, helped establish trust. Similarly, Battle et al. (2015) found that pregnant women felt safer when they were escorted to a health facility by a CHW because they trusted their CHW. Many health workers mentioned they were better prepared and were able to assist mothers more quickly when CHWs were present with the mothers because of the health information they were able to provide onsite (Battle et al., 2015).

Antenatal and Postnatal Care

Evidence suggests the benefits of antenatal care (ANC) include improving maternal and child health by providing education and creating a connection between women, their families, and the health care system along with preventing, detecting and treating diseases or maternal morbidities (Benski et al., 2017). The use of mHealth interventions has the potential to improve ANC and postnatal care attendance and education in low resource settings. A study by Larsen-

Cooper, Bancroft, Rajagopal, O'Toole, and Levin (2016) found that the proportion of users of the mHealth program who knew the recommended number of times a pregnant woman should go for an ANC visit was 25% higher when compared to that of nonusers. Likewise, findings from a study by Jennings, Omoni, Akerele, Ibrahim, and Ekanem (2015) concluded that women without mobile phone access were considerably less likely to utilize skilled ANC and delivery care services when compared to mobile-connected women who were eligible to take part in patient-based maternal mHealth interventions. Women without mobile phone access had 54% lower odds than female mobile phone users of knowing the benefits of ANC, after controlling for demographic characteristics (Jennings et al., 2015). In a cluster randomized controlled trial by Lund et al. (2014), women in the mHealth intervention group had greater than double the odds for attending the recommended four or more ANC visits and there was a positive trend for more antepartum referrals among the intervention group, signifying more women were being identified and treated earlier.

There were, however, mixed findings on the impact of mHealth interventions on postnatal care attendance. Battle et al. (2015) found that total rates of postnatal attendance were as high as 88% among mothers in the program compared to lower rates during the earlier stages of implementation. The Jennings et al. (2015) study found postnatal care attendance was lower than ANC and found no remarkable differences observed in the odds of postnatal care attendance by phone status within a day of birth or one week after birth.

Pregnant women themselves recognized the value of ANC and postnatal care due to information sent to them through mobile phones. The Mobile Midwife application (app) initiated in Ghana frequently sent women reminders of upcoming ANC appointments and the benefits of

attendance (Entsieh et al., 2015). As a result, the women themselves stated that the frequency of their ANC attendance improved, the women grasped the value of ANC, and appreciated receiving medication since they were relying less on local herbs (Entsieh et al., 2015).

Delivery of Care

The use of mobile phones in maternal care allows for faster and more reliable delivery of care. In Zanzibar, the intervention period had a significant increase in facility delivery rates, and according to health worker informants, that was attributed to transportation that was arranged for the pregnant women (Battle et al., 2015). According to a study by Mangwi et al. (2016), health facility delivery in Uganda was three times higher in the intervention group (87%) compared to the control group (28%). Oyeyemi et al. (2014) concluded that cell phones improved the primary health care delivery system in Nigeria because total facility utilization rates were considerably higher in the project area compared to the control (t-test, $t(1478) = 9.261$, $p < 0.001$). In a pilot study conducted by Benski et al. (2017), 62.7% of the participants in Madagascar reported their delivery was attended by a skilled birth attendant, and 94.9% had been assisted by either a skilled birth attendant or a traditional midwife during delivery. Women who lacked access to a mobile phone in Nigeria had an 82% significant decrease (OR = 0.18, 95% CI: 0.15–0.22) in the odds of delivering with a skilled attendant as compared to those with mobile phone access (Jennings et al., 2015). This relationship was maintained at 44% significantly lower odds (OR = 0.56, 95% CI: 0.45–0.70) of delivering with a skilled provider after controlling for demographic factors (Jennings et al., 2015). An experimental design in Nigeria by Omole et al. (2018), highlighted a 29% increase in facility-based delivery in the intervention group when compared with a 13% increase in the control group.

There were mixed findings of facility delivery regarding residence status. Lund et al. (2012) concluded the wired mothers' intervention was highly significant amongst urban women who had odds five times higher for delivering with skilled attendance, though the intervention did not improve skilled delivery attendance among women living in rural areas. Conversely, Shiferaw et al. (2016) found that using a phone-based app that had features of decision support, sending reminders about subsequent visits and educational messages, significantly increased delivery and postnatal care service utilization regardless of the age of the women, residence (urban/rural) or parity in Ethiopia. The multivariate analysis showed that women who visited the intervention health centers were substantially more likely to have delivery in the health facility (43.1%) compared to the control group (28.4%) (Shiferaw et al., 2016).

The use of mHealth has improved communication between health workers and developed a better way to manage data collection. Battle et al. (2015) discovered that CHWs called ahead to the facilities to inform staff of the referral, which led to an increase in facility preparedness. The majority of CHWs discussed the positive relationships that arose between themselves and the health workers due to their frequent communication (Battle et al., 2015). In a systematic review by Amoakoh-Coleman et al. (2016), mHealth interventions were considerably more efficient than traditional methods used for communication and improved the effectiveness of community health services in terms of managing logistics, reporting events, and addressing emergencies. A study conducted in Ethiopia suggested that mobile technologies allow health managers to more quickly and reliably have access to data which can help them identify whether there are issues in service delivery (Amoakoh-Coleman et al., 2016). In Malawi, mobile phones were used to reduce the communication gap between health workers and their district teams since the mHealth

intervention was at least four times cheaper and 134 times more efficient, compared with traditional methods of transportation to reach supervisors face to face (Amoakoh-Coleman et al., 2016). The Pregnancy and Newborn Diagnosis Assessment (PANDA) mHealth system initiated in Madagascar created clinical charts through the digital network, enabling distance monitoring and supervision as well as mapping of high-risk pregnancies and communicable diseases for better care management (Benski et al., 2017).

Research suggests that most cell phones users are men in sub-Saharan Africa, making it beneficial to incorporate men into mHealth programs to reduce maternal morbidity and mortality. According to a study by Entsieh et al. (2015), the women stated that Mobile Midwife enhanced levels of male involvement during pregnancy. In a study by Roberts et al. (2015), almost all the participants – men and women – reported that they would be interested in calling a toll-free number to receive maternal health education on pregnancy and delivery. Furthermore, participants' interest in receiving these lessons by calling a toll-free number was not related to their level of education suggesting that this mode of delivering maternal health education may be appealing to a wide range of men and women with diverse education levels (Roberts et al., 2015).

Acceptability by Pregnant Women

Several studies agreed that pregnant mothers recognized and accepted the benefits of the mHealth solutions. A study by Benski et al. (2017) in Madagascar, concluded 100% level of satisfaction expressed by women regarding their ANC visit, and 98% of participants mentioned they had gained new knowledge using the PANDA mHealth system (Benski et al., 2017). The sense of feeling supported, safe, and secure was a strong theme that emerged from the data and a

major reason for women getting to their ANC visits in Zanzibar (Battle et al., 2015). The women using Mobile Midwife in Ghana slowly gained trust in the counseling being provided by the mHealth program and gradually, started moving away from traditional practices that could be harmful to their health (Entsieh et al., 2015). The women voiced that after they started eating the recommended foods from Mobile Midwife, their health improved and it was reflected in their medical reports, which increased their trust (Entsieh et al., 2015).

The different mHealth programs influenced positive changes in maternal health care. Lund et al. (2014) found the majority of pregnant women (n = 1311; 59%) in the intervention group stated that receiving text messages influenced the number of times they attended their ANC visits, and 71% felt the educational messages helped them in numerous areas. Consistently, 99.5% of women voiced that SMS influenced their decision to attend ANC, helped them improve ANC attendance (n = 260; 99.4%), and influenced their decision to deliver in a health facility (95.2%) (Omole et al., 2018). Furthermore, 96.6% of the women indicated their support for SMS as a platform for informing ANC clients about obstetric danger signs (Omole et al., 2018). Entsieh et al. (2015) found that participants acknowledged that Mobile Midwife assisted them in reasoning logically like saving some money to buy items that were needed for the birth. The overall high response rate (71%) of a mHealth program in Kenya demonstrated that women were comfortable taking this survey and were willing to share sensitive and even taboo information through mobile phones (Leidich et al., 2018).

Barriers to mHealth

Despite the potential benefits that come with implementing a mHealth initiative, specific barriers that ultimately affect the successfulness of the program need to be addressed. Studies

show that cultural and cost-related barriers need to be considered before implementation. In Zanzibar, mothers were discouraged from calling the CHW too early by older family members and their husbands so the mother could deliver at home if the labor seemed normal to avoid the cost and inconvenience (Battle et al., 2015). Several mothers also mentioned they were afraid to utilize maternal health facilities because of the stories of bad birth experiences from other mothers, and some stated they themselves had not been treated well (Battle et al., 2015). Shiferaw et al. (2016) mentioned barriers to utilization of health services in Ethiopia included the cost of service and distance to health facilities.

Other barriers that were highlighted included remoteness of certain areas that lead to poor infrastructure and unequal access to the web. In a systematic review, Amoakoh-Coleman et al. (2016) found that weaknesses include inadequate telephone maintenance and lack of or limited access to electricity in a great majority of rural communities. It was then concluded that the major factors that hindered successful implementation of mHealth initiatives were lack of reliable web coverage, which limits the potential of mHealth in the public sector, limited capacity to manage damaged phones, low literacy levels, and lack of appreciation of health workers of the need to use data where it is created (Amoakoh-Coleman et al., 2016). In Nigeria, reported barriers regarding the Abiye cell phones were mostly related to the infrastructure: 36% cited electricity to charge the phone was a challenge, 27% cited network failure as the major issue, while 37% did not report any challenges to the use (Oyeyemi & Wynn, 2014).

Lund et al. (2012) agreed that barriers to care include geographical distances, poverty, quality of care, and sociocultural factors. Rural women were greatly challenged by limited access to mobile phones, electricity to charge mobile phones and higher levels of illiteracy, leading to

difficulties in reading text messages (Lund et al., 2012). Pagalday-Olivares et al. (2017) concluded that the main challenge to connect rural and urban areas is the lack of wired networks. The coverage in rural areas was very unstable and vary between operators; urban facilities have good mobile connections to allow video and web communications, but rural facilities were limited to web browsing (Pagalday-Olivares et al., 2017). Likewise, the Ethiopian Demographic and Health Survey found service access is generally higher in urban areas as indicated by a significant percentage of women (69%) having at least one ANC visit from health professionals as compared to only 24% among rural women (Shiferaw et al., 2016). There are disproportionate opportunities for maternal health access for rural and urban areas that need to be considered before implementing a mHealth initiative.

Feasibility of Integration

Research highlights that incorporating younger CHWs and including men in maternal health care can potentially increase the feasibility of mHealth programs. A study by Amoah et al. (2016) observed that younger CHWs grasped the use of technology faster than their older peers, even with the same level of education between them. Entsieh et al. (2015) found that most pregnant women registered with their husbands' phone so they would be the first to receive the voice messages. Over time, the husbands became more interested in listening to the Mobile Midwife messages and often helped their pregnant wives as recommended (Entsieh et al., 2015). Equally, the radio was proven to be an efficient method of education and sensitization, especially in reaching men who are often the decision-makers in this and many other situations. Since men are more likely to own mobile phones, it would be beneficial to involve male partners and

community male leaders through mHealth programs to improve maternal care-seeking and education (Jennings et al., 2015).

Evidence suggests engaging the private sector, applying multiple mHealth approaches, and building on existing health policies encourage sustainability of mHealth programs. In Rwanda, the Ministry of Health (MOH) turned towards the private sector to create a public-private partnership to lower recurrent cost of SMS (Ngabo et al., 2012). As a result, the agreed-upon cost of SMS dropped by ten times from 30 Rwandan Francs (0.05 USD) to 3 Rwandan Francs (0.005 USD) (Ngabo et al., 2012). In Zanzibar, the successfulness of the Safer Deliveries program was attributed to integrating multiple mHealth approaches like decision support, data storage, mobile banking, and communications which in turn, transformed the mHealth initiative into a broader community-based intervention that efficiently linked institutional and community level to overcome barriers to hospital deliveries (Battle et al., 2015).

If technological innovations are to be successful, crucial leaders at both the local and national health systems need to be encouraged to take ownership of the mHealth programs and be able to transition from grant-funding to self-supporting interventions (Entsieh et al., 2015). The findings asserted that success regarding mHealth interventions, like Mobile Midwife, depends on existing policies like free maternal health services since there is a need for strong political will from key stakeholders (Entsieh et al., 2015). Having those policies already in place makes it easier to build and refine the guidelines to fit the country's specific needs. Similarly, Amoakoh-Coleman et al. (2016) asserted that a public-private partnership could reduce cost and facilitate the expansion of mHealth interventions in low-resource settings. Huang et al. (2017)

stated that implementers need to focus as much on the perceptions, attitudes, and needs of stakeholders as on the technology. The claim is that the stakeholders may have investments regarding experience in using the existing systems and feel justified in seeing evidence of the potential net benefits before they accept the programs (Huang et al., 2017).

Remote access and management of the network by cloud services are available in Ghana, offering a feasible solution to reduce connectivity challenges that might hinder the sustainability of mHealth programs (Pagalday-Olivares et al., 2017). Likewise, remote access allows supervision of CHWs and maintenance of their work. The SMS web-user interface initiated in Rwanda allowed CHW's activity reports to be accessed, decreasing the distance issue that hindered supervisors from tracking and monitoring the productivity of CHWs (Ngabo et al., 2012). Program staff were available remotely by phone and would monitor CHWs performance regularly by viewing the real-time data on a dashboard (Battle et al., 2015). Additionally, random inspections were conducted sporadically to ensure visits were being reported along with birth outcomes being conveyed correctly (Ngabo et al., 2012).

Before implementing mHealth programs, community characteristics need to be considered in order to gain a high level of acceptance and to meet the setting's needs (Pagalday-Olivares et al., 2017). Incorporating the values of each community increases the utilization of maternal health services and encourages the feasibility of mHealth programs. Entsieh et al. (2015) agreed that mHealth programs have to be context specific and tailored towards the needs identified by the targets groups themselves. Applying equitable maternal mHealth programs involves information on women's different health needs by mobile phone strata (Jennings et al., 2015). In order to accomplish this feat, assessment of the potential distributional impact of

mHealth strategies on maternal outcomes should be strategized (Jennings et al., 2015). A daunting issue to implementation is the maintenance of the technology. Difficulties with replacing or repairing broken equipment need to be accounted for, and a solution offered is to operate technology from companies that have technical support across the country (Pagalday-Olivares et al., 2017).

Discussion

An ongoing challenge that predominantly affects LMICs is maternal morbidity and mortality. These settings do not have the knowledge nor access to necessary health interventions to manage complications or to safely deliver with a skilled birth attendant. MHealth offers a possible solution to provide expecting mothers with necessary health care to reduce maternal death and meet the SDGs by 2030 (WHO, 2015). Incorporating the use of CHWs can bring about added change in LMICs. CHW programs are already present in most communities, and the use of mobile phones improves the duties of the CHWs when compared to conventional methods (Mushamiri et al., 2015). Mobile phone usage by CHWS enhanced communication between health facilities leading to effective care being provided to pregnant mothers. CHWs knowledge and self-efficacy increased, which in turn, amplified the pregnant women's trust to seek experienced health care (Battle et al., 2015).

Pregnant women that were in the mobile phone intervention groups had more knowledge on the benefits of antenatal care which led to increased utilization of antenatal care visits and referrals (Entsieh et al., 2015; Benski et al., 2017; Larsen-Cooper et al., 2016; Jennings et al., 2015; Lund et al., 2014). There were mixed findings on postnatal care utilization among the articles (Battle et al., 2015; Jennings et al., 2015). Battle et al. (2015) found that overall rates of postnatal care in Zanzibar were high when compared to earlier stages of the mobile phone interventions. However, Jennings et al. (2015) found no significant differences in postnatal care attendance related to mobile phone status in Nigeria. These findings could be related to many different factors, with one being the different community characteristics and values in these two countries. These studies were also looking at different variables in their study: Battle et al.

(2015) were measuring the impact of a specific mobile phone intervention, while Jennings et al. (2015) were measuring the critical differences in mobile phone status on maternal health.

In most of the studies, rates of health facility delivery with a skilled birth attendant have increased in the project groups (Battle et al., 2015; Benski et al., 2017; Jennings et al., 2015; Mangwi et al., 2016; Omole et al., 2018; Oyeyemi et al., 2014). That, in part, is due to the education or access to information the women are receiving with mobile phones. Some of the mHealth initiatives in these countries are sending pertinent information to the pregnant women which increases their awareness of safer health practices. Offering valuable incentives aids in health facility utilization. Battle et al. (2015) had arranged transportation for the pregnant women which played a significant role in the increase of facility delivery rates. However, there were mixed findings regarding facility delivery and residence status. Lund et al. (2012) found that urban women were five times more likely to deliver with skilled attendance in the intervention group, yet the intervention did not improve this variable among rural women. In the study by Shiferaw et al. (2016), the phone-based application increased delivery and postnatal care utilization despite residential status. This difference again can be attributed to community characteristics since these two technology interventions happened in different countries (Zanzibar and Ethiopia). Other variables include the reliability of the technology infrastructure in each setting and the strength of the proposed mobile phone intervention.

Specific articles mentioned mobile phones led to efficient communication and health service delivery when compared to traditional modes (Amoakoh-Coleman et al., 2016; Battle et al., 2015). It led to a faster and more reliable transfer of information and management of data. The communication gap between health workers and their district supervisors was significantly

reduced with the incorporation of mobile phones (Amoakoh-Coleman et al., 2016). Since many cell phone users are men in these LMICs, mHealth initiatives should incorporate this group into their implementations. Studies suggest that men are willing to receive information on maternal health (Roberts et al., 2015) and have shown an increase in male involvement during pregnancy (Entsieh et al., 2015). Rates of acceptability among pregnant women increased in most of the mHealth programs. Women expressed an overwhelming majority of satisfaction and trust from attending their ANC visits and from the new knowledge gained from mobile phones. Many women agreed that the messages that were sent through the mobile phones influenced their decision to seek health facility delivery and care (Omole et al., 2018). Acceptability of mHealth programs by the community members increases the retention of the educational messages and assists in safer maternal practices.

Specific barriers to mHealth interventions should be addressed before implementation. Cost of service is a major factor in the successfulness of mHealth initiatives. Some family members would discourage pregnant mothers to seek skilled health delivery to avoid the burden of the cost of care (Battle et al., 2015). MHealth programs should have reasonable costs for the population being served or at least offer other resources that would be beneficial to the community members to increase utilization of health services. Poor infrastructure and unequal access to the web are other barriers that affect mHealth programs (Amoakoh-Coleman et al., 2016; Oyeyemi et al., 2014; Pagalday-Olivares et al., 2017). Women living in remote areas are more susceptible to maternal deaths since they have such unequal access and opportunities compared to more urban settings. The electrical coverage in rural areas is very unstable and varies between operators, limiting their connection to just web browsing while urban facilities

have good mobile connections to allow video and web communications (Pagalday-Olivares et al., 2017). MHealth programs should work to bridge this resource gap to achieve successful implementation.

Building a relationship with the public and private sector increases the feasibility of integrating mHealth programs. For example, Rwanda's MOH developed a partnership with the private sector, tremendously reducing the cost of the mHealth program that was initiated (Ngabo et al., 2012). Having this partnership can facilitate the expansion of mHealth interventions in low-resource settings (Amoakoh-Coleman et al., 2016). Cost of service is a major barrier to mHealth implementation so taking steps to find solutions, like building public-private partnerships, can positively impact mHealth outcomes. Incorporating multiple mHealth approaches to facilitate communication between levels of health care can assist in finding solutions to multiple maternal health problems these settings are experiencing. Building on top of existing health policies leads to more resources available to community members and an increase in affordability of the mHealth programs. Successfulness of mHealth programs, like Mobile Midwife in Ghana, depends on existing policies like free maternal health services since there is a need for strong political will from key stakeholders (Entsieh et al., 2015). Sustainability of mHealth programs is a crucial factor in successful implementation. Several studies mentioned having remote access reduced connectivity issues and allowed management and maintenance of CHWs, reducing the distance issue that delayed proper supervision (Pagalday-Olivares et al., 2017; Ngabo et al., 2012; Battle et al., 2015).

Taking into consideration the community's characteristics can gain a high level of acceptance and can meet the setting's needs (Pagalday-Olivares et al., 2017). There is a higher

rate of health facility utilization by the community when the values of the population are factored in the implementation. Entsieh et al. (2015) agree that mHealth programs have to be context specific and tailored towards the needs identified by the targets groups themselves. Assessment of the potential provisional impact of mHealth strategies on maternal outcomes should be strategized (Jennings et al., 2015).

Strengths and Limitations

The limitations of this review deserve mention. A limited amount of research has been done on the topic of digital health technologies and the impact on maternal health in resource-limited settings. As a result, there is a gap in knowledge about the effect of mHealth interventions on maternal health outcomes. It would have been advantageous to integrate further studies into this analysis. Many of the articles examined were qualitative, and the designs ranged from interviews to surveys which limit the findings based on the reliability of the surveys and interviews conducted. Additionally, there were four controlled trial studies out of the nineteen studies analyzed which limits the validity of the impact of mobile phones on maternal health.

Despite these limitations, the results of this review show great promise in the positive impact of digital health technologies on maternal health. Outcomes of this review contribute to the generalizability of the results to other remote areas in LMICs in Africa since the articles examined many communities and stakeholders. The significant increase in facility delivery and utilization in the intervention groups highlights the potential of mHealth programs to decrease maternal death in LMICs.

Conclusion

Overall, evidence suggests that mobile phones have the potential to positively impact maternal health in low- and middle-income settings. Findings showed an increase in awareness of safer health practices and health facility utilization among the interventional groups. There were mixed findings on the effect of mHealth on the residential status and the impact on postnatal care attendance, which can be attributed to available resources in those settings and the strength of the proposed study designs. The impact of mHealth on maternal health in LMICs include the influence on the duties of CHWs, the acceptability of the pregnant women, and delivery of care while also looking at the barriers of implementation in these settings and the feasibility of integrating these strategies.

However, there is limited research to suggest that mHealth has the potential to increase maternal health outcomes. Findings demonstrated an increase in community member's satisfaction, trust, knowledge on safer health practices, and utilization of health facilities but there was no research conducted on mHealth's effect on direct health outcomes. This review highlights the enormous contributions mHealth has on maternal health and demonstrates as a potential solution to reducing maternal deaths in LMICs. As more research is done on this topic, mHealth can continue to offer solutions not only in maternal health but also in various health disparities across the globe.

Nursing Implications

Given that nursing is a global profession, the findings in this review can contribute to nursing care worldwide. Nurses can use mHealth programs to serve low-resourced settings and reduce disparities among different population groups. Since technology is fundamentally available worldwide, nurses can use mobile phones to increase awareness of safer health practices in communities that need it the most. Mobile phones allow better communication between different levels of health care and faster modes of data management.

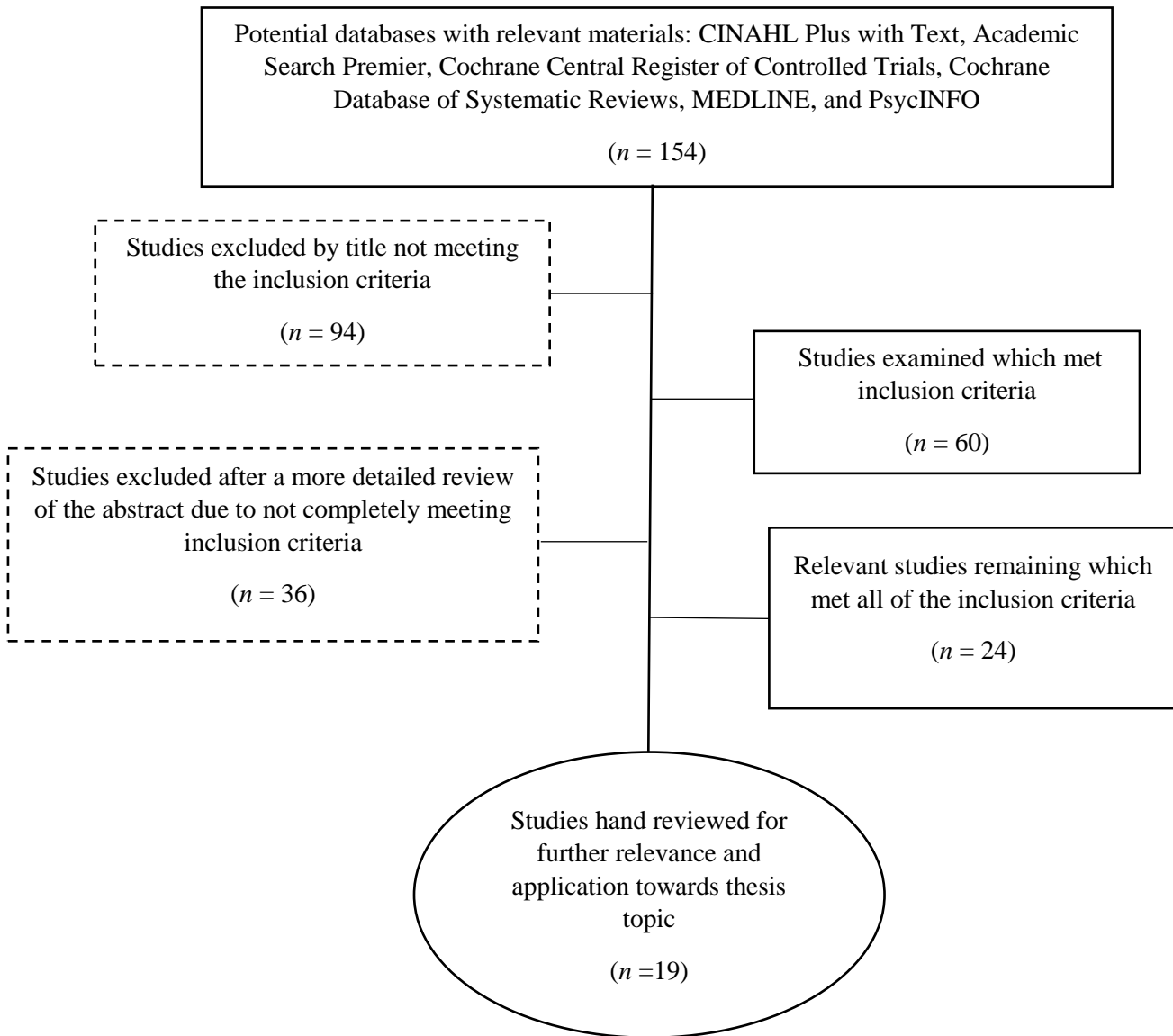
Many volunteer and study abroad trips are done in LMICs. Health professionals can incorporate the use of technology during these trips to better serve the population. Nurses must increase their involvement in mHealth programs since they are the health professionals providing direct care. By using digital health technologies in LMICs or any low-resource setting, nurses can help reduce disparities and address the issue of maternal mortality. Further studies need to be done on the effects of mHealth programs on direct maternal health outcomes and cost of service. More cost-analysis studies need to be done to identify the feasibility of success in implementing mHealth programs.

Appendix A: Flow Chart - Article Selection Process

Figure 1: Article Selection Process

Key Search terms: telehealth, telemedicine, telenursing, mobile app*, remote consultation, cellular phone, mHealth, wireless communication, mobile technolog*, smartphone app*, Africa South of the Sahara, west Africa, east Africa, Sub-Saharan Africa (and countries listed as low income or middle income in the 2017 Word Bank list of economies)

Inclusion criteria: English language, articles published between 2008-2018



Appendix B: Table of Evidence

Articles	Method and Design	Sample Size	Countries	Technology being used	Key Findings
Amoah, B., Anto, E. A., Osei, P. K., Pieterse, K., & Crimi, A. (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. <i>BMC Pregnancy & Childbirth</i> , 16, 1-10. doi:10.1186/s12884-016-0888-x	Structured questionnaire and in-depth interviews	N= 323 pregnant women from four rural communities Snow-ball sampling technique	Central Region of Ghana	Mobile phones (mHealth) and portable ultrasound with use of skilled attendants	Findings showed that women who attended antenatal care (ANC) were more likely to have a delivery at hospital/clinic and women who attended at least four visits were less likely to practice self-medication. Ultrasound scans helped detect complications, but the overall improved ANC is due to CHWs. Younger CHWs grasped technology faster than their older peers.
Amoakoh-Coleman, M., Borgstein, A. B.-J., Sondaal, S. F. V., Grobbee, D. E., Miltenburg, A. S.,	Systematic review	19 studies; 10 intervention and nine		Mobile phones (mHealth)	Multiple studies described a low-cost, efficient way for communication compared to traditional methods, and the ability to integrate all levels of

<p>Verwijs, M., . . . Klipstein-Grobusch, K. (2016). Effectiveness of mHealth interventions targeting health care workers to improve pregnancy outcomes in Low- and middle-income countries: A systematic review. <i>Journal of Medical Internet Research</i>, 18(8), e226-e226. doi:10.2196/jmir.5533</p>		<p>descriptive studies</p>			<p>health workers as strengths of mHealth interventions.</p> <p>Weaknesses included remoteness of location sites limited web-based education, technological problems like poor reception and difficulty with specific mobile phone models, and poor telephone maintenance.</p> <p>This systematic review indicated that mHealth interventions targeting health care workers have the potential to materially improve maternal and neonatal health services in LMICs.</p>
<p>Battle, J. D., Farrow, L., Tibaijuka, J., & Mitchell, M. (2015). mHealth for safer deliveries: A mixed methods evaluation of the effect of an</p>	<p>Mixed methods evaluation Semi-structured</p>	<p>N = 13,231 pregnant women (quantitative)</p>	<p>Zanzibar, Tanzania</p>	<p>Mobile phone (mHealth)</p>	<p>Of the sample of pregnant women who delivered in the program, 75% did at a facility and 78% under skilled care compared to a baseline of 35%, which demonstrates a</p>

<p>integrated mobile health intervention on maternal care utilization. <i>Healthcare (Amsterdam, Netherlands)</i>, 3(4), 180-184. doi:10.1016/j.hjdsi.2015.10.011</p>		<p>N = 27 mothers, 25 CHWs, 12 health facility workers (qualitative)</p>			<p>large increase in facility delivery rates in all regions.</p> <p>CHW participants felt a greater sense of self-efficacy due to the use of a phone broadening their knowledge.</p> <p>The sense of feeling safe and supported were strong themes that emerged from the data collected and a primary reason for women getting to the facilities.</p>
<p>Benski, A. C., Stancanelli, G., Scaringella, S., Herinainasolo, J. L., Jinoro, J., Vassilakos, P., . . . Schmidt, N. C. (2017). Usability and feasibility of a mobile health system to provide comprehensive antenatal care in low-income countries: PANDA mHealth pilot study in</p>	<p>Cross-sectional pilot study</p> <p>One-on-one interviews</p>	<p>N= 100 pregnant women</p>	<p>Ambanja District, Madagascar</p>	<p>Mobile phone system (mHealth)</p>	<p>This specific system was able to create an electronic patient chart for the participants, provide an interactive approach for health care workers to collect data, and generate risk-flagging alerts which highlight the feasibility of the system.</p> <p>Further research on the benefits is needed to evaluate the system on a larger scale.</p>

Madagascar. <i>Journal of Telemedicine and Telecare</i> , 23(5), 536-543. doi:10.1177/1357633X16653540					
Entsieh, A. A., Emmelin, M., & Pettersson, K. O. (2015). Learning the ABCs of pregnancy and newborn care through mobile technology. <i>Global Health Action</i> , 8, 29340-29340. doi:10.3402/gha.v8.29340	Three focus group discussions and 19 individual interviews	N= 29 pregnant and nursing mothers	Central Region of Ghana	Mobile application (mHealth)	The results showed one overarching theme: embracing the mobile app as a trustworthy and constant source of support and four main themes including: steadily grasping advice given in relation to pregnancy, partially being caught between nutritional myths and reality, recognizing the need to be prepared for specialized care, and gaining self-confidence to care for their children.
Huang, F., Blaschke, S., & Lucas, H. (2017). Beyond pilotitis: Taking digital health interventions to the	Literature review and case study analysis		Uganda and China	Digital health information systems	Implementers need to focus on the perceptions, attitudes, and needs of the stakeholders on the technology. The political, social, and historical context where information systems

national level in China and Uganda. <i>Globalization & Health, 13</i> , 1-11. doi:10.1186/s12992-017-0275-z					function needs to be addressed before implementation.
Jennings, L., Omoni, A., Akerele, A., Ibrahim, Y., & Ekanem, E. (2015). Disparities in mobile phone access and maternal health service utilization in Nigeria: A population-based survey. <i>International Journal of Medical Informatics, 84</i> (5), 341-348. doi:10.1016/j.ijmedinf.2015.01.016	Population-based survey Two-stage cluster design	N = 3,390 women aged 15-49 from five states	Nigeria	Mobile phone (mHealth)	Mobile phone coverage varies across different parts of the country and men were more likely to own a mobile phone compared to women. Women with no mobile phone access were less likely to utilize skilled antenatal and delivery care services when compared to mobile-connected women. Increasing efforts are needed to improve women's access to mobile phones and minimize potential health inequities brought on by health systems and technological barriers in access to care.
Larsen-Cooper, E., Bancroft, E.,	Cost-outcome analysis		Malawi	Toll-free hotline and	As this mHealth intervention continues to expand and

<p>Rajagopal, S., O'Toole, M., & Levin, A. (2016). Scale matters: A cost-outcome analysis of an m-Health intervention in Malawi. <i>Telemedicine Journal and E-Health: The Official Journal of The American Telemedicine Association</i>, 22(4), 317-324. doi:10.1089/tmj.2015.0060</p>				<p>mobile phone-based tips and reminders service (mHealth)</p>	<p>increase utilization, it will begin to operate at a lower cost per contact.</p> <p>MHealth interventions have the potential to decrease time, distance, and cost of health education and health care.</p>
<p>Leidich, A., Jayaweera, R., Arcara, J., Clawson, S., Chalker, C., & Rochat, R. (2018). Evaluating the feasibility and acceptability of sending pregnancy and abortion history surveys through SMS</p>	<p>One-time mobile SMS survey</p>	<p>N = 500 women aged 18-24</p>	<p>Kenya</p>	<p>SMS text messaging (mHealth)</p>	<p>Women who participated in the survey were willing to share sensitive and sometimes culturally-taboo information and most indicated they had positive or neutral feelings about answering the questions.</p> <p>There is a benefit to mobile data collection's reduction of social desirability bias and</p>

<p>text messaging to help reach sustainable development goal 3. <i>International Journal of Medical Informatics</i>, 114, 108-113. doi:10.1016/j.ijmedinf.2017.10.017</p>					<p>opportunities for fast, widespread, and cost-effective data collection.</p>
<p>Lund, S., Hemed, M., Nielsen, B., Said, A., Said, K., Makungu, M., & Rasch, V. (2012). Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: A cluster-randomised controlled trial. <i>BJOG: An International Journal of Obstetrics & Gynaecology</i>,</p>	<p>A cluster-randomized controlled trial Structured questionnaires</p>	<p>N = 2,550 pregnant women</p>	<p>Unguja in Zanzibar</p>	<p>Mobile phone intervention (mHealth)</p>	<p>There showed no significant difference in baseline characteristics (age, occupation, literacy, education, marital status, religion, mobile phone status, parity, and residence status) between control and intervention groups.</p> <p>Levels of skilled delivery attendance increased with socioeconomic status.</p> <p>This study showed the use of mobile phones can be used to influence women's choice of</p>

119(10), 1256-1264. doi:10.1111/j.1471-0528.2012.03413.x					delivery attendance, in turn showing mHealth can be a tool for behavioral change.
Lund, S., Nielsen, B. B., Hemed, M., Boas, I. M., Said, A., Said, K., . . . Rasch, V. (2014). Mobile phones improve antenatal care attendance in Zanzibar: A cluster randomized controlled trial. <i>BMC Pregnancy & Childbirth</i> , 14(1), 1-10. doi:10.1186/1471-2393-14-29	Cluster randomized controlled trial	N = 2,550 pregnant women	Zanzibar	Mobile phone intervention (mHealth)	Women in the intervention group had more than double odds for attending four or more antenatal care visits as recommended in national and international guidelines. The wired mothers' mobile phone intervention showed a trend towards more women receiving preventive health services, more women attending antenatal care late in pregnancy and more women with antepartum complications identified and referred.
Mangwi Ayiasi, R., Kolsteren, P., Batwala, V., Criel, B., & Orach, C. G. (2016). Effect of	Community-based randomized trial	N = 1,385 pregnant women	Masindi and Kiryandongo, Uganda		Health facility delivery was three times higher in in the intervention group (87%) compared with control group (28%).

<p>village health team home visits and mobile phone consultations on maternal and newborn care practices in Masindi and Kiryandongo, Uganda: A community-intervention trial. <i>PLoS ONE</i>, 11(4), 1-19. doi:10.1371/journal.pone.0153051</p>					
<p>Mushamiri, I., Luo, C., Iiams-Hauser, C., & Ben Amor, Y. (2015). Evaluation of the impact of a mobile health system on adherence to antenatal and postnatal care and prevention of mother-to-child transmission</p>	<p>Post-intervention analysis</p> <p>Structured one-on-one and focus group interviews</p>	<p>N = 67 women and 20 CHWs</p>	<p>Kenya</p>	<p>Mobile health system (mHealth)</p>	<p>Women enrolled in the mobile health system were more likely to undergo the four recommended ANC visits and six baby follow-ups compared to women not enrolled.</p> <p>Registration in the system eliminated vertical HIV transmission rates in the sample.</p>

of HIV programs in Kenya. <i>BMC Public Health</i> , 15, 102. doi: 10.1186/s12889-015-1358-5					Results showed the use of CHW programs and mHealth tools strengths adherence to ANC and PNC.
Ngabo, F., Nguimfack, J., Nwaigwe, F., Mugeni, C., Muhoza, D., Wilson, D. R., . . . Binagwaho, A. (2012). Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda. <i>The Pan African Medical Journal</i> , 13, 31-31. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3542808/pdf/PAMJ-13-31.pdf	Pilot study	N = 432 CHW	Musanze district in Rwanda	SMS-based system (mHealth)	This study helped to reduce delay in seeking health care through an SMS sent by a CHW alerting the health system for timely and appropriate medical assistance. The SMS system can serve as the most remote data entry point for pregnant women and children's health status into the national health information systems and as an interface to provide real-time data to health facilities and program manager.

<p>Omole, O., Ijadunola, M. Y., Olotu, E., Omotoso, O., Bello, B., Awoniran, O., . . . Fatusi, A. (2018). The effect of mobile phone short message service on maternal health in southwest Nigeria. <i>The International Journal of Health Planning and Management</i>, 33(1), 155-170. doi:10.1002/hpm.2404</p>	<p>Questionnaire for baseline data</p> <p>SMS messages</p>	<p>N = 508 pregnant women</p>	<p>Ife-Ijesa, Nigeria</p>	<p>SMS intervention (mHealth)</p>	<p>Most of the clients lost to follow-up were not in the intervention group.</p> <p>This study showed the mHealth intervention improved the rate of delivery by skilled health personnel among both the intervention and control groups.</p> <p>Findings concluded that pregnant women support and accept the use of SMS-based interventions for maternal health promotion.</p>
<p>Oyeyemi, S. 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. <i>Reproductive Health</i>, 11(1), 1-16.</p>	<p>Case-control study</p> <p>Data collected from case files and hospital records in 10 participating health facilities</p>	<p>N = two health care facilities</p>	<p>Nigeria</p>	<p>Mobile phones (mHealth)</p>	<p>The use of cell phones may have strengthened the primary health system and reduced the inequalities in accessibility to health care facilities which in turn, has been a strengthening factor in primary health care delivery system.</p> <p>Since there was no significant difference in the rate of the five major causes of maternal</p>

doi:10.1186/1742-4755-11-8					mortality (severe bleeding, preeclampsia/ eclampsia, infection, obstructed labor, unsafe abortion), it could be noted that the occurrence of these causes does not automatically translate to death, it could be the delay in seeking aid.
Pagalday-Olivares, P., Sjöqvist, B. A., Adjordor-van de Beek, J., Abudey, S., Silberberg, A. R., & Buendia, R. (2017). Exploring the feasibility of eHealth solutions to decrease delays in maternal healthcare in remote communities of Ghana. <i>BMC Medical Informatics and Decision Making</i> , 17(1), 156-156. doi:10.1186/s12911-017-0552-z	Literature review, semi-structured interviews, focus group discussions, and Information and Communication Technologies (ICT) infrastructure assessment.	N = 15 interviewees, 24 individuals for focus group, 20 locations for infrastructure assessment.	Kpando, Ghana	eHealth	The use of eHealth solutions can reduce delay in receiving adequate maternal health care. It can spread health information and provide access to financial services to reduce the delay of the decision to seek care. It can allow communication systems to reduce the delay in identifying and reaching a facility and improve clinical practices. MHealth can provide care at a distance and use health management systems The main challenge for implementation is to achieve a

					high level of acceptance hence, community characteristics need to be considered.
Roberts, S., Birgisson, N., Julia Chang, D., & Koopman, C. (2015). A pilot study on mobile phones as a means to access maternal health education in eastern rural Uganda. <i>Journal of Telemedicine & Telecare</i> , 21(1), 14-17. doi:10.1177/1357633X14545433	A pilot study Interviews	N = 42 men, 41 women	Eastern rural Uganda	Mobile phones and a toll-free telephone line (mHealth)	Men were more likely than women to report they owned a mobile phone and use them more frequently. Feasibility of accessing maternal health education through a toll-free number was supported by high levels of access to mobile phones among participants.
Shiferaw, S., Spigt, M., Tekie, M., Abdullah, M., Fantahun, M., & Dinant, G. J. (2016). The effects of a locally developed	Non-randomized controlled study Cross-sectional surveys and	N = 10 health facilities, 933 women at baseline and 1037 at follow-up	Amhara region, Ethiopia	Mobile phone (mHealth)	Use of mHealth interventions significantly increased delivery and postnatal care service utilization regardless of age, residence, and parity. To ensure proper utilization, it is important to be responsive

<p>mHealth intervention on delivery and postnatal care utilization; A prospective controlled evaluation among health centres in Ethiopia. <i>PLoS ONE</i>, 201611(7), e0158600-e0158600. https://doi.org/10.1371/journal.pone.0158600</p>	<p>longitudinal follow-up</p>				<p>to the immediate demands of health workers.</p> <p>Even though the findings showed positive response in adherence to the recommended visits, it did not extend beyond the immediate postpartum period, showing the need to convince patients of added value of a repeat visit at six weeks postpartum.</p>
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