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# The Post-2015 Development Agenda: Progress Towards Sustainable Development Goal Target On Maternal Mortality and Child Mortality In Limited Resource Settings with mHealth Interventions: A Systematic Review In Sub-Saharan Africa and Southern Asia

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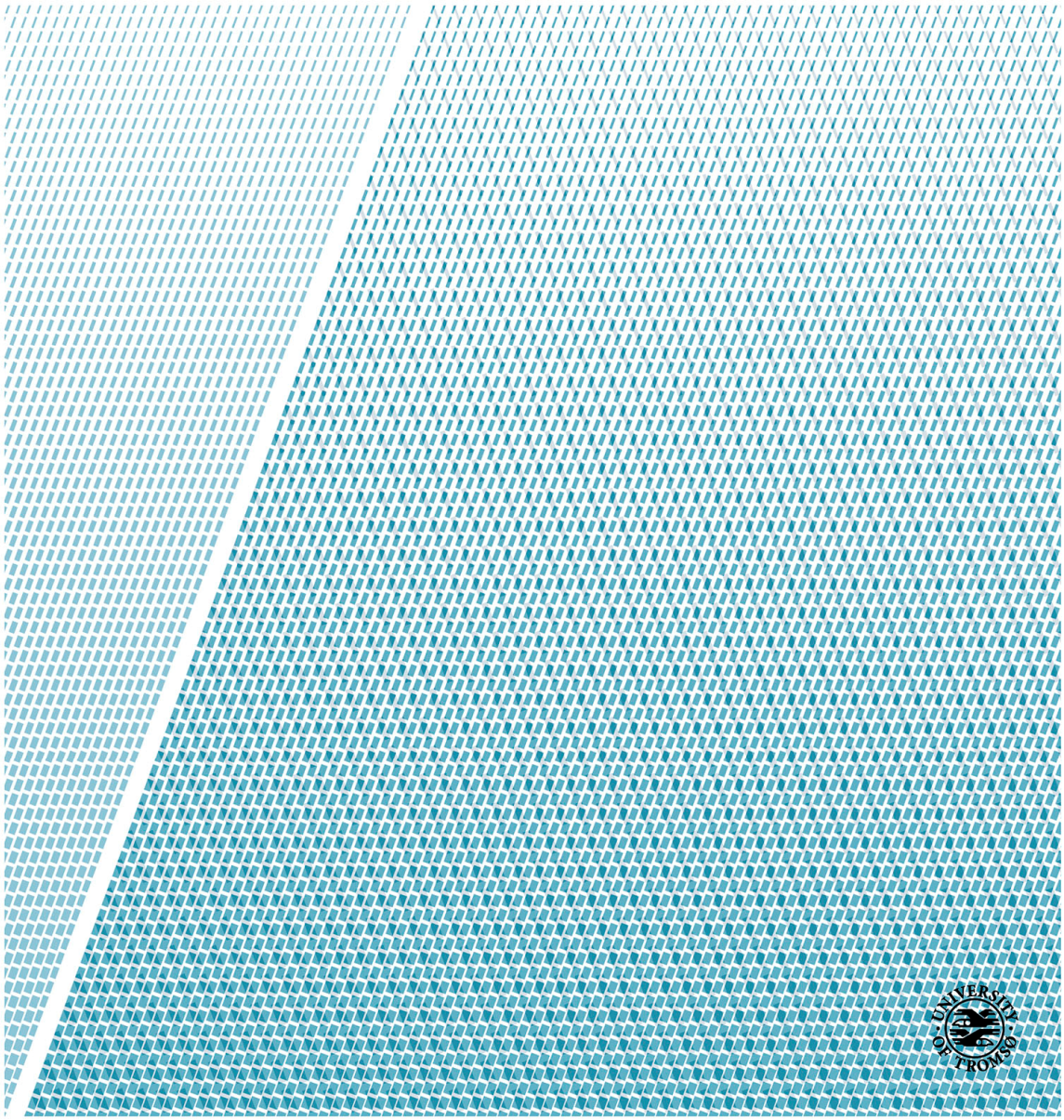

# Declaration

I, Elvis Bossman, do hereby declare that the thesis entitled " The Post-2015 Development Agenda: Progress Towards Sustainable Development Goals Target On Maternal Mortality and Child Mortality in Limited Resource Settings with mHealth Interventions: A Systematic Review in Sub-Saharan Africa and Southern Asia" is the result of my own original research work conducted under the supervision of Associate Professor Paolo Zanaboni and Monika Johansen (PhD), and that no part of this research work has been presented in parts or in whole for another degree in this university or elsewhere.

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# Dedication

This work is dedicated to my wife, Ine Susann Rehnlund and my Son

Also, to Mad. Cynthia Mensah (my late mum) and Nana Kwadwo Boahen II (my father) who have worked tirelessly to bring me this far, and my siblings: Mavis Bossman, Dorcas Bossman, Linda Bossman-Yeboah and Princess Nana A. Boahemaa

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# Definition of Terms and Acronyms

| Terms / Acronyms | Explanation |
|---|---|
| MDGs | Millennium Development Goals |
| SDGs | Sustainable Development Goals |
| HEWs | Health Extension Workers |
| CHWS | Community Health Workers |
| MVP | Millennium Village Project |
| APAS | ANC/PMTCT Adherence System |
| SMS | Short Message Service |
| ANC | Antenatal Care |
| PNC | Post-natal Care |
| SBA | Skilled Birth Attendant |
| MMR | Maternal Mortality Ratio |
| NMR | Neonatal Mortality Ratio |
| U5MR | Under-Five Mortality Ratio |
| EPHPP | Effective Public Health Project |
| SDA | Skilled Delivery Application |
| AEFI | Adverse Events Following Immunization |
| DiD | Difference-in-Difference |
| M-SIMU | Mobile Solution for Immunization |
| WHO | World Health Organisation |
| SUSTAIN-MNCH | Supporting Systems to Improve Nutrition, Maternal, New-Born, And Child Health |

# Summary

In resource-constrained areas, mostly the low-income countries, mortality rates continue to remain higher than in high-income countries in spite of the ongoing efforts to make progress and improve maternal and child health. During the fifteen-year period of the Millennium Development Goals (MDGs), we witnessed a significant decline in child and maternal mortality rates despite their inability to harness the 75% reduction in maternal mortality and to reduce the under-five mortality by two-thirds as stipulated in the MDG5 and MDG4 respectively. Another fifteen-year plan was necessitated to achieve these targets by 2030, as captured in the United Nations Sustainable Development Goal (SDG) 3. Prior to the introduction of the MDGs in the year 2000, the annual rate of maternal mortality reduction was 1.2%, which significantly rose to 3% in the MDG era. To achieve the global goal in 2030 will require at least a 7.5% annual reduction between 2016 and 2030.

Health interventions delivered through mobile technologies have been implemented in low-income countries to address the challenges in maternal and child health by supporting pregnant women, mothers and health workers behavior and introducing decision support functionalities. The rational for this study was to conduct a systematic review of the literature to ascertain the progress made by mHealth interventions toward SDGs 3.1 and 3.2 in Sub-Saharan Africa and Southern Asia, where the global burden of maternal and child mortality is high. The primary outcomes of interests were maternal mortality and under-five / neonatal mortality. Secondary outcomes were increasing coverage and utilization of antenatal care (ANC), postnatal care (PNC), skilled birth attendance/ facility delivery and childhood immunizations through behavior change.

Thirty-six quantitative full-text articles were reviewed, 19 of which met the inclusion criteria. Most studies used SMS or voice message reminders to influence patient behavior change and were conducted in Sub-Saharan Africa. All studies showed at least some evidence that mHealth contributed to support behavior change of participants and training of health workers and to improve antenatal care attendance, postnatal care attendance, childhood immunization coverage/ rates and skilled delivery attendance.

The findings from this review show that mHealth interventions implemented in Sub-Saharan Africa and Southern Asia can support the global effort towards SDG 3.1 and 3.2 to improve neonatal and maternal deaths. More good-quality studies addressing the role of mHealth in reducing maternal and child health outcomes are needed, especially in Southern Asia

# Chapter One

# 1.0 Introduction

## 1.1 Background

Generally, the Millennium Development Goals (MDGs) established in 2000 following the Millennium Summit of the United Nations, demonstrated a remarkable result despite their inability to achieve all the global health targets within the stipulated fifteen-year period between 2000 and 2015. This period witnessed a substantial decline in child and maternal mortality which correspond to MDG 4 and MDG 5 respectively. Between the twenty-year period from1990 to 2010, the global under five year mortality decline from 11.9 million deaths to 7.7million as reported by Rajaratnam et al. (2010) [1]. Specifically, 3.1 million neonatal deaths(0-28days), 2.3 million post-neonatal deaths(1-12months), and 2.3 million childhood deaths (deaths in children aged 1–4 years) represented 2.1%, 2.3%and 2.2% yearly reductions respectively. It was reported that within all the World Health Organization (WHO) regions including Sub-Saharan Africa , we witness an accelerated decline within the second decade of the twenty year period in comparison with the former [1]. With no MDG region attaining the goal of decreasing maternal mortality by 75%, all showed significant improvement. As captured in the MDG 5, there was a call for a 75% reduction in maternal mortality ratio within this period ending in the year 2015 [2].

After the announcement of the MDGs in 2000, the estimated global annual reduction rate for the period 2000-2015 was 3% which is a significant increase in comparison to the 1.2% rate observed in the 1990–2000 period. This advance reflects a widespread escalation of efforts to reduce maternal mortality, stimulated by the MDGs. Maternal mortality has proved to be a valuable indicator both for tracking progress and for stimulating action to improve maternal health [3]. A third of global burden of premature deaths is accounted for by pregnant women and children irrespective of the fact that most of these deaths can be avoided [3]. Africa alone as cited by Oluwaseum et al, has an unprecedented higher maternal and child mortality and accounts for about 50% of all maternal deaths worldwide even though it only has 15% of the world's population. Giving the necessary information on pregnancy prevention and complications from child birth,75% of this deaths could have been avoided according to a WHO

fact sheet [4]. Low income countries has maternal deaths rate 19 times higher than the high income countries and also its 8 times more likely in under five-year-old children [5, 6].

Globally, there has been a remarkable progress in child survival and millions of children have better survival chances than in 1990. The under-five year mortality rate dropped from 93 deaths per 1,000 live births in 1990 to 39 deaths per 1000 live births in 2017. This translates into 1 in 11 children dying before attaining the age of five in 1990, compared to 1 in 26 in 2017. In most of the Sustainable Development Goal (SDG) regions, the under-five year mortality rate was reduced by at least half since 1990. According to a WHO report, More than two thirds reduction in the under-five mortality rate in 74 countries was observed. Thirty (33) low and lower-middle-income countries out of these 74 countries studied accomplished a two-thirds or more decline in the under-five mortality rate since 1990. The year 2017 witnessed 5.4 million under-five deaths which is a drop from 12.6 million observed in 1990. On the average, 15,000 children died globally every day in 2017, compared to 34,000 in 1990 [5].

In the first month of life during the neonatal stage, there is a greater the risk of dying among children. In 2017, neonatal mortality was estimated at 18 deaths per 1,000 live births globally. The risk of death among new borne after the first month and prior reaching age 1 was 12 per 1,000, and the probability of death among children between age 1 and age 5 was 10 per 1,000. The neonatal mortality rate worldwide fell by 51% from 1990 to 2017. In spite of the diminishing neonatal mortality levels, there still exist differences in neonatal mortality across countries and among the United Nations Sustainable Development Goal (SDG) regions. Among the SDG regions, Sub-Saharan Africa recorded the maximum neonatal mortality rate in 2017 with 27 deaths per 1,000 live births. There is nine times likelihood of dying among a child born in Sub-Saharan Africa or in Southern Asia in the first 28 days than a child born in a high-income country [5].

During the MDG era universally, the under-five mortality rate (U5MR) decline by 53%, falling short of the MDG target of two-third decrease, and likewise the maternal mortality ratio fell by 44% also short of the target[3]. Globally, nearly 830 women died every single day as a result of problems during the gestation period or delivery in 2015. To this end, the SDGs was implemented with another 15-year plan due by 2030 which is a comprehensive blueprint for sustainable development with health and wellbeing as both outcomes and foundations for social protection. Reproductive, maternal , new-born and child health is one of the main thematic areas for the more than fifty SDG health related indicators in measuring health outcomes and health service delivery [7]. Fragile health systems in most countries are still major hindrance to

progress and results in setbacks, as far is coverage is concerned even for the most basic health services as well as inadequately equipped facilities to manage health emergencies [7].

A very promising tool to increase efficiency in health and enhance service utilization in low and middle-income countries is information and communication technology in the inform of mobile phone usually called mHealth. This will complement the global effort in harnessing the Sustainable Development Goals (SDGs) 3 especially target 3.1 and 3.2 which duels on improving maternal and neonatal/child health respectively[8, 9]. Goal three(3) of the sustainable development goal calls for an end to avoidable deaths of infants and children under 5 years of age and requires all countries globally to aim at decreasing the neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births by 2030. Worldwide, children between one and four years constituted 25 percent of the 5.4 million under-five deaths in 2017 whiles those in range of one and eleven months of age accounted for 29 percent and neonates for 47 percent. In high income countries, the average under-five mortality rate is low (5.4 deaths per 1,000 live births) with children aged 1−4 years accounting for 15 percent of all under-five deaths in 2017 [5, 6].

According to a United Nation report, a global annual rate of not less than 7.5% is needed to achieve SDG target 3.1 which aim at reducing the global maternal mortality ratio (MMR) from 216 per 100000live births to less than 70 per 100000lives births at the end of 2030 [5]. With the necessary health technological interventions, most of this maternal death can be eschewed [10]. More essentially it is very vital to maximize women access to quality care starting from the antenatal stage through to the post-natal period [10]. Statistics show that in 2016 alone, millions of births worldwide occurred unsupervised by a trained health personnel, with only seventy-eight percent assisted by a skilled birth attendant. Global statistics in 2015 indicated that neonatal deaths rate and under-five mortality rate was 19 per 1000 live births and 43 per 1000 lives-births respectively [7].

### 1.2 Geographical Difference in Maternal and Neonatal/Child Mortality

Globally, the maternal mortality ratio (MMR; number of maternal deaths per 100 000 live births) fell by approximately 44% over the past 25 years; this falls short of the MDG target 5A which called for a reduction of at least 75% in MMR. All MDG regions of the world have experienced considerable reductions in maternal mortality. In spite of remarkable worldwide progress in terms of the maternal and child health at the end of the MDG era aimed at reducing maternal mortality and child mortality, urgent action is required to harness the ambitious sustainable Development Goal 2030 target 3.1 and 3.2. The Sustainable Development Goals

(SDGs) now call for an acceleration of current progress in order to achieve a global MMR of 70 maternal deaths per 100 000 live births, or less, by 2030, working towards a vision of ending all preventable maternal mortality. Achieving this global goal will require countries to reduce their MMR by at least 7.5% each year between 2016 and 2030 which is more than three times the 2.3% annual rate of reduction observed globally between 1990 and 2015 [2, 3] .

The end of the MDG era in the year 2015 also marked the beginning of the transition into the SDGs which encompass global targets of reducing maternal mortality, neonatal mortality and under five-year mortality. Several studies evaluated and reported a growth in maternal and child health indicators. This notwithstanding, a report by United Nations on the MDGs evaluations indicates 'regardless of the progress achieved, the reduction in maternal and child mortality across most regions was not uniform. This culminated in our inability to achieve the MDGs [11]. This assertion can be explained by Solow (1956) growth model reported by Barro &Sala-I-Martin (1991) which stipulates that 'if the progress is greater among the developing countries compared with developed countries, it leads to convergence across the world countries. On the contrary, if the progress is greater among the developed countries, it widens the gaps leading to overall divergence among countries'[11, 12]. There is therefore a call for a strong program of action and interventions to bring equity to eliminate this consequence of divergent progress between high income countries and low-income countries in terms of maternal and child health. Interventions aim at eradicating preventable maternal and child mortality are require in Laggard regions like the sub-Saharan Africa to ensure convergence progress worldwide in the global effort to harness the SDGs on maternal mortality, neonatal mortality and under five mortality. In a 2016 study by Alkema et. Al, the global maternal mortality ratio declined by 43.9% from 385 deaths per 100000 live births in the year 1990 to 216 in the year 2015 with a 2.3% annual rate of decline. Evidence based data and current rate of maternal mortality differ greatly between the SDG regional classifications. Between 1990 and 2015, eastern Asia recorded the highest regional rate of decline with a 5% continuous rate of reduction. At the end of the 2015, regional MMRs ranged from 12 deaths in high income countries to as much as 546 deaths per 100000 live births in sub Saharan Africa [2].

A 2015 estimated maternal deaths in low income regions worldwide was 302,000 constituting 99% of the global estimate. in 2015, with sub-Saharan Africa alone accounting for roughly 66% (201 000), followed by Southern Asia (66 000). Among the developing regions, the fewest maternal deaths (an estimated 500) occurred in Oceania. The lifetime risk of maternal mortality is estimated at 1 in 36 in Sub-Saharan Africa, which is in sharp contrast with 1 in 4900 estimates in the high-income countries. In the year 2015, maternal deaths were 58 000 maternal deaths

(19%) and 45 000 maternal deaths (15%) for Nigeria and India respectively at the country level. This figures together forms more than one third of all maternal deaths worldwide and represented 19% and 15% of the global estimates. With a maternal mortality ratio (MMR) of 1360 per 100,000 live births, Sierra Leone tops the chart with the highest MMR globally. Sierra Leone together with seventeen other countries, all located in Sub-Saharan Africa, are estimated to have very high MMR in 2015. Chad and Sierra Leone are the countries with the maximum estimated lifetime risk of maternal mortality with an approximate risk of 1 in 18 and 1 in 17 respectively for these two Sub-Saharan African countries. There is a 1 in 3300 lifetime risk of maternal mortality in high-income countries is in comparison with 1 in 41 in low-income countries. There is the need for a substantial higher annual rate of reduction among thirty countries with the highest MMRs at the end of the MDGs in 2015 to attain MMRs below 140 per 100,000 live births in 2030. Projections indicate that accomplishing this target will result in over 60% fewer deaths in 2030 than the estimated number in 2015 and cumulatively save approximately 2.5 million women's lives within the SDGs era. This will be difficult to harness if the current reduction trajectories remain same according to a 2015 report by the World Health Organisation. With rapid acceleration of the efforts and progress catalysed by MDG 5, ending preventable maternal mortality on a global level can be achieved by 2030 [3].

The problem of child deaths differs geographically, with most deaths taking place in just two regions thus, Sub-Saharan African and Southern Asia. In 2017, half of the deaths among children under age five occurred in sub-Saharan Africa which has the highest burden of child deaths worldwide. Owing to rising child populations and movement of the population distribution to high mortality regions, the portion of global under-five deaths that happen in sub-Saharan Africa rose from thirty percent in 1990 to fifty per cent in 2017 and is projected to rise even further in subsequent decades. A projected 60 percent of under-five deaths will take place in Sub-Saharan Africa by 2050. Eliminating disparities across the SDG regions and for that matter between countries globally would save millions of lives. In 2017 alone, some 4.4 million deaths could have been averted had under-five mortality in each country been as low as in the lowest mortality country in the SDG region; the total number of under-five deaths would have been reduced to 1 million. Analysis from 195 countries indicated that 118 already met the SDG target on under-five mortality, and 26 countries are expected to meet the target by 2030, if current trends continue. Efforts to accelerate progress need to be scaled up in the remaining 51 countries, two-thirds of which are located in sub-Saharan Africa, in order to reach the SDG target by 2030. Accelerating progress to achieve the SDG target by 2030 in countries that are falling behind would mean averting almost 10 million under-five deaths compared with the

current scenario. On current trends, about 56 million children under 5 years of age will die between 2018 and 2030, half of them new-born. More than half of these 56 million deaths will occur in Sub-Saharan Africa [5].

Sub-Saharan Africa continues to be the region with the highest under-five mortality rate in the world 76 deaths per 1,000 live births in 2017. This translates to 1 child in 13 dying before his or her fifth birthday which is 14 times higher than the average ratio of 1 in 185 in high-income countries. Six countries with mortality rates above 100 deaths per 1,000 live births were in sub-Saharan Africa. Sub-Saharan Africa remains the region with the maximum mortality rate in the world; given the projected growth in the child population of this region, the number of under-five deaths in the region may surge or stagnate if the decline in mortality rates does not outpace the increase in births. In 2017 alone, some 4.4 million lives would have been saved had under-five year mortality in each country been as low as in the lowest mortality country in the region. The total number of under-five deaths would have been reduced to 1 million [5].

The risk of dying for a new-born in the first month of life is about 50 times larger in the highest mortality country than in the lowest mortality country. The burden of neonatal deaths is also unevenly distributed across regions and countries. Two regions account for almost 80 percent of the new-born deaths in 2017; sub-Saharan Africa accounted for 39 per cent of all such deaths and Southern Asia accounted for 38 per cent. In 23 countries in Sub-Saharan Africa, the number of neonatal deaths did not decline from 1990 to 2017 even though the rates of neonatal mortality fell over the same period. The burden of new-born deaths stagnated in Sub-Saharan Africa. Despite the modest 41 percent decline in the neonatal mortality rate from2000 to 2017 in Sub-Saharan Africa, the number of neonatal deaths stagnated around 1 million deaths per year due to an increasing number of births. More countries will miss the SDG target on neonatal mortality than on under-five mortality, if current trends continue. On current trends, more than 60 countries will miss the target for neonatal mortality by 2030, while 51 countries will miss the target for under-five mortality. Accelerating progress in these 60 some countries to achieve the SDG target on neonatal mortality would save the lives of 5 million new-borns from 2018 to 2030. Based on current trends, 28 million new-borns would die between 2018 and 2030, and 80 per cent of these deaths would occur in Southern Asia and sub-Saharan Africa [5].

In 2017 alone, 5.4 million children died before reaching their fifth birthday – 2.5 million of those children died in the first month of life. At a time when the knowledge and technology for life-saving interventions are available, it is unacceptable that 15,000 children died every day in 2017 mostly from preventable causes and treatable diseases. Continued preventive and curative lifesaving interventions need to be provided to children beyond the neonatal period, particularly

in low-income countries, where the mortality rates for children aged 1–4 remain high. Meeting the SDG target in the 50 some countries in which acceleration is required would reduce the number of under-five deaths by almost 10 million between 2018 and 2030. Concerted and urgent action is needed in the countries that are falling behind [5].

The use of mHealth interventions demonstrated that mobile phones can contribute to reducing the phases of delay in obtaining help for pregnant women, reduction in program cost and also improving correct management of patients when it is use as a decision support tool [13]. In 2015, an approximate of 5.9 million children under five were expected to die. Even though this figure is unreasonably high, it comparatively represents more than a halving of the 1990 global child mortality rate. Among the causes of this deaths includes manageable conditions around birth hence the need to explore existing cost-effective life-saving interventions that need to scale up further. There is a continual growth in evidence to support the inclusion of perinatal mortality and appropriate use of technology in the post-2015 agenda to further reduce child mortality in developing countries [14-16]. mHealth interventions from numerous studies on vaccination has demonstrated positive outcomes which was found to very effective strategy on increasing coverage and enhancing timeliness as far as childhood immunization is concerned [17-19]. These interventions range from simple text messages (SMS) [20-23] and call reminders [24] to smartphone-base applications [25-27] and complex services [19, 28, 29]. Interventions like this will assist in harnessing the WHO recommendation of 90% annual coverage before the age 2 years in routine immunizations to achieve the greatest potential advantages. Several studies, as reported in a systematic review, attest to the importance of parental and healthcare reminders as the best strategy to maximize immunization coverage in developing countries [30].

### 1.3 The Potential of mHealth

The recent surge in mobile phone usage and ownership globally and even in low and middle-income countries has created a lot of potentials in providing mobile health solutions as it is the new edge of innovations in healthcare by addressing public health challenges and move the paradigm accessing health care and also the delivery of it [31]. Ninety percent (90%) of total population worldwide and eighty percent(80%) of world's population in rural area are exposed to mobile phone coverage according the International Telecommunication Union [32]. The reasons backing the recent speedy growth of mobile health (mHealth) interventions in low income countries in general and in Africa in particular includes the increasing number

of phone users, growing coverage of mobile networks, the decreasing phone costs, and innovation in mobile technology [10, 33].

There have being severally definitions of mHealth which is basically driven by mobile technology inculcated in mobile system for health care delivery. Definitions of mHealth ranges from simple ones like ‘ the use of mobile communications such as PDAs and mobile phones for health services and information [34] to the classification of it as a subset of eHealth thus, the utilization of mobile communications for health information and service to improve health outcomes [35]. For the purpose of this systematic review, the World Health Organization (WHO) definition of mHealth will be relied on. It defined mHealth as “medical and public health practices supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistant (PDA), and other wireless devices[36]. Their definition goes further to embrace the utilization and capitalization on mobile phones core utility of voice and short message services (SMS) as well as more complex functionalities and applications including general package packets radio services (GPRS), third and fourth generation mobile telecommunication(3G and 4G systems), global positioning system (GPS), and Bluetooth technology [37]. It provides a conductive platform to provide healthcare anytime and anywhere cutting through organizational barriers and geographical barriers.

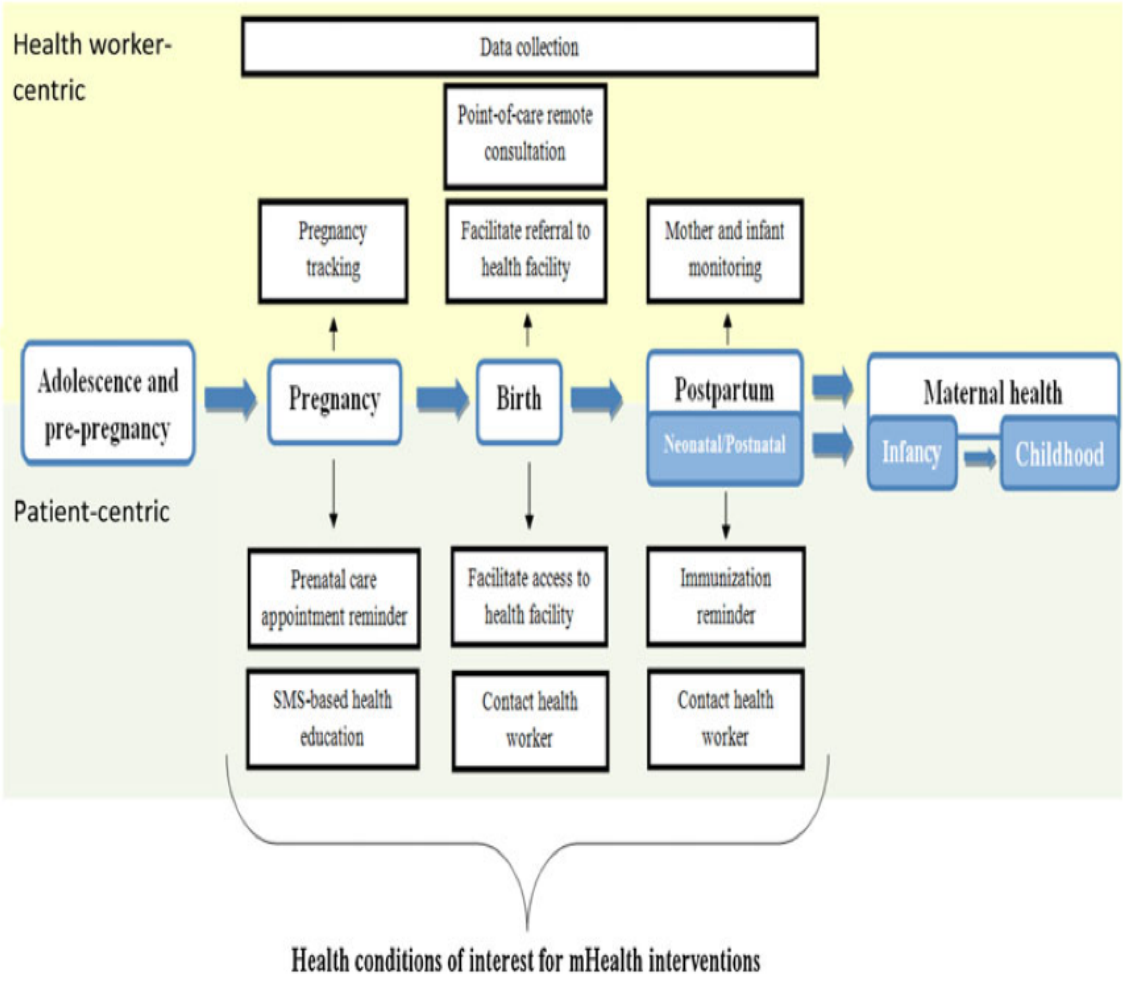
Health systems in resource constraint countries, in spite of the lack of technology and needed infrastructure, mobile phones are still thriving and permits innovative ways to curtail health challenges, address health needs of countries in the global south particularly Sub-Saharan African and Sothern Asia [28, 38, 39]. Main areas of mHealth systems intervention has impact and focuses healthcare monitoring and alerting systems and data collection for clinical decisions and administrative purpose, detection prevention systems, healthcare delivery programs etc [40-43]. There is rising indication that commonly used mobile phone interventions (mHealth) like text messaging (SMS), video messaging, voice calling, and internet connectivity can enhance health service delivery processes and health outcomes, mostly in the areas of treatment adherence, appointment compliance and patient monitoring[44].

### 1.4 Research Challenges

This systematic review is targeted on the use of mobile health concentrating on the focal areas in goal three of the SDGs as stipulated by the United Nations thus, the pregnancy and child birth phase, postpartum phase and maternal health phase along the stages of continuum of care as illustrated in the figure below[45]. As illustrated in ***figure1***, mHealth provides a new and

pervasive way to addressing prenatal and new born health with demonstration that mobile technology is an effective tool that empowers pregnant women and healthcare providers[45]. There have being several studies on mHealth interventions in the areas of maternal, new-born, and child health outcomes particularly in Sub-Saharan African [46-50] and Southern Asia [51-53] which together are the two SDG regions with the highest burden in terms of mortalities. A 2015 literature review by Watterson et al. concluded with some ample evidence that mHealth intervention can enhance antenatal and postnatal care and also immunization [54]. Prior to the commencement of the current SDG era, there were studies that indicated that leveraging mobile health can be a positive strategy for the MDGs targets on reducing child mortality and improving maternal mortality [31, 39, 55, 56].

**Figure 1.** Use of mHealth along the Continuum of Care for maternal and new-born from both patient and health worker perspectives [45].



mHealth is applied in various ways all to assist in the global effort of achieving target 3.1 and 3.2 of the Sustainable Development Goal. To start with the advent of mHealth has enhance mechanisms for data collection and management in the course of delivering health services like complimenting immunization programs, improving quality of pregnancy and it outcomes and execution of referral care [29, 57]. In Tanzania and Thailand for instance, records of women and the progress of the pregnancy are kept in a central health data system via a linked with SMS services [58, 59]. In India rural paramedics have easy access to demographic information due to use of mobile handheld device used by outreach workers in gathering information on immunizations records. Likewise midwives in Indonesia and outreach workers in Peru as cited by Tamarat and Kachnowski 2012 collects patients data and send to a databases which is easily accessible by professionals to inform prescription of therapy and monitoring in spite of the physical barriers between them and patients [45].

Secondly mHealth interventions have being applied in various ways to increase health facility attendance in terms of increasing utilization antenatal care and postnatal care services. Studies have shown that mHealth applications during ANC has a positive effect on postnatal care utilization among mothers by encouraging behavioral change among health workers and their clients [26, 60-64]. As reported in a Randomized Control Trail (RCT) study in Tanzania called the '*wired mother',* the ability of mHealth intervention via SMS approach to have a positive significant impact on ANC visits by pregnant women per the WHO recommended four visits in the gestational period [65].

Another important health outcome of interest when mHealth intervention has been applied is vaccination or immunization. There have been several implementation studies on mHealth in the areas of vaccination or immunization in the Sub-Saharan Africa and Southern Asia regions which are challenge with low coverage of vaccination and immunization uptake [17-19, 66, 67]. The utilization of mobile phones for improving vaccinations coverage in rural resource constraint communities is achievable and has significant health impact according to study done in Bangladesh [68]. mHealth intervention have also been applied in increasing access to skill birth attendance and also facilitating facility delivery, ensuring that every baby delivered with the aid of a skilled birth attendant or personnel is very important strategy in decreasing maternal mortality[69]. This has necessitated it inclusion as indicator 3.1.2 under goal 3 and target 3.1 of the Sustainable Development Goals. Several studies on mHealth in improving maternal and child health outcomes have also investigated its effects on facility delivery or having skilled birth personnel at birth[8, 70].

Several studies have been published on health interventions regarding improving maternal and child health. To health policy implementers, studies may be too many to consider and identify to support decision making in delivering maternal and childcare. Systematic reviews of these individual studies provide a great potential as a prerequisite to evaluate, summarize and put together existing studies in a uniform place to inform decision making. It is generally acknowledged that mHealth positively impacts on the quality of health service delivery and presents a great potential for adaptation on large scale, but still lacks enough evidence in respect to its effectiveness in diverse areas. There are various studies ongoing in the mHealth space in an attempt to find out how availing information to mothers, enhancing timely delivery of care, improving data gathering and response systems with real-time accountability can improve the fate 7.6million children under-five and infants who die each year. mHealth solutions is seen to scale up evidence -based interventions through the antenatal, intrapartum and postnatal stages to improve neonatal health outcomes[71, 72].

Also, the high percentage of births and maternal deaths that occur outside of health-care facilities, there is a critical need to obtain and communicate vital events data from the community level. Digital innovations delivered via mobile devices (mHealth tools) that connect frontline health workers to national health systems can simultaneously improve health-care service delivery, strengthen accountability, and generate real-time data. Reliable estimates of child and young adolescent mortality at the national, regional and global level are necessary for evidence-based policymaking to improve the survival chances of the world's children[3, 5, 73, 74].

Proponents of mHealth strategies suggest that such mobile solutions could generate significant health gains in sub-Saharan Africa, mainly among women and children under five[45]. This leaves us with the question: Does mHealth interventions presents innovative mechanism through which the SDGs targets on maternal and child mortality can be accomplished?

### 1.5 Goal

To assess the progress made in effort to achieve the SDG targets 3.1 and 3.2, we performed a systematic literature review on the mHealth interventions directed at reducing preventable maternal deaths, neonatal death and under five deaths in Sub Saharan Africa which is SDG lagged region in terms of SDGs bench mark for maternal, neonatal and under five mortality.

The aim of this study was to perform a systematic review on mHealth interventions in limited resource settings and their contributions in the attempt to achieve the Sustainable Development Goal three (3). The understanding may potentially allow effective interventions for an

accelerated progress towards harnessing the SDG targets on maternal mortality and child mortality by 2030.

Specifically, the study aims to addresses the following objectives:

- To explore the effects of mHealth directed at frontline health care providers on under-five / neonatal health outcomes in achieving SDG Target 3.2 by 2030'
- To identify and examine the effects of mHealth directed at frontline health care providers on maternal mortality health outcome in achieving SDG Target 3.1 by 2030

# Chapter Two

## 2.0 Methods

The method chapter shall explain the 'protocol' to address the objectives of this study. This study attempts to gather all literatures that conforms to the eligibility criteria. The study relied on clear, systematic method as recommended by Liberati et al, with the view of minimizing bias and ultimately providing reliable findings upon which conclusions can be made and subsequently infer decisions [75]. The contribution of mHealth was investigated based on the following areas.

### 2.1 Protocol and Registration

In clinical practice and policy directions in health, decision making on health care interventions based on a well conducted systematic review or meta-analysis that used a predefined, clear methodology in locating and synthesizing all the pertinent evidence are usually perceived as a reliable evidence in comparison to individuals' trails. Much credibility is accorded reviews that stems from main components integral in the process of conducting a systematic review[76]. Registration of protocols for systematic reviews allows for an increased clarity pertaining to the conduct of the review[76, 77]. Based on this a study protocol of this review was registered prior its commencement in PROSPERO (***Appendix I - pg.64***) with registration number **CRD42019109434** and published on 17th January 2019 in accordance with best practices in the conduct of systematic review[78]**.** PROSPERO is an international database of prospectively registered systematic reviews in health and social care, welfare, public health, education, crime, justice, and international development, where there is a health-related outcome. Main components from the review protocol are documented and kept as a permanent record. The goal of PROSPERO is to offer a comprehensive listing of systematic reviews registered at inception to help avoid repetition and lessen chance for reporting bias by permitting comparison between completed review and what was initially planned in the protocol.

### 2.2 Study design

This study is a systematic review of studies to assesses the impact on mHealth solutions in health service delivery directed towards maternal and child health in resource constraint areas. This study type, if carried out well, allows the review to come nearer to estimating the actual

impact of an intervention than any single study can, for two key reasons. Reviews of such nature gathers and synthesize all relevant studies and also secondly, this review evaluate each of the studies that meets the eligibility criteria for risk of bias. Preferred Reporting Item for Systematic Reviews and Mata-Analyses (PRISMA) statement was relied on in undertaking this study to ensure a transparent and complete reporting of the study [75].

### 2.3 Inclusion and Exclusion criteria

Prior to the start of this review, an inclusion and exclusion criteria was established in advance in a written and published protocol[78]. According to the protocol, the eligibility criteria for study inclusion took into account the;

- Type of study: Only quantitative comparative studies were considered eligible for inclusion in this review. This included Randomised Control Trails (RCTs), Non-Randomised Control Trails (CCT), Case Control trails, Pre-Post study designs.
- Setting: eligible studies should be conducted or implemented in Sub-Saharan Africa or Southern Asia region of the World Bank country classification. Studies conducted in countries outside this region were excluded from the study.
- Language: studies with full text available in English language will be included. Studies which are not available in English translation will be excluded in this review.
- Publication date : using the Global targets for ending preventable maternal mortality (EPMM) as a basis which stipulates that, by 2030, every country should reduce its maternal mortality ratio (MMR) by at least two thirds from the **2010 baseline**, and no country should have an MMR higher than 140 deaths per 100 000 live births. The eligibility period for study publication for inclusion was January 2010 and date for data extraction. Studies published before January 2010 was excluded from the study.
- Measured outcomes: studies with mHealth interventions focusing on women in the antenatal and postnatal period. Also, studies on child mortality specifically involving targets groups of neonates (0-28days) and children under five years (0-5yrs). Studies with outcomes addressing the sustainable development goal 3.1 and 3.2 was considered. studies with the following secondary outcomes which impacts maternal mortality and child mortality; Skilled birth attendance, Antenatal care (ANC) and postnatal care (PNC) attendance, Vaccination Coverage and Civil Registration.
- Intervention: Eligible studies for inclusion those involving mHealth interventions. Any ICT intervention outside the scope of the definition of mHealth was be excluded. Also, studies with mHealth intervention in both in the control and intervention arm was excluded. The

purpose of this review mHealth was defined by World Health Organisation as 'medical and public health practices supports by mobile devices mobile phones, patient monitoring devices, personal digital assistants and other wireless devices [36] was used as scope for in the identification of mHealth interventions for potential inclusion in this review.

- Risk assessment: studies with overall score of 'STRONG or MODERATE' after risk assessment was included. Studies with overall 'WEAK' rating was excluded in this review

### 2.4 Information Source

The utilization of a common search strategy of scientific databases, restricting the search by publication date, language, and parameters in methodology and content.

MEDLINE, EMBASE and Web of Science are the electronic bibliographic databases that was searched for relevant articles in the area under study bordering on terms that describe or relate to mHealth interventions that meet the inclusion and exclusion criteria stipulated in the study protocol. In developing the search terms for this study, PICOS was used to group the search terms into categories based on the research questions: population, intervention, outcome and study setting. Where appropriate Medical Subject Headings (MeSH) was used to make uniform search terms.

**Table 1.** Search terms under the PICOS concept.

| **PICOS - CONCEPTS** | | | |
|---|---|---|---|
| **Intervention** | **Populations** | **Outcomes** | **Study settings** |
| mHealth,<br>mobile health,<br>m-Health,<br>mobile phone,<br>Cell phone, Smartphone,<br>mobile application,<br>short message service,<br>Text messaging,<br>mobile device | Pregnant women,<br>matern*, gestation,<br>women, mother,<br>Infant,<br>Infant health<br>infant,Newborn,<br>newborn, neonat*,<br>Perinat*,<br>Child,Preschool<br>Health facilit* | Perinatal Death, Infant Death,<br>Perinatal mortality,<br>Infant mortality,<br>Pregnancy complication,<br>Child death, Neonatal mortalit*,<br>Neonatal Death, Mortalit* Death*<br>Under five mortality,<br>Antenatal attend*<br>Postnatal care, Postnatal visit*<br>Vaccinat*, Immunizat*<br>Civil registration, Vital statistics<br>Skilled birth attend* | Africa south of the sahara,<br>Sub-saharan Africa<br>Aghanistan,<br>Bangladesh,<br>Bhutan,<br>India,<br>Iran,<br>Maldives,<br>Nepal,<br>Pakistan,<br>Sri Lanka |

The search strategy was tested before the formal screening. The pre-test was done on Wolters Kluwer Ovid platform Medline and Embase with some selected search terms under each of the concepts shown in ***table 1***.

### 2.5 Search Strategy and Study Selection

Through the Arctic university of Norway, UiT library's homepage, access was granted to the Ovid Medline and Embase databases. Based on recommendation, the two different databases were not search concurrently but individually. This allowed the Map Term to Subject Heading function to be included in the search. This feature is not activated when searching multiple databases (i.e. Medline + Embase). Each search terms under the PICOS concept is search individually and if available translated into MeSH (Medical Subject Headings) terms when the aforementioned feature is activated. This maps terms that are closely related or usually searched with it. The Explode function was used for each of the selected MeSH terms after a review of the scope note that served as a guide in identifying and ensuring that the terms were used in the way as it was intended and to avoid straying into other concepts. Terms that has no MeSH terms was then searched as keyword in title and abstract (ti.ab.kw). As illustrated in ***Appendix II- pg. 69,*** the search term for the intervention mHealth mapped to Telemedicine and Mobile application as MeSH terms which was exploded and search mHealth searched as keyword (mHealth).ti,ab,kw. All search terms under each concept (i.e. Intervention, Population, study 16area, outcome) were run separately and then combined with OR boolean operator. Concepts were then combined together with the AND boolean to display possible articles relevant to this study.

To start with, screening of titles and abstracts of papers to be reviewed resulting from the search strategy was done by master student with the guidance and recommendations of the supervisor and co- supervisor. This allows for progressive exclusion for studies that do not meet the inclusion criteria. Find duplicates query in the databases searched was used to identify duplicates and also manual deduplication was also done. Title and abstract screening were done to further identify and exclude records. Full text of selected studies was retrieved and subsequently evaluated for eligibility.

### 2.6 Data Collection Process and Data items

A customized and standardized data extraction form was designed and on MS Excel spreadsheet. The sheet was then piloted, and adjustment made by two review members before it was finally use by two reviewers to extract data from the full text of the included eligible studies for evidence synthesis.

The data extracted from the selected studies retrieved for inclusion in this systematic literature review included;

- first author,
- year of publication,
- study title, objectives,
- type of study design,
- population / participants
- intervention and control (comparison)
- level of intervention implementation (e.g. primary, secondary or tertiary level)
- countr(ies) and SDG region
- primary outcome/or indicator (Maternal mortality Ratio-MMR, Neonatal Mortality Ratio-NMR and Under five Mortality Ratio-U5MR)
- secondary outcomes (Skilled birth delivery, Antenatal care visits, postnatal care visits, vaccination/immunization coverage)
- quality assessment (e.g. selection bias, study design, confounders, blinding, withdrawals/dropouts)

### 2.7 Definition of outcomes

Below follow the definitions I have used regarding the primary and secondary outcomes in this study.

#### 2.7.1 Primary Outcomes

*2.7.1.1 Maternal Mortality(deaths):* 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 (from direct or indirect obstetric death), but not from accidental or incidental causes in the gestation period and childbirth or within 42 days after termination of pregnancy regardless of the length and site of the pregnancy.

*2.7.1.2 Neonatal Mortality(deaths):* neonatal deaths (deaths among live births during the first 28 completed days of life) may be subdivided into early neonatal deaths, (occurring during the first 7 days of life) and late neonatal deaths (occurring after the 7th day but before the 28th completed day of life.). The rational for mortality rates among young children are a main output indicator for child health and well-being, and to a larger extent social and economic development. It is a closely observed public health indicator because it mirrors accessibility of children and communities to basic health interventions such as vaccination, medical treatment of infectious diseases and adequate nutrition. The first 28 days is the most crucial period for child survival. Estimates indicate that deaths of approximately 2.5 million new-borns occurred in the first month of life in 2017. This estimate shows that an average of 7,000 dies every day with majority of these deaths happening in the first week after birth. Around 36 percent died the same day they were born, and close to three-quarters of all new-born deaths in 2017 occurred in the first week of life.12 The global neonatal mortality rate fell from 37 deaths per 1,000 live births in 1990 to 18 in 2017[5].

*2.7.1.3 Under-Five Mortality(deaths):* under-five mortality is related to the probability of a child born in a specific year or period dying before reaching the age of 5 years, if subject to age specific mortality rates of that period, expressed in 1000 live births. In spite of the significant advancement in decreasing child mortality, intensive action is needed to eschew preventable under-five deaths in the coming years and to accelerate progress in enhancing child survival further. immediate actions are required mostly in regions and countries with high under-five mortality rates, especially those in sub-Saharan Africa and south Asia. Worldwide, the majority of child and young adolescent deaths happens at the youngest ages. Eighty-five percent (5.4 million) of the 6.3 million deaths in 2017 happened in the first five years of life and about half (47 per cent) of the under-five deaths in 2017 occurred in the first month of life. Across all the SDG regions and in both high income and low-income groups, over 80 percent of the deaths under age 15years happened in the first five years of life irrespective of the mortality level[5]**.**

### 2.7.2 Secondary Outcomes

*2.7.2.1 Skilled Birth Personnel:* skilled delivery attendance as a proxy of improved pregnancy outcome for mother and child, as, internationally, there is ample evidence linking skilled delivery attendance with reduction in maternal mortality. in limited resource settings, accessibility to a skilled attendant at the time of delivery is a vital lifesaving intervention for both mothers and babies. Not having access to this key assistance is detrimental to women's

health because it could lead to the demise of the mother. Percentage of births attended by skilled health personnel (generally doctors, nurses or midwives) is the percentage of deliveries attended by health personnel trained in providing lifesaving obstetric care, including giving the necessary supervision, care and advice to women during pregnancy, labor and the post-partum period, conducting deliveries on their own, and caring for new-borns. In some areas in the world, women still access care from personnel who don't possess the requisite knowledge on risk factors; signs and symptoms of complications; preventive and proactive care for hemorrhage and hypertensive disorders of pregnancy; and the direct and indirect causes that can be fatal to the mother, foetus, and neonate [79].

*2.7.2.2 Antenatal visits/Prenatal visits and Postnatal visits:* Studies show that antenatal and postnatal visits have impact on maternal and child mortality. When mothers miss postnatal clinic attendance after childbirth, it affects completion of the care during the period and invariably contributes to maternal morbidity and for that matter mortality as well. Sub-Saharan Africa is consistently characterized with poor nature of postnatal clinic attendance. Having access to antenatal care and postnatal care has a significant impact on infants deaths and also impacts on trends in a maternal mortality through the provision of encouragement deliver with skilled birth attendant or in a health facility[80]

*2.7.2.3 Vaccination/immunization Coverage:* In spite of the recent success, almost 20% than 8.8million under-five years of age die from vaccine-preventable disease each year globally. With the introduction of primary vaccination through the Expanded Programme on Immunization (EPI) WHO, Childhood vaccination has proved to be the most effective public health intervention. In spite of evidence demonstrating the merits that vaccines are efficient, children in limited resource areas are Sub-Saharan Africa and Southern Asia either get vaccinated late or unvaccinated all together[81, 82].

*2.7.2.4 Civil Registration and Vital Statistics*: Taking effective actions to prevent future deaths require knowing who has died and why they died. This is vital to support measurement efforts and also help track progress towards reaching SDG 3.1 and SDG 3.2. Attempts to save lives within countries with high maternal deaths must be enhanced and must also augmented with country-driven efforts to correctly register both child births and deaths and also the cause of death. Data that can be disaggregated to determine trends and quantify the mortality burden

within the most fragile and most frequently ignored populations are vital for implementing strategies to tackle inequities and accelerate progress towards maternal mortality reduction [3].

### 2.8 Risk of Bias in Individual Studies

A quantitative studies review will be conducted. A quantitative systematic review encompasses studies that have numerical data. To harness an acceptable study quality of the eligible quantitative studies to be included in this review, the "*Quality Assessment Tool for Quantitative Studies"* was utilized [83]. This quality appraisal tool can be used for doing knowledge synthesis of articles of any public health topic area to support decision making process. this includes designing, implementation and the assessment of public health programs and policies. The "Quality Assessment Tool for Quantitative Studies" has a checklist comprising of eight main thematic areas upon which a methodological rating of strong, moderate or weak will be scored (***Appendix VII- Page.79***). This section ranges from Selection bias, study design, confounders, blinding, data collection methods, withdrawal and dropouts, intervention integrity and analysis [84]. A summary of articles included was created based on the components of the "Quality Assessment Tool for Quantitative Studies" (***table 5***). Based on the dictionary for using the risk assessment tool as shown in (***Appendix VIII- Page.82),*** each of conditions for assessing under the six main components was translated into an excel formula with a corresponding score of 1,2 and 3 respectively for 'Good' , 'Moderate' and 'Weak' as shown in ***table 2***. This tool was used to characterize the quality of the included studies at three (3) levels or global ratings: Strong (no WEAK ratings), Moderate (one WEAK rating), Weak (two or more WEAK ratings).

### 2.9 Synthesis of results

A report summarizing the characteristics of the included studies was presented in form of a table. From the data extracted from the eligible studies for inclusion, synthesis will be organized based on the type of intervention, purpose of intervention, outcomes measured. Findings from the data synthesis was be analyzed and structured around the study designs and indicators for measuring the outcomes of the mHealth interventions to answer the research questions.

# Chapter Three

## 3.0 Results

### 3.1 Study Selection

One hundred and eighty-four (184) articles were retrieved from the search on Ovid Medline. On the same page we change the database from Ovid Medline to Embase and the search was run again elucidated 447 articles as shown in (**Appendix III – Page.71)**. The two databases Ovid Medline and Embase were then run concurrently displaying 631 results (**Appendix IV- Page.73)**. 138 records were removed after deduplication amounting to 493 displayed results and shown in (**Appendix V- Page.75).** From Appendix V, the language limiter was applied which reduce the records by two (2) followed by the year limiter restricting the searches between 2010 to the day the last search was run bringing the final number of articles on the Ovid platform to 464. The year limiter further reduced the search records on the Ovid platform by 27. Additionally, a search for potentially eligible articles on Web of Science database with search terms base on the PICO yielded 279 records after the application of the English language and year range limiter. In all 743 were exported to endnote from all the three databases (Medline + Embase=464 and Web of Science = 279).

A total of 19 studies were identified for inclusion in the review. The search of Ovid Medline, Embase and Web of science databases provided a total of 743 citations. After adjusting for duplicates 513 remained after the elimination of 230 duplicates. Out of the 230 duplicates removed, 199 was identified with the find duplicate query in endnote and further 31 through manual identifications. Four hundred and seventeen (417) out of the 513 studies were discarded after reviewing title and abstracts, when these papers clearly did not meet the criteria. After title and abstract screening, 96 potentially additional studies were retained for further full text screening. seven (7) were discarded because full text of the study was not available. The full text of the remaining 89 citations was examined in more detail. It appeared that 53 studies did not meet the inclusion criteria as described in the study outcome of interest. The Risk Assessment Tool for Qualitative study was applied to the remaining 36 studies as shown in ***table 2*.** Seventeen (17) papers were deemed not eligible for inclusion after the Risk assessment as shown in *table 2*. Nineteen (19) studies met the inclusion criteria satisfying all the criteria indicated in the pre-publish protocol and were included in the systematic review. No unpublished relevant studies were obtained.

**Figure 2.** Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) study flow diagram.

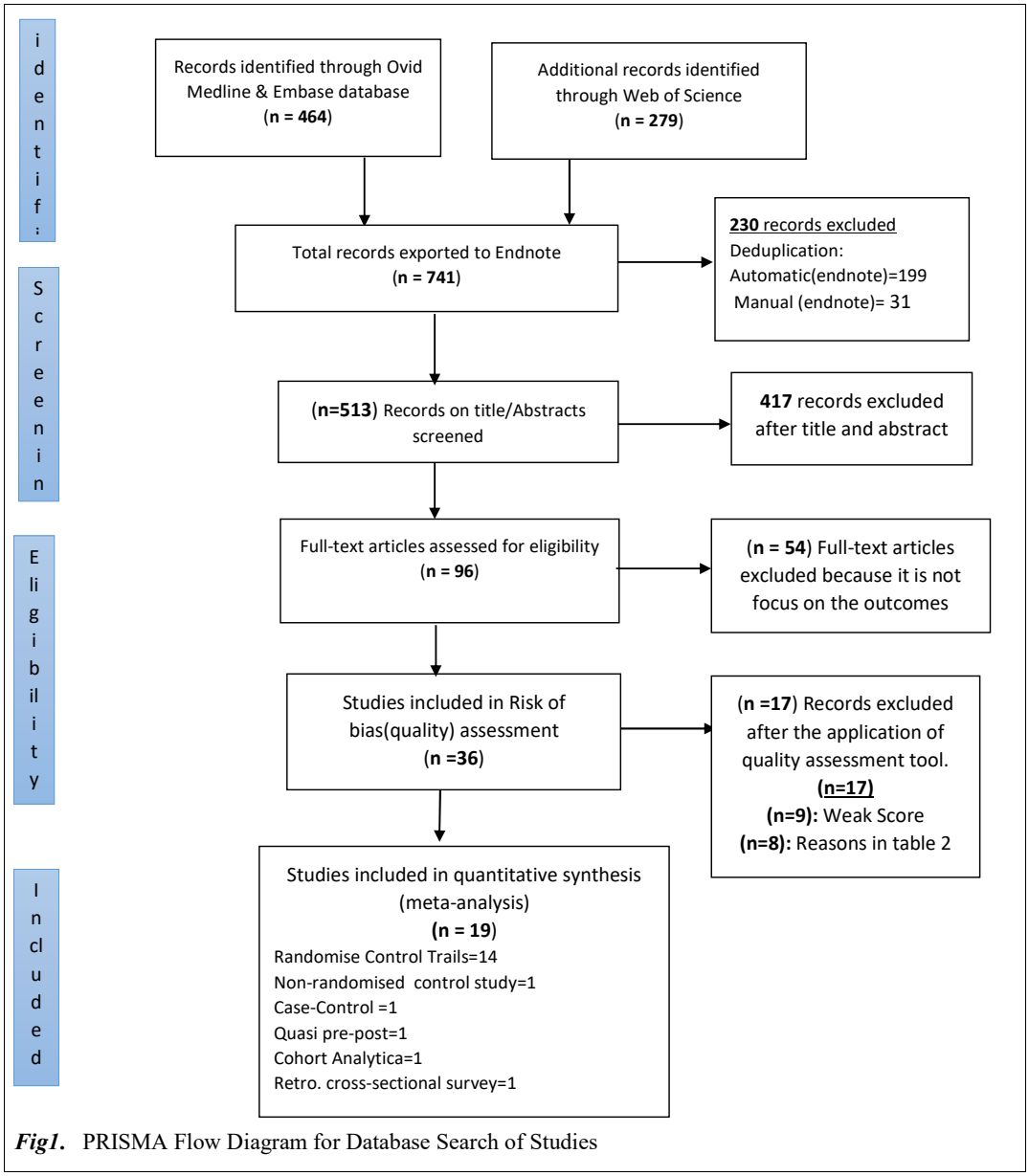



***Fig1.*** PRISMA Flow Diagram for Database Search of Studies

**Table 2**. Quality assessment of potentially eligible studies.

| Reference, Author(Year) | Selection Bias(A) | | | Study design(B) | | | Confounders(C) | | | Blinding (D) | | | Data collection methods(E) | | | Withdrawal and dropouts (F) | | | FINAL RATIING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | TOT | Q1 | Q2 | TOT | Q1 | Q2 | TOT | Q1 | Q2 | TOT | Q1 | Q2 | TOT | Q1 | Q2 | TOT | |
| [20], Adanikin(2014) | 2 | 1 | **3** | 3 | | **2** | | | **1** | 3 | 3 | **3** | 1 | 1 | **1** | 3 | 4 | **3** | **Weak** |
| [24], Afzal(2017) | 4 | 1 | **3** | 5 | | **2** | 3 | 4 | **3** | 3 | 2 | **2** | 1 | 1 | **1** | 1 | 2 | **2** | **Weak** |
| [21], Akinrinade (2018) | | | **The study has no comparator or was not a comparative study** | | | | | | | | | | | | | | | | Excluded |
| [85], Alam (2017) | 2 | 2 | **2** | 3 | | **2** | 1 | 1 | **1** | 1 | 2 | **2** | 1 | 1 | **1** | 2 | 2 | **2** | Strong |
| [25], Amoah (2016) | 3 | 1 | **3** | 7 | 1 | **3** | 3 | 4 | **3** | 3 | 3 | **3** | 1 | 3 | **2** | 4 | 4 | **2** | **Weak** |
| [86], Ateudjieu (2014) | 1 | 2 | **2** | 1 | 2 | **1** | 2 | 1 | **1** | 2 | 3 | **2** | 1 | 1 | **1** | 1 | 1 | **1** | Strong |
| [61], Atnafu (2017) | 1 | 1 | **1** | 1 | 2 | **1** | 1 | 2 | **2** | 3 | 2 | **2** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [87], Bangure(2015) | 2 | 2 | **2** | 1 | 2 | **1** | 2 | 1 | **1** | 1 | 2 | **2** | 1 | 3 | **2** | 1 | 1 | **1** | strong |
| [88], Brown (2017) | 1 | 1 | **1** | 1 | 2 | **1** | 1 | 1 | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [22],Coleman (2017) | 3 | 1 | **3** | 4 | 1 | **2** | 2 | 1 | **1** | 1 | 3 | **3** | 1 | 1 | **1** | 3 | 1 | **3** | **Weak** |
| [89], Gibson (2017) | 1 | 1 | **1** | 1 | 2 | **1** | 1 | 1 | **1** | 1 | 1 | **3** | 1 | 3 | **2** | 1 | 1 | **1** | Moderate |
| [90], Hackett (2018) | 1 | 1 | **1** | 1 | 2 | **1** | 1 | 2 | **2** | 1 | 3 | **3** | 1 | 1 | **1** | 1 | 2 | **2** | Moderate |
| [91], Haji (2016) | 2 | 2 | **2** | 1 | | **1** | 2 | 4 | **1** | 3 | 3 | **3** | 1 | 3 | **2** | 1 | 2 | **2** | Moderate |
| [92], Ibraheem (2017) | 2 | 1 | **3** | 8 | | **3** | 1 | 1 | **1** | 3 | 1 | **3** | 3 | 3 | **3** | 3 | 5 | **2** | **Weak** |
| [93], Jennings (2015) | 1 | 2 | **2** | 8 | | **3** | 3 | 3 | **3** | 1 | 2 | **2** | 3 | 3 | **3** | 4 | 4 | **2** | **Weak** |
| [28], Jo (2014), | | | **Projections, extrapolation and modelling was used in this study hence makes the risk assessment impossible.** | | | | | | | | | | | | | | | | Excluded |
| [57], Joos (2016) | | | **Both intervention arm and the control arm have an mHealth (SMS) component** | | | | | | | | | | | | | | | | Excluded |
| [18], Kazi (2018) | 2 | 2 | **2** | 1 | 2 | **1** | 2 | 1 | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 3 | **3** | Moderate |
| [94], Lund (2016) | 1 | 1 | **1** | 1 | | **1** | 2 | | **1** | 2 | 3 | **2** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [95], Lund (2012) | 1 | 1 | **1** | 1 | | **1** | 2 | | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [65], Lund (2014) | 1 | 1 | **1** | 1 | | **1** | 2 | | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [96], Lund (2014) | 1 | 1 | **1** | 1 | | **1** | 2 | | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 1 | **1** | strong |
| [97], Mathew (2016) | | | **Commentaries on safe delivery app. And perinatal survival by Lund. S et al. (2016)[94]** | | | | | | | | | | | | | | | | Excluded |
| [98], Mathew (2018) | | | **Commentaries on an India study to enhance routine immunization by Seth. R et al. (2018) [19]** | | | | | | | | | | | | | | | | Excluded |
| [29], Modi (2016), | 2 | 1 | **3** | 7 | | **3** | 3 | 3 | **3** | 3 | 3 | **3** | 1 | 3 | **2** | 1 | 1 | **1** | **Weak** |
| [62], Mushamiri (2015) | 1 | 1 | **1** | 3 | | **2** | 1 | 1 | **1** | 1 | 3 | **3** | 1 | 1 | **1** | 1 | 1 | **1** | Moderate |
| [67], Nagar (2018) | 1 | 2 | **2** | 1 | | **1** | 1 | 1 | **1** | 3 | 2 | **2** | 1 | 1 | **1** | 1 | 2 | **2** | Strong |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [99], Odeny (2014) | 1 | 1 | **1** | 1 | | **1** | 1 | 2 | **2** | 2 | 2 | **1** | 1 | 1 | **1** | 3 | 1 | **3** | Moderate |
| [23], Omole (2018) | | | **Both groups were sent SMS messages but different content. mHealth intervention in both arms** | | | | | | | | | | | | | | | | Excluded |
| [100], Oyeyemi (2014) | 2 | 2 | **2** | 4 | | **2** | 2 | 4 | **1** | 4 | 2 | **2** | 1 | 1 | **1** | | | **3** | Moderate |
| [26], Prinja (2017), | 2 | 1 | **3** | 7 | | **3** | 1 | 1 | **1** | 1 | 3 | **3** | 1 | 1 | **1** | 3 | 4 | **3** | **Weak** |
| [19], Seth (2018), | 4 | 1 | **3** | 7 | | **3** | 2 | 4 | **1** | 1 | 1 | **3** | 3 | 3 | **3** | 1 | 4 | **3** | **Weak** |
| [60], Shiferaw (2016) | 1 | 1 | **1** | 2 | | **1** | 1 | 2 | **2** | 1 | 1 | **3** | 1 | 1 | **1** | 1 | 1 | **1** | Moderate |
| [27], Spindler (2018), | | | **Non- comparative study. exclusion criteria per the protocol for this study** | | | | | | | | | | | | | | | | Excluded |
| [68], Uddin (2016) | 1 | 2 | **2** | 3 | | **2** | 1 | 1 | **1** | 2 | 2 | **1** | 1 | 1 | **1** | 1 | 2 | **2** | Strong |
| [101], Ye (2018) | | | **Not focusing directly on the outcomes of interest according to the protocol of this study [78].** | | | | | | | | | | | | | | | | Excluded |

### 3.2 Study Characteristics

A breakdown of the nineteen studies included in this systematic review encompasses fourteen RCTs [18, 61, 65, 67, 86-91, 94-96, 99], one study each for the following study designs; case-control study [100], cohort study [62], non-randomized control trial [60], quasi-experimental pre-post study [68], retrospective cross-sectional survey[85]. All the studies in this review were published between 2012 and 2018. Six studies among these were published before the year 2015; one was published in 2012 [95], Five(5) were published in 2014 [65, 86, 96, 99, 100]. Among the thirteen papers published after 2014 includes two(2) in 2015[62, 87], four (4) in 2016 [60, 68, 91, 94], four(4) publications in 2017[61, 85, 88, 89] and finally three publications in 2018[18, 67, 90]. Fifteen studies were undertaken in Sub-Saharan Africa (Nigeria[88, 100], Ethiopia[60, 61, 94], Kenya [62, 89, 91, 99], Tanzania/Zanzibar [65, 90, 95, 96], Cameroon [86], Zimbabwe [87]. The remaining four studies representing 21% of the included studies were undertaken in Southern Asia(Bangladesh[68, 85], India[67], Pakistan[18])

The final global rating of the included studies following risk assessment identified twelve studies as STRONG (with no weak component rating) [60, 61, 65, 67, 68, 85-88, 94-96], seven identified as MODERATE (with one weak rating)[18, 62, 89-91, 99, 100]

**Table 3**. Characteristic of included studies.

| Reference, first author | year/ publication | Study Design | Population (s) | Setting (s) (primary, secondary or tertiary) | Location/ sdg.Region | Intervention(s) | FINAL RATING |
|---|---|---|---|---|---|---|---|
| [85], Alam. M | 2017 | Retrospective cross-sectional survey | Mothers whose last-born child is between 3 and 18 months. | primary health care level | Bangladesh | SMS: mothers enrolled and exposed to the messages during pregnancy | Strong |
| [86], Ateujieu | 2014 | Randomised Control Trail | health facilities. | Primary health care | Cameroon-SSA | SMS: Mobile phone numbers of AEFI focal points in health facilities | Strong |
| [61] ,Atnafu | 2017 | Randomised Control Trail | Health Extension Workers(HEWs) and Community Health Workers(CHWs) | Primary health care | Ethiopian-SSA | mobile phone with a customized software app and phone with Frontline SMS | strong |
| [87] ,Bangure | 2015 | Randomised Control Trail | Woman or caregiver recruited after delivery or 3rd and 7th day visits after delivery. | primary health care | Zimbabwe-SSA | SMS: health education and SMS reminders | Strong |
| [88], Brown | 2017 | Randomised Control Trail | Mothers-infant pair. infants aged 0–3 during the infants' first immunization visit | primary health centre | Nigeria-SSA | CALLS: cell phone calls reminding them to take child for immunizations. | Strong |
| [89], Gibson | 2017 | Randomised Control Trail (4arm RCT) | (from 158villages) Caregivers were eligible if they had a child younger than 5 weeks yet to received a first dose of pentavalent vaccine | primary health centre | Kenya-SSA | 38villages in each INT. arm 1).SMS reminders only 2) SMS plus 75KES incentive. 3):SMS plus 200KES incentive. | Moderate |
| [90], Hackett | 2018 | Cluster Randomised control trail. cRCT | Community health workers | primary health care | Tanzania | Smartphone based | Moderate |
| [91], Haji | 2016 | Randomise control Trail. (3Arm) | Children aged <12 months presenting for their first dose of pentavalent vaccine were enrolled | primary health setting | Kenya-SSA | 2 interventions 1). **SMS** reminder 2) stickers reminder | Moderate |
| [18], Kazi | 2018 | Randomised Control Trail | child less than 2 weeks of age | Tertiary health setting | Pakistan-SA | SMS: 4 SMS reminders PLUS One-time standard verbal counselling | Moderate |
| [95], Lund. S | 2012 | Cluster RCTs | Pregnant who attended antenatal care (ANC) | Primary healthcare facilities in Zanzibar | Zanzibar-SSA | SMS: Wired Mothers: pregnant woman | Strong |
| [94], Lund. S | 2016 | Cluster RCTs | health care facilities | Primary healthcare facilities | Ethiopian-SSA | Smartphone App: with the Safe Delivery Application. | Strong |
| [65], Lund. S | 2014 | Cluster RCTs | Pregnant women attending first ANC | primary healthcare facilities | Zanzibar-SSA | SMS: providing wired mothers with unidirectional text | Strong |
| [96], Lund. S | 2014 | CLUSTER RCTs | Pregnant women attending first ANC | primary healthcare facilities | Zanzibar-SSA | SMS: mobile phone text messages | Strong |
| [62], Mushamiri | 2015 | Cohort Analytica: Retrospective | Women who begun ANC care recruited and followed until 18months after baby birth | primary health setting | Kenya-SSA | Group2: SMS services were registered in the APAS | Moderate |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| [67], Nagar | 2018 | Cluster Randomized control Trail: (3Arm cRCT) | All mothers with an infant less than 6 months old in this population | Primary health setting | India | 1)Allocated to NFC Pendant). 2) Allocated to NFC Pendant + Voice Call | Strong |
| [99], Odeny | 2014 | Randomised Control Trail. RCT | HIV-positive pregnant women at least 18 years old and enrolled in PMTC program | | Kenya | Intervention SMS: Participants receive either text messages (SMS | Moderate |
| [100], Oyeyemi | 2014 | case–control study | health facilities. All women who attended the health facility. | primary health care level | Nigeria-SSA | Closed-Users' Group (CUG) cell phones | Moderate |
| [60], Shiferaw | 2016 | Non randomised Control Trail | pregnant women. Unit of allocation is health facilities | primary health setting | Ethiopian-SSA | Application with SMS reminders, Decision support, Report Module | strong |
| [68], Uddin | 2016 | quasi-experimental pre-post study | pregnant women, mothers with children age 0–11 months, and | Rural and Urban settings | Bangladesh | mTika included (i) smart phone-based SMS reminders and registration of pregnant women | Strong |

The modes of intervention delivery utilized were ten (n = 10) for SMS with mobile phones[18, 65, 85-87, 89, 91, 95, 96, 99], three(n =3) studies used smartphone-based application for their intervention[61, 90, 94]. Three (n = 3) studies in these review used smartphone application and SMS module for data collection and reminders and three (n = 3) studies used voice calls as a means of communication between patients and providers[67, 88, 100].

**Table 4.** Categorization of included studies based on the type of mHealth intervention.

| **19 INCLUDED STUDIES** | | | | |
|---|---|---|---|---|
| *Mobile Health Intervention Classification* | | | | |
| Education/ Awareness (Behaviour) [18, 60, 62, 65, 67, 68, 85-91, 95, 96, 99, 100] | | Communication and Training [60, 94] | Registries/ vital event tracking [60-62, 68, 90] | |
| *Outcomes of interest* | | | | |
| Neonatal Mortality rate (NMR) [94, 96] | Skilled Birth Attendance (SBA) [60, 61, 85, 90, 94, 95] | Antenatal care visits (ANC) [60-62, 65, 90, 100] | Postnatal care visits (ANC) [60, 62, 85, 99] | Vaccination/ immunization coverage [18, 65, 67, 68, 86-89, 91] |
| *Modes of Intervention Delivery* | | | | |
| SMS reminders [18, 61, 65, 85-87, 89, 91, 95, 96, 99] | Voice calls [67, 88, 100] | Smartphone App [60, 90, 94] | App + SMS [60, 62, 68, 90] | Data collection modules [60, 68] |

Majority of the studies included in this review used mHealth interventions on the provision of health education and awareness creation and ultimately encouraging behavioral change among participants through SMS delivery as illustrated in table 4. As shown in the table above, some of the studies were overlapping due to some mHealth intervention classified both under registries /vital event tracking and also has SMS module for health education and reminders.

### 3.3 Risk of Bias within Studies

The risk of bias within study as presented in the table above was assessed using a standard approach for all the included studies with a defined criterion. It was based on the six main markers of validity used to the component ratings as enshrined in the quality assessment tool for quantitative studies by the Effective Public Health Practice Project. Among the 114 component ratings assessed from the all the nineteen included studies, five (4%) weak ratings were identified. Two and three weak ratings respectively on blinding and withdrawals and drop-outs. With this minimal percentage, there is enough leverage against detection bias and reporting bias respectively for blinding outcome assessors and participants. There were no weak ratings for selection bias, study design, confounders and the method for data collections. Seven-six (67%) and thirty-three (29%) out of the total 114 component ratings were classified as strong (good) and moderate(fair) respectively. Ninety-six percent of ratings were at least fair(moderate) positively impacts on representativeness of the participants, effectiveness of the study design as it is a good indicator of the extent of the bias. No weak or poor ratings were discovered in evaluating both intervention and control groups were balanced at baseline with respect to confounders. Similarly, the reliability and validity of the data collection methods showed no weak ratings as well.

**Table 5.** Quality measures of the included studies based on the six markers of EPHPP tool

| Refernce, Author(year) | Selection Bias(A) | Study design(B) | Confounders(C) | Blinding (D) | Data collection methods(E) | Withdrawal and dropouts (F) |
|---|---|---|---|---|---|---|
| **Alam (2017)** | Moderate | Moderate | Strong | Moderate | Strong | Moderate |
| **Ateudjieu (2014)** | Moderate | Strong | Strong | Moderate | Strong | Strong |
| **Atnafu (2017)** | Strong | Strong | Moderate | Moderate | Strong | Strong |
| **Bangure(2015)** | Moderate | Strong | Strong | Moderate | Moderate | Strong |
| **Brown(2017)** | Strong | Strong | Strong | Strong | Strong | Strong |
| **Gibson (2017)** | Strong | Strong | Strong | Moderate | Moderate | Strong |
| **Hackett (2018)** | Strong | Strong | Moderate | Moderate | Strong | Moderate |
| **Haji (2016)** | Moderate | Strong | Strong | Weak | Moderate | Moderate |
| **Kazi (2018)** | Moderate | Strong | Strong | Strong | Strong | Weak |
| **Lund (2016)** | Strong | Strong | Strong | Moderate | Strong | Strong |
| **Lund (2012)** | Strong | Strong | Strong | Strong | Strong | Strong |
| **Lund (2014)** | Strong | Strong | Strong | Strong | Strong | Strong |
| **Lund (2014)** | Strong | Strong | Strong | Strong | Strong | Strong |
| **Mushamiri (2015)** | Strong | Moderate | Strong | Strong | Strong | Strong |
| **Nagar (2018)** | Moderate | Strong | Strong | Moderate | Strong | Moderate |
| **Odeny (2014)** | Strong | Strong | Moderate | Strong | Strong | Weak |
| **Oyeyemi (2014)** | Moderate | Moderate | Strong | Moderate | Strong | Weak |
| **Shiferaw (2016)** | Strong | Strong | Moderate | Weak | Strong | Strong |
| **Uddin (2016)** | Moderate | Moderate | Strong | Strong | Strong | Moderate |

### 3.4 Synthesis of Results

#### 3.4.1 Primary Outcomes

None of the studies included in this review reported on maternal mortality rate outcome and under-five mortality rate outcomes. In addition, only two studies from the same author but conducted in two different countries all located in Africa (Zanzibar and Ethiopia) reported on neonatal mortality outcomes[94, 96].

**Table 6.** Overview of included studies and their outcomes.

| Reference, Author (year) | Primary Outcomes | | | Secondary Outcomes | | | |
|---|---|---|---|---|---|---|---|
| | Maternal mortality | Neonatal mortality | Under-five mortality | Skilled Birth attendant | Antenatal care / visits | Postnatal care / visits | Vaccination Coverage |
| Alam (2017) | | | | × | | × | |
| Ateudjieu (2014) | | | | | | | × |
| Atnafu (2017) | | | | × | × | | |
| Bangure (2015) | | | | | | | × |
| Brown (2017) | | | | | | | × |
| Gibson (2017) | | | | | | | × |
| Hackett (2018) | | | | × | × | | |
| Haji (2016) | | | | | | | × |
| Kazi (2018) | | | | | | | × |
| Lund (2016) | | × | | | | | |
| Lund (2012) | | | | × | | | |
| Lund (2014) | | | | | × | | × |
| Lund (2014) | | × | | | | | |
| Mushamiri (2015) | | | | | × | × | |
| Nagar (2018) | | | | | | | × |
| Odeny (2014) | | | | | | × | |
| Oyeyemi (2014) | | | | | × | | |
| Shiferaw (2016) | | | | × | × | × | |
| Uddin (2016) | | | | | | | × |

NB: No data is shown as N/A (not applicable).

### 3.4.2 Secondary Outcome

Six studies out of the nineteen studies reported on outcomes on pregnant women having access to skilled birth delivery. These included skilled delivery personnel, health facility delivery. among these six studies are four randomised control trails [61, 90, 94, 95], one retrospective cross-sectional design[85] and one clinical control trail [60]. Antenatal care and antenatal visits outcomes were reported by in six studies all conducted in Sub-Saharan Africa including three RCTs [61, 65, 90], one Case-Control study [100], one Cohort Analytica [62], one clinical control trail [60]. One study each using the following study design reported on outcomes on postnatal care (PNC) visits or post-partum care; Retrospective cross-sectional study, Cohort Analytica, randomised control trail and clinical control trail. Three out of these four studies were conducted in Sub-Saharan Africa [60, 62, 99] and one in southern Asia [85]. Nine studies from the nineteen eligible studies included in this review reported outcomes on immunization and vaccination coverage. One of these studies was a quasi-experimental design conducted in Bangladesh in the southern Asia [68] with the remaining eight utilising a randomised control trail design conducted in Zanzibar [65], Cameroon [86], Zimbabwe [87], Nigeria [88], Kenya [89, 91], Pakistan [18], India [67].

## 3.5 Effects of mHealth Interventions on Outcomes

### 3.5.1 Effect of mHealth Neonatal mortality

The two RCTs studies examined neonatal mortality were conducted in Ethiopia and Zanzibar [94, 96]. Pregnant women in one study used SMS reminders and mobile phone voucher component (*Wired mother)* for appointment reminders and to contact their health worker when needed respectively. In this study of evaluating mHealth intervention on perinatal mortality, the death of a child within 42 days after birth was use as a proxy for neonatal deaths. The overall perinatal mortality rate was 27 per 1000 births with a significant decline in the intervention cluster (19 per 1000 births) compared to the control cluster (36 per 1000 births) with no mHealth intervention. The reduction in neonatal mortality in this study was not significant in the intervention cluster compared to the control with an odds ratio OR=0.79, 95%CI (0.36-1.79) [96].

The second study that addressed neonatal mortality outcomes utilized a smartphone with safe delivery application to provide training for rural health workers on the management of obstetric and neonatal complications. Early neonatal mortality (death within first 7 days of life) is a composite of the main primary outcome, perinatal mortality. Out of the 60 neonatal deaths, 21

was recorded in the interventional cluster with the remaining 39 in the control cluster. Over all the mHealth safe delivery application in the intervention cluster was associated with non-significant reduction in perinatal mortality (OR= 0.76, 95%CI, 0.32-1.81) [94]. All studies identified positive association between the mHealth interventions designed to reduce perinatal mortality and for that matter neonatal mortality in the intervention cluster compared to the control.

Findings from the two studies compliments each other with both indicating that the decline in neonatal mortality in the mHealth intervention clusters compared to the control cluster were not significant. A secondary outcome analysis of safe delivery application intervention on knowledge acquisition and skills gained by health workers in the intervention group improved significantly to those in the control cluster [94]. These two studies found that text messages base reminders for pregnant women and smartphone-based application for training health workers are might be effective in lowering neonatal mortality in area with limited resources. Indications from the insignificant nature of the mHealth effects on neonatal mortality allows for the need for further studies.

### 3.5.2 Effect of mHealth on access to Skilled birth delivery

Six (32%) of the articles studied outcomes on access to skilled birth delivery ranging from having a skilled birth attendant during birth, delivery at health facility, provision of training for health workers on safe delivery. Three out of the six studies uses short message service (SMS) as mode of delivery of the intervention with two RCTs conducted in Sub-Saharan African [61, 95] and one retrospective cross-sectional study [85]. A study conducted in primary healthcare facilities in Zanzibar sent automated SMS reminders and health education to pregnant women in the intervention cluster and found an association with an increase in skilled birth attendance in intervention cluster (60%) compared to the control group with the standard care (47%). With an odds five times higher on access to skilled birth delivery, the intervention (*wired mothers*) was highly significant among women residing in the urban areas (AOR, 5.73. 95% CI 1.51-21.81) [95]. Similarly, another SMS based RCT conducted in Ethiopian indicated that deliveries conducted in the presence of HEW the intervention cluster was significantly higher with P value of less than 0.005 whiles the control cluster had a statistically significant decline in deliveries attended by HEW at $P<0.001$ [61]. These two studies attest to the positive contributions of SMS based mobile phone intervention in encouraging pregnant women access to skilled delivery which is crucial to save lives of women and new-borns. A retrospective cross-sectional survey conducted in Bangladesh on the impact of SMS on maternal and child

healthcare behavior concluded that there was no significant association between exposure to SMS during pregnancy and the presence of a skilled delivery attendance at birth. Skilled birth delivery at home in the exposed group was (54/210) compared to (57/266); having SMS during pregnancy was not statistically significantly associated with skilled delivery at home (RRR: 1.2; 95% CI 0.71–1.9; p = 0.514). Also the presence of SBA have a relative risk ratio of 1.0 in both the exposed (133/210= 63%) and unexposed group (174/266= 66%) [85].

Two studies utilize a smartphone-based application for data collection with an SMS component for appointment reminders and health educational messages. Both demonstrated that mHealth intervention through smartphone base application contributes positively towards health facility delivery [60, 90] where there is the presence of a skilled birth attendant. One of these two studies was a non-randomized control trail conducted in Ethiopia. Findings from this study showed that pregnant women in the mHealth intervention group were significantly more likely to deliver their baby in the health center compared to the control group (43.1% versus 28.4%; AOR: 1.98, 95%CI ,1.53–2.55) [60]. Similarly, a randomized control trail in Tanzania by Hackett et al. (2018) found agrees the odds of delivering at or on the way to a facility among women in the SP+ group were double compared to the odds among women in the control group. (OR, 1.96; CI, 1.21–3.19; adjusted analyses) [90]. This finding was similar to that in the Ethiopian study by Shiferaw et al. (2016). The last study with skilled delivery outcome is a RCT in Ethiopian utilizing a mHealth intervention with safe delivery application through the provision of training of healthcare workers in the intervention facilities in birth related complications. At the end of the study, the skill scores of intervention health care workers increased significantly compared with those of controls at 6 months (mean difference, 6.04; 95% CI, 4.26-7.82) and 12 months (mean difference, 8.79; 95% CI, 7.14-10.45) from baseline, corresponding to 80% and 107%, respectively, above the control level[94]. All the six studies reporting on access to skilled delivery demonstrated positive impact of the various mHealth intervention except one with insignificant conclusion.

### 3.5.3 Contribution of mHealth on Antenatal care services

Two RCTs [61, 65] among the six studies examining antenatal care attendance uses mHealth intervention with SMS reminders and health educational messages for pregnant women. Additionally, mobile phone vouchers are provided to them to contact the health workers when the need arise [65]. Pregnant women in the *'wired mothers'* intervention demonstrated a statistically significant increase of over 10% in the proportion of women accessing not less than four antenatal care visits between the intervention and the control cluster. The odds for

receiving four or more antenatal care visits were more than double for women benefiting from the mobile phone intervention (OR, 2.39; 95% CI, 1.03-5.55)[65]. The second study also with a SMS intervention conducted in Ethiopia showed 14.52% statistically significant increase (P=0.001, 95% CI, 0.0794-0.2109) in the proportion of women having more than four ANC visits from baseline (45.32%) to end line after the intervention (59.84%). Compared to the control area, there was an insignificant decrease in ANC attendance (P=0.67, 95%CI, -0.0681-0.0439) from baseline (24.48%) to post-intervention (23.27%). The study indicated that mothers receiving more than four ANC visits increased significantly in the intervention areas (P=0.001, 95% CI (0.3258-0.4056) showed insignificant decrease, in the control area [61]. Results from these two studies supports role of SMS in increasing access to ANC visits among pregnant women.

Another RCT [90] and a Non-randomized control trail [60] were conducted in rural Tanzania and Ethiopia respectively with smartphone based application with SMS component and data collection module. The evaluation of a smartphone-based application developed to aid CHWs impacted positively on the likelihood of pregnant women receiving two or more community health worker visits during pregnancy in the intervention areas than in the control area 72% vs. 60%; chi-square = 6.9; $p < 0.01$)[90]. In the non-randomized control trail although it was not statistically significant, pregnant women in the intervention health centers were more likely to have at least 4 antenatal visits (27.0% versus 23.4%; AOR: 1.31(95%CI 1.00–1.72). The intervention was statistically significant among women living in the urban areas compared to the rural areas in terms accessibility to at least four antenatal care visits[60]. Support to the importance of smartphone-based application with SMS and data collection module on antenatal care visits is further demonstrated in these two studies [60, 90].

A case control study was conducted among pregnant women in Nigeria aim at increasing primary health facility utilization with the 'Abiye-*safe motherhood*' mHealth intervention. Mobile cell phones were given to pregnant women and health workers in the intervention area facilitate communication among the pregnant women and also with the health services free of charge. The overall health facility utilization rates by pregnant women in the intervention area (44%) was significantly higher than in the control area (36.7%) at P-valve = 0.0001. Similarly, facility utilization in the primary health centers demonstrated significantly higher usage in the project area than the control area (t-test, $t(1478) = 9.261$, $p < 0.001$) [100]. A study in western Kenya evaluated the health-seeking behavior in ANC and PNC following the implementation of a mobile health tool (ANC/PMTCT Adherence System - APAS) utilizing SMS to manage the activities of the CHW during this period. Findings from this Retrospective Cohort Analytica

among pregnant women living in the Millennium Village Project (MVP) area who had their first antenatal attendance in the second trimester and were in the APAS had three times the odds of having more ANC attendance compared to women who were not registered(control: paper-based tracking forms) but resided in the cluster (AOR = 2.58, 95%CI, 1.10-6.01). Again the effect of the intervention also led to twice the odds of having more ANC visits among women in the intervention cluster compared to women who were not registered and resided outside the cluster [62]. These studies have shown that mHealth intervention through simple mobile phone voice calls [100] and multi-functional module [62] can lead to significant improvement in ANC attendance

### 3.5.4 Contribution of mHealth on Postnatal Care Services

A two-way SMS mHealth intervention RCT was conducted in Kenya to determine its effects on the rates of clinic attendance among pregnant women [99]. One group was allocated the SMS intervention with the control group suing the usual care or standard care. According to intent-to-treat analyses, more women in the SMS group (19.6%) attended maternal post-partum visits or PNC than (11.8%) of the women in usual care group (RR=1.66, P=0.04, 95% CI ,1.02–2.70). findings from a per-protocol analysis (RR 1.83, 95% CI 1.11–3.01) supports the previous analysis with women in the SMS arm having a significantly higher probability of attending clinic within 8 weeks compared to those in the control arm [99]. A retrospective cross-sectional study in Bangladesh [85] was conducted to find the impact of SMS (*Aponjon services*) on maternal and childcare behavior. Results on PNC visits shows that women's exposure to mobile phone messages during pregnancy had no association with the number of PNC visits at the 95% confidence interval (IRR: 1.2; 95%CI, 0.94–1.6; p = 0.117) [85] which is in contrast with findings from the Kenyan study [99].

Two additional studies reported on post-natal care outcomes; one is a non-randomized clinical control trail conducted in Ethiopia [60] and another one conducted in Kenya with retrospective cohort Analytica study design [62]. A logistic regression analysis in the Ethiopian study shows a significantly higher proportion of women in the intervention group had PNC in the health centers compared to the control health centers (41.2% versus 21.1%: AOR; 2.77, 95%CI (2.12–3.61)) [60]. Likewise, the APAS mHealth intervention in Kenya demonstrated an increased likelihood of women accessing the six recommended post-delivery baby follows-ups for women registered under the mHealth project area [62].

### 3.5.5 Contribution of mHealth on Vaccination /Immunization Coverage

A total of nine (9) studies reported on vaccination/ immunization outcomes with eight RCTs design [18, 65, 67, 86-89, 91] and one quasi-experimental pre-post design[68]. Five studies presented information on vaccination/immunization coverage; four of which employed SMS reminders [18, 65, 87, 89] and the fifth study used a software for registration and an SMS reminder component called '*mTika*' [68]. One presented result on an evaluation of SMS mHealth intervention on reducing routine vaccination dropout rate and also on vaccination coverage[91]. The study found that the intervention group receiving SMS reminders had less vaccination dropout rate compared to control group (OR=0.2 CI 0.04-0.8) and also vaccination coverage was significantly higher in SMS reminder intervention group than the control receiving routine reminders. SMS reminders accounted for 13 % of the children vaccinated in the SMS intervention group who likely would not have been vaccinated if SMS reminders had not been used at 14 weeks [91]. Two studies presented information on mHealth intervention with voice calls for immunization improvement [88] and immunization adherence [67]. Results shows that cell-phone reminder/recall mHealth intervention to enhance routine childhood immunization are achievable primary health setting (PHC). Receiving the required number of doses of routine vaccines at the appropriate age at recommended interval was 79.2% among the children in intervention group and 46.4% in the control group ($p < 0.001$) [88]. The study on immunization adherence did not observe a significant difference between pendant only group and the pendant plus SMS group. Immunization completion within two camps after the first dose of diphtheria, tetanus toxoid and pertussis vaccine (DTP1) showed higher adherence in the Control (Sticker) (74.2%) arm compared to the Pendant (67.2%) and Pendant and Voice call arms (69.3%) [67]. Two of the three SMS base mHealth intervention with vaccination/immunization coverage as primary outcome demonstrated a significant increase in vaccination coverage in the intervention group [18, 87] and absence of a significant association between SMS only group compared to the control group with regards to immunization coverage in RCT conducted in Kenya [89] contradicts the earlier findings from a study in Sub-Saharan Africa [87] and Southern Asia. Another RCT conducted in Zanzibar with '*wired mothers'* SMS intervention reported on tetanus vaccination coverage as secondary outcome indicated an insignificant impact of the intervention (OR, 1.62; 95% CI, 0.81-3.26). In the intervention group 72% of nullipara women received two doses of tetanus vaccination versus 56% in the control group [65].

### 3.6 Detailed Results of Individual Studies

In this section detailed description and results of the nineteen individual studies included in this systematic review is presented below.

A pragmatic randomized control trial in primary health care facilities in Zanzibar was conducted to examine the association between mHealth intervention and skilled delivery attendance. A total of 2550 pregnant women attending antenatal at one of 24 primary health facilities in six districts were selected and followed until 42 days after giving birth. Twelve primary healthcare facilities were allocated to the intervention group and control group with 1311 and 1239 pregnant women respectively. The mHealth intervention was associated with a surge in skilled delivery attendance with sixty percent (60%) of the women in the intervention group versus forty percent (47%) in the control group delivered with skilled attendance. mHealth solutions may assist to the saving of lives of women and their new-borns and also contribute in harnessing the Millennium Development Goals 4 and 5(also captured in sd3) and should be considered by maternal and child health policy makers in developing countries.

**Table 7.** Results on '*wired mothers'* intervention and Skilled Delivery Attendant.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [95]Lund et al. (2012), Zanzibar | Randomised controlled trial (RCT), primary healthcare facilities | Two thousand, five hundred and fifty pregnant women (1311 interventions and 1239 controls) who attended antenatal care at one of the selected primary healthcare facilities | Wired Mothers: pregnant woman link to health system with mobile phone intervention | Skilled Delivery Attendance (SBA) | The interventions is associated with 60% as against 47% in intervention and control group respectively for skilled delivery attendance. Produce a significant increase in SBA in urban areas (AOR, 5.73. 95% CI 1.51-21.81) but not in rural areas | Low risk |

An Ethiopian study by Lund et al. was undertaken with an mHealth Safe Delivery Application (SDA) to determines its effects on perinatal survival and also knowledge and skills of health care workers in neonatal resuscitation. The study utilizes a cluster randomized Clinical Trail design among 176 healthcare workers with the mHealth training tool in emergency obstetric neonatal care. 3601 women and 176 health care workers were analyzed. Use of the SDA was associated with a nonsignificant lower perinatal mortality of 14 per 1000 births in intervention

clusters compared with 23 per 1000 births in control clusters. The skill scores of intervention health care workers increased significantly compared with those of controls at both six months and twelve months to 80% and 107%, respectively, above the control level. Similarly, knowledge score increases significantly to 39% and 38% for 6months and 12 months respectively above the control level. The study demonstrated that SDA intervention effectiveness in improving and sustaining health knowledge and skill in the neonatal resuscitation

Table 8: Results on '*Safe Delivery Application* intervention and Perinatal survival

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [94]Lund et al. (2016), Ethiopia | Randomised controlled trial (RCT), primary healthcare facilities | In five rural districts with 176 healthcare workers, 73 health care facilities were randomized to the mobile phone intervention or to standard care (control) | Health care workers in intervention facilities received a smartphone with the SDA. The SDA is a training tool in emergency obstetric and neonatal care that uses visual guidance in animated videos with clinical instructions for management | The primary outcome was perinatal death. Secondary outcomes included the knowledge and clinical management of neonatal resuscitation (skills) of health care workers before the intervention and after 6 and 12 months | Non-significant decline in **perinatal mortality** (odds ratio, 0.76; 95% CI, 0.32-1.81).<br><br>At 6 months significant increase in **skill score** (mean difference, 6.04; 95% CI, 4.26-7.82) and 12 months (mean difference, 8.79; 95% CI, 7.14-10.45) from baseline.<br><br>**Knowledge score** at 6months and 12months were (mean difference, 1.67; 95% CI, 1.02-2.32) and (mean difference, 1.54; 95% CI, 0.98-2.09) respectively above the control level. | Low risk of bias |

A pragmatic cluster randomized controlled trial was conducted in primary healthcare facilities of Zanzibar. The primary outcome measure of the trial was four or more ANC visits. The intervention consisted of two components SMS and mobile phone voucher component. The SMS component was used to send appointment reminders and educational messages to women

regarding ANC and PNC. For the SMS component, web-based system was developed to register women with their phone numbers. The mobile phone voucher component allowed pregnant women (mothers) to directly communicate with primary healthcare providers. The intervention was related with an improvement in ANC visits in the intervention group. In the intervention group, 44% of women attained four or more ANC visits versus 31% in the comparison group (OR, 2.39; 95% CI 1.03–5.55). Although there was an improvement in tetanus vaccination as a secondary outcome, it was not statistically significant. In the intervention group 72% of nullipara women received two doses of tetanus vaccination versus 56% in the control group (OR, 1.62; 95% CI, 0.81-3.26). For women benefitting from the mobile phone intervention. 59% of intervention women stated that received text messages influenced the number of times they attended antenatal care

**Table 9.** Results on '*wired mothers'* intervention and Antenatal care visits.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [65]Lund (2014), Zanzibar | Randomised controlled trial (RCT), primary health | Pregnant women Intervention group: 1311 Control group: 1239 Total: 2550 | Text message reminders and educational messages for mother delivered to mobile phone and mobile vouchers to contact health workers. Tools used: custom Wired Mothers software | Recommended four or more antenatal visits.<br><br>Tetanus vaccination | The odds for receiving four or more **antenatal care visits** were 2.39 (1.03–5.55).<br><br>In the intervention group 72% of nullipara women received two doses of **tetanus vaccination** versus 56% in the control group (OR, 1.62; 95% CI, 0.81-3.26) | low risk of bias |

In Zanzibar, similar a pragmatic cluster randomized controlled trial was conducted in primary health facilities. Twenty-four healthcare facilities were randomized to either intervention group or usual care group. The intervention consists of two components which include SMS and mobile phone voucher. The outcome measured included stillbirth, perinatal mortality, and death of a child within 42 days after birth as a proxy of neonatal mortality. Two thousand four hundred and eighty-two children were born alive within 42 days of live excluding 54 still births and 36 died. The overall perinatal mortality rate in the study was 27 per 1000 total births. The rate was lower in the intervention clusters, 19 per 1000 births, than in the control clusters, 36 per 1000

births. Apart from perinatal mortality, the intervention indicated an insignificant reduction on the other secondary outcomes thus still birth and death within 42 days of live.

**Table10.** Results on '*wired mothers'* intervention and perinatal mortality rate.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [96]Lund (2014), Zanzibar | Randomise control trail (RCT), primary healthcare level | Pregnant women Intervention group: 1311 Control group: 1239 Total: 2550 | Text message reminders and educational messages for mother delivered to mobile phone and mobile vouchers to contact health workers. Tools used: custom *Wired Mothers* | Perinatal mortality<br><br>Neonatal mortality (death within 42days of life)<br><br>Still birth | significant reduction in **perinatal mortality**; (OR) of 0.50 (95% CI 0.27-0.93).<br><br>Non-significant reduction in **Neonatal mortality** (OR 0.79, 95% CI 0.36-1.74).<br><br>Non-significant reduction in **stillbirth** (OR 0.65, 95% CI 0.34-1.24) | Low risk of bias |

A retrospective cross-sectional study from Bangladesh was conducted to assess the association between a mHealth based messaging services (Aponjon) and practices regarding childbirth and mother care. A total of 476 mother-infant pair with age of child between 3 and 18months were recruited in this study. One group of mothers received the early warning messages from Aponjon during pregnancy (exposed; n = 210) while the other group of new mothers did not receive the messages during pregnancy as they had enrolled in the service after childbirth (non-exposed; n =266). There was no significant association between exposure to *Aponjon messages* during pregnancy and presence of a SBA at birth and postnatal care visits. Negative binomial analysis showed that women's exposure to mobile phone messages during pregnancy had no association with the number of PNC visits at the 5% significance level (IRR: 1.2; 95%CI 0.94–1.6; p = 0.117)/ Exposure to messages during pregnancy was not statistically significantly associated with the presence of an unskilled birth attendant at a home delivery (RRR: 1.6; 95% CI 0.84–2.9; p = 0.156) or with a skilled birth attendant at home (RRR: 1.2; 95% CI 0.71–1.9; p = 0.514) relative to a health facility delivery

**Table 11.** Results on '*apojon- messaging'* intervention on PNC visits and SBA.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [85]Alam (2017), Bangladesh | Retrospective cross-sectional study | 476 mother-infant pair. Intervention (n=210) and control (n=266) | One group of mothers received the early warning messages during pregnancy | Skilled birth attendant (SBA) Number of postnatal care (PNC) visit | exposure to mobile phone messages during pregnancy had no association with the number of **PNC visits** at the 5% significance level (IRR: 1.2; 95%CI 0.94–1.6; p = 0.117) or with a **skilled birth attendant** at home (RRR: 1.2; 95% CI 0.71–1.9; p = 0.514) relative to a health facility delivery | Low risk of bias |

A case–control study from Nigeria compared rates of facility utilization and maternal morbidity in health care facilities where pregnant women had received mobiles as a communication platform. In the intervention area, the facility utilization rate was significantly higher in the primary health care centres than in the secondary healthcare facility unlike the control area where it was observed that the facility utilization was significantly higher in the secondary healthcare facilities than in the primary health care facilities. For primary health care centres, the usage of health facilities was significantly higher in the intervention area that the control. Similarly, the overall utilization in the intervention area was significantly higher in the intervention with 43.4% against 36.7% in the control area with a P-value (p=0.0001). The number of recorded cases of all the five major causes of maternal death in the intervention and the control areas were 23 and 29 respectively. The difference was not statistically significant (OR =1). Improved access to health services and increased facility utilization could lead to a reduction in the rates of the five major causes of maternal death and also the use of cell phones could strengthen the primary healthcare system and increase access to healthcare.

**Table 12.** Results on '*Abiye project'* intervention and Facility utilization.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [100]Oyeyemi and Wynn (2014), Nigeria | Case–control study, primary and secondary settings | Pregnant women Cases = 1429 Controls = 1801 | Giving mobile phones to pregnant women to increase primary health facility utilisation (cases) vs no | Primary outcome: Facility utilisation rate Secondary outcome: Frequency of occurrence of 5 major causes of | Facility utilisation: Cases 43.4%; Controls 36.6; OR 1.32 (95% CI 1.15–1.53)<br><br>Number of illness cases: Cases 1.6%; | Moderate risk of bias |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | mobile phones (controls) | maternal death | Controls 1.6%; OR 1.00, (95% CI 0.58–1.74) | |

In a three-arm randomize control trail in conducted in Cameroon to assess the effect of mHealth intervention on rate of reporting adverse effect following immunization with meningitis vaccine. The incidence rate of reported AEFI per 100 health facility per week was 20.0 (15.9–24.1) in the SMS group, 40.2 (34.4–46.0) in supervision group and 13.6 (10.1–16.9) in the control group. Supervision led to a significant increase of AEFI reporting rate compared to SMS with adjusted (RR = 2.1 (1.6–2.7); $p < 0.001$ and control (RR = 2.8(2.1–3.7); $p < 0.001$)) groups. The attributable risk of AEFI reporting per 100 health facilities per week in the SMS and supervision groups compared to the control group were 6.38 (0.1–12.8) and 26.6 (9.9–33.3) respectively. This rate in the supervision group compared to the SMS group was 20.3 (13.3–27.3).

**Table 13.** Results on SMS intervention and AEFI reporting rate.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [86]Ateujieu et al. (2014), Cameroon | Randomised control trail (3arm-RCT) | 348 health facilities SMS arm= 116 Supervision arm= 116 No intervention arm= 116 | **1.** Weekly standardized SMS asking them to report all medical events occurring during the intervention period in persons immunized during the campaign. **2**. weekly standardized supervisory visit by trained health district focal points for AEFI detection and reporting processes. | AEFI reporting rate during a meningitis immunization | The effect of SMS led to some **increase in AEFI reporting rate** compared to the control group, but the difference was not statistically significant (RR = 1.4(0.8–1.6); p = 0.07)). | Low risk of bias |

Another Ethiopian randomized control trail with 3-arm was carried out to find the role of mHealth intervention utilizing SMS based data exchange software to connect community health workers (CHWs) and its effect on some selected maternal and child health outcome including ANC attendance , skilled delivery attendance and immunization coverage. The proportion of mothers receiving more than four ANC visits increased significantly in the intervention area

(SMS only: P=0.001, Z =17.96 and SMS+CHW: P=0.001, Z=4.04). The control area with no mobile phone intervention demonstrated an insignificant decrease in ANC visits. The number of home deliveries alone in the control area was more than those experienced in the two intervention areas. Deliveries carried out under the supervision of a Health extension worker (HEW) in the SMS only group increase significantly (P<0.050) while control area experienced a statistically significant reduction in deliveries attended by an HEW, at a P value less than 0.001. The study indicated that the vaccination rates decreased across all the three groups (at base line vaccination coverage was 88.63%, 76.19% and 81.82% and after the intervention it was 58.31%, 58.72% and 62.98% for SMS only, SMS and CHW, control).

**Table 14.** Results on 'Frontline SMS based intervention on maternal and child health services.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [61]Atnafu et al. (2017), Ethiopia | Randomised control trail (RCT), community based | Mother infant pair: | SMS based data exchange software to connect community health workers (CHWs) | Change in ANC visits<br>Change in skill birth attendance<br>Change in immunization coverage | **ANC visits:**<br>SMS only (P=0.001, Z =17.96)<br>SMS+ (P=0.001, Z=4.04)<br><br>**SBA:**<br>SMS only(P<0.05) increase deliveries in presence of HEWs Vs. baseline.<br>Control(P<0.001) reduction in deliveries in presence of HEWs.<br><br>**Vaccination coverage:** decrease across all the groups | Low risk of bias |

Bangure et al (2015) conducted a study on the effectiveness on SMS reminders on immunization program in Zimbabwe utilizing a randomized control design.304 women who had delivered and were residence in the study area were recruited with 152 each into the intervention and control group. SMS reminders were sent at week 6, 10 and 14 in the intervention group together with health education while as the control group had only health education. Immunization coverage was significantly higher in the intervention than control group. The overall increase in immunization coverage was attributed to use of SMS. At 14 weeks. the risk difference (RD) for the SMS group than those in the non-intervention group

was 16.3% (95% CI: 12.5-28.0). The use of SMS was not associated with delay in getting immunization.

**Table 15.** Results on SMS reminders on immunization coverage in Zimbabwe.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [87] Bangure et al. (2015), Zimbabwe | Randomised control trail (RCT) | Women who delivered (n=304), 152 allocated to the intervention and control group | SMS reminders were sent at 6, 10 and 14 weeks in addition to routine health education | Immunization coverage.<br><br>Delay in immunization | **Immunization coverage** *(Interventions Vs.Control)*<br><br>@week6: *93% Vs. 82% (P<0.001)*<br>@week10: *96% Vs. 80% (P<0.001)*<br>@week14: *95% Vs. 75% (P<0.001)*<br><br>**Delay in immunization**<br>@week6: 89% (P<0.001) less likely in intervention group<br>@week10: 81% (P<0.001) less likely in intervention group<br>@week14: 75% (P<0.001) less likely in intervention group | Low risk of bias |

A descriptive report by Brown and Oluwatosin in 2017 was undertaken in primary health centers in Nigeria using a randomized control trail to describe the adaptability and acceptability of immunization reminder and recall system. Five hundred and ninety-five mothers/infant pairs were purposively recruited to participate in the study with the infants between the ages of 0-3 months. 295 out of the 595 were randomized into the intervention group with the remaining 300 in the control group. The primary contacts which in this case are the mothers were giving one mobile phone call reminder two days prior the child's next immunization appointment followed with a second one a day before. Provision was made for missed appointments with mobile phone recalls. The study reported that the compliance rate of immunization which is the receiving the needed number of doses of vaccine at the appropriate age and also at the interval recommended was significantly higher in the intervention group with 79.2% as against 46.4% in the control among the children.

**Table 16.** Results on Cellphone call and recall reminder on routine immunization in Nigeria

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [88]Brown and Oluwatosin (2017), Nigeria | Randomised control trail (RCT) | 295Mother-infant pair(0-3months) Intervention= 295 Control= 300 | Cell phone-based reminder/recall strategy | Immunization compliance rate | Immunization **compliance rate** @ intervention= 79.2% @control = 46.4% Significant: (P<0.001) | Low risk of bias |

An assessment of SMS reminders called '*Mobile Solution for Immunization – (M-SIMU)'* with and without monetary incentives ability to enhance immunization uptake using a 4-arm randomized control trail study design was conducted in Kenya by Gibson et al. (2017). A total of 2018 mother/infant with children no exceeding 5weeks and had not received their first dose were selected for the study. Participants the four-intervention group received SMS only, SMS plus 75 Kenya Shilling (KES) and SMS plus 200KES with 476, 562 and 491 were respectively assigned to those groups. The control group had 489 participants. After 12months of age, the full immunization was 82%, 86%, 86% and 90% respectively for the control, SMS only, SMS plus 75KES and SMS plus 200KES. The uptake of immunization at 12months in the intervention groups was only significant in the SMS plus 200KES group than the control group (relative risk 1·09, 95% CI 1·02–1·16, p=0·014). No significant differences was observed in the primary outcome both in the SMS only or the SMS plus 75KES. 0n the timeliness of the immunization all the three intervention groups demonstrated a significantly higher full immunization within two weeks with SMS only (RR 1·18, 95% CI 1·01–1·39, p=0·045), SMS plus 75 KES (1·37, 1·18–1·59, p<0·0001), and SMS plus 200 KES (1·42, 1·23–1·65, p<0·0001) compared to the control group.

**Table 17.** Results on M-SIMU on immunization coverage and Timeliness in Kenya

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [89]Gibson et al, (2017), Kenya | Randomised control trail (4 Arm RCT) | 2018 mother/infant pair (< 5weeks) SMS only= 476 SMS+75KES= 562 SMS+200KES= 491 Control= 489 | **Interventions:** SMS only, SMS plus 75 Kenya Shilling (KES) and SMS plus 200KES | Full immunization at 12months | **At 12months** Control: 82% *SMS only*: 86% (1·04 (0·97–1·12), *p=0.29* *SMS+75KES*: 86(1·04 (0·96–1·11), *P=0.33* | Moderate risk of bias |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | *SMS+200KES*= 1·09 (1·02–1·16), *P=0.014* | |

A randomized control trail study in rural Tanzania by Hackett et al.(2018) was conducted to evaluate a smartphone based application developed to aid community health workers (CHWs) with data collection, pregnancy danger sign identification, referral and education on delivery. 572 pregnant women from 32 randomly selected village were randomly selected to participate. Sixteen(16) villages each was assigned to either the intervention cluster or control cluster with 16 pairs of CHWs allocated smartphone embedded with application(total=31). The control cluster or group was additionally randomly assigned 16 CHWs pair. Both groups were trained to use iMNCH photo book. In addition, the intervention group were given smartphone-based application in their house hold visits while as had to use the standard paper-based protocol in addition. Facility delivery in the intervention group was significantly higher with 74% of mothers in the intervention as against 63% in the control group. The was double odds of facility delivery among smartphone aided health workers to those in the control area (OR, 1.96; CI, 1.21–3.19; adjusted analyses). Visits from community health workers during pregnancy was more likely in the intervention cluster than the control area (72% vs. 60%; chi-square = 6.9; $p < 0.01$). The surge in facility delivery via an increase in the number of prenatal home visits (ANC) is as a result of community health worker use of smartphones.

**Table 18.** Results on Smartphone Assisted home visits on use of facility delivery in Tanzania.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [90]Hackett et al. (2018), Tanzania | Cluster Randomised Control Trail | 32viilages with community health workers, pregnant women. *Intervention*= 16 villages, 32 (CHWs) *Control*=16 villages, 32 (CHWs) | Smartphone application assisted prenatal visits | Facility delivery<br><br>Prenatal home visits | ***Facility delivery:*** (AOR, 1.96; CI, 1.21–3.19) Intervention: 74% Control: 63%<br><br>***Prenatal home visits:*** Intervention Vs. Control area (72% vs. 60%; chi-square = 6.9; $p < 0.01$) | Moderate risk of bias |

An evaluation was undertaken in three districts selected in Kenya with two interventions (text messages reminders and stickers reminders) with the aim of reducing routine vaccination dropout rates. The intervention was to remind parents to avail their children for immunization.

Children less than 12 months presenting for their first dose vaccine (pentavalent) were eligible for enrolment. One thousand one hundred and sixteen (1116) children were enrolled with 372 in each of the intervention group and also the control group where (routine reminder) with the next schedule indicated on booklet. Dropout rates in the text messages intervention group was less likely than in the control group (OR 0.2, CI 0.04–0.8). unlike the text message group, the stickers group demonstrated no statistical difference compared to the controls (OR 0.9, CI 0.5–1.6). SMS reminders was associated with a significantly higher vaccination coverage than the routine reminders in the control group. Within the SMS intervention group, thirteen (13%) will not have been vaccinated if the SMS reminders had not been used 13 % (95 % CI: 5.6–21.26).

**Table 19.** Results on mHealth intervention to reduce Vaccination dropout rate in Kenya.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [91]Haji et al. (2016), Kenya | Randomise control Trail. (3Arm | 1116 Children less than 12 months.<br><br>372 children allocated to each group | Text messages reminders<br><br>Stickers reminders | **Dropout rate** | **Dropout rate**<br>@SMS= 4%<br>@Stickers=16%<br>@control= 17%<br><br>SMS Vs. control (OR 0.2, CI 0.04–0.8).<br><br>Stickers Vs. control: (OR 0.9, CI 0.5–1.6) | Moderate risk of bias |

Another randomized control trail in Pakistan was conducted to find out if SMS services reminders has an effect on routine immunization uptake and timeliness. Infants less than two weeks of age with at least a family member having a valid mobile number. Participants were allocated by randomization to intervention group (standard care + one-way SMS reminders) or to the comparison group which is given only standard care. A comparison of the proportion of immunized children not more than 18 weeks of age was the main outcome of interest. Per the Intention-To-Treat (ITT) analysis, there was a demonstration of consistently insignificant higher immunization coverage in the intervention group than the control on schedule visit at week 6 (76.0% vs 71.3%, P=.36), week 10 (58.7% vs 52.7%, P=.30) and week 14 (31.3% vs 26.0%, P=.31). immunization coverage was only significantly higher in 6 week per protocol analyses (PP) in the intervention arm compared to the control arm (96.0%, 86/90 vs 86.4%, 102/118; P=.03). The study concluded that one-way SMS reminders might enhance routine vaccination coverage.

**Table 20.** Results on SMS reminders on Immunizations uptake in Pakistan.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [18]Kazi et al. (2018), Pakistan | Randomised control trail (RCT) | 300 Infants less than 2 weeks of age. Intervention= 150 Control= 150 | ***Intervention***= (standard care + one-way SMS reminder)<br><br>***Control=*** (standard care) | Vaccination uptake/ coverage | **<u>Vaccination coverage</u>**<br><br>***ITT analyses***<br>*@ 6weeks=* (76.0% vs 71.3%, P=.36)<br>*@10 weeks=* (58.7% vs 52.7%, P=.30)<br>*@14 weeks=* *(*31.3% vs 26.0%, P=.31)<br><br>***PP analyses***<br>Coverage was only significant at 6 weeks. (96.0% vs 86.4%; P=.03). 10 weeks and 14 weeks show an insignificant increase in coverage. | Moderate risk of bias |

Mushamiri et al. (2015), Kenya, an evaluation study was conducted to assess the impact of mobile health system on antenatal and postnatal attendance. CHWs (n = 20) were interviewed to assess the adherence to ANC and PNC following registration of 800 women in to mobile health system Antenatal (APAS). All CHWs communicated that APAS help them track vital events efficiently, as compared to paper-based tracking system. Three groups were derived for comparison in this study: women not registered in the APAS who are from outside the MVP cluster but uses the services provided by the MVP health facilities (Group 0), those who lives in the MVP cluster but not registered in the APAS (Group 1) and Group 2 is those who are both residence in the MVP cluster and are registered in the APAS. 75 women were sample from each 8 health facilities and additional 50 from 1 health facility. The study demonstrated a statistically significant association between group two (2) in comparison to group one (1) and the number of ANC visits. There were three times odd of going for more ANC visits in group2 compared to group 1.

**Table 21.** Results on mHealth system evaluation on adherence ANC and PNC in Kenya.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| Mushamiri et al. (2015), Kenya | Cohort Analytica: Retrospective | 9 health facilities<br>20 (CHWs)<br>75 women with 25 each in group0, group1, and group2<br>Additional 50 women from LHC | SMS reminders in APAS system | Adherence to :<br>Antenatal care (**ANC**)<br>Postnatal care (**PNC**) | *Antenatal visits (ANC)*<br>(2 vs. 0)<br>OR=2.30, 95% CI (0.97-5.48)<br>(2 vs 1)<br>OR=2.9, 95%CI (1.26-6.73)<br><br>*Postnatal visits (PNC)*<br>***(2 vs 0 )***<br>OR = 9.00, 95% CI (4.15-19.51)<br>***(2 vs 1)***<br>OR = 5.14, 95% CI (2.34-11.33) | Medium risk of bias |

*Group0*: outside cluster and outside APAS. *Group1:* inside cluster and outside APAS. *Group2:* in cluster and in APAS.

A rural Indian intervention to increase infant immunization adherence was conducted to find out how digital pendant and voice reminder platform impacts on it. The study design was a three-arm cluster Randomized control trail with 96 village health camps as the unit of randomization. Sticker, pendant and pendant with voice call reminders were allocated to the three arms of the study. In the control arm Near Field Communication (NFC) stickers were placed on existing immunization card. Records on immunization are electronically saved on a pendant and by the child. In the third arm, mothers are given voice call reminders in addition to the pendant(P+V) worn by the child a day before immunization schedule. No tests showed a significant effect of treatment arm on DTP3 vaccination adherence. Both treatment arms (pendant and pendant with voice calls) resulted in an increase in primary outcome, infant immunization timeliness via DTP3.

**Table 22.** Results on mHealth voice reminder on infant immunization adherence – India.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [67]Nagar et al. (2017), India | 3-arm Cluster Randomised control trail (cRCT) | Mother/ infant pair (< 6mnths)<br>***Sticke***r= (n = 24 villages, 62 mothers)<br>***Pendant only***= (n = 24 | Digital pendant worn by child<br><br>Pendant plus voice calls reminders to mother | ***DTP3 adherence:***<br>Within 2months<br><br>Before 180 days | ***DTP3 adherence***<br>@2 months:<br>*Stickers vs. P vs. P+V*<br>74.2% vs. 67.2% vs. 69.3%<br>(P= 0.684, $\chi 2$= 0.684) | Low risk of bias |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | villages, 62 mothers)<br>***P+V***= (n = 24 villages, 62 mothers) | | | @180 days<br>*Stickers vs. P vs. P+V*<br>69.4% vs. 57.4% vs. 58.7%<br>(P=0.315, $\chi 2$= 0.315) | |

Odeny et al conducted an RCT evaluating the effect of SMS appointment reminders among HIV-positive pregnant women. Women in the intervention group (n = 195) received a text message every 2 weeks starting on week 28 of gestation and weekly during the puerperium; women in the control group received standard care (n = 193). Almost 20% of women in the intervention group attended postpartum visits compared with 12% in the control group. Relative risk, RR= 1.66; 95% CI, (1.02-2.70).

**Table 23.** Results on the effects of SMS on maternal post-partum clinic attendance – Kenya.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [99]Odeny et al (2014), Kenya | Randomised controlled trial (RCT), | Pregnant women in week 28 of gestation Interventio n group, n = 195 Control group, n = 193 | Up to 14 SMS sent to HIV-positive pregnant women; SMS sent every 2 wk starting on week 28 of pregnancy | Maternal post-partum attendance (PNC) | 19.6% of intervention women attended a maternal postpartum clinic vs. 11.8% women in control group (RR, 1.66; 95% CI, 1.02-2.70)<br><br>• 92% of intervention group infants received HIV testing compared with 85% of control group (RR, 1.0.8; 95% CI, 1.00-1.16) | moderate |

A study undertaken in Bangladesh utilizes a quasi-experimental pre-post designed on mHealth intervention directed at improving vaccination coverage among 0-11 months old children. This study was conducted in rural hard to reach areas and urban areas. A mHealth intervention composed of a smartphone-based application is connected with a web-based database was used to electronically register children at birth and also send reminder to mothers on vaccination

schedules using SMS. These devices are given to health assistants/vaccinators and supervisors in the intervention area for the aforementioned purposes. Before and after vaccination coverage was survey in both intervention arm and the control arm.

The difference-in-difference (DID) estimates for full vaccination in children over 298 days old were +29.5% for rural intervention versus control areas and +27.1% for urban areas. Among all age groups, intervention effects on age-appropriate vaccination coverage were positive: DIDs +13.1–30.5% and ORs 2.5–4.6 ($p < 0.001$ in all comparisons. Results from the study indicated that mHealth interventions impacts positively on vaccination coverage with respect to rural and urban dwellers.

**Table 24.** Results on smartphone-based SMS intervention on vaccination coverage-Bangladesh.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [68]Uddin et al. (2016), Bangladesh | quasi-experimental pre-post designed | 0-11 months old children | mTika: birth registration and sms reminders | Full Vaccination coverage | **Control: decrease: (*P<0.001*)** Rural baseline 65.9% to endline 55.2%. Urban baseline 44.5% to endline 33.9%<br><br>**Intervention: increase: (*P<0.001*)** Rural baseline 58.9% to endline 76.8%, difference +18.8% (95% CI 5.7–31.9) Urban baseline 40.7% to endline 57.1%, difference +16.5% (95% CI 3.9–29.0) | Low risk of bias |

An Ethiopian Clinical control trail (CCT) determined whether mHealth intervention can improve Antenatal care attendance, usage of postnatal care service and also facilitating access to institutional delivery in comparison to the standard care or approach. Ten health facilities with 5 in the intervention group and another 5 in the control group. A smartphone-based application which sends SMS reminders for subsequent visits of clients to health workers and also educational messages on danger signs of pregnancy. The intervention also made provision for decision support module and a report module. Women in the intervention group were significantly more to deliver in health center, have at least 4 antenatal visits (43.1% versus 28.4%; Adjusted Odds Ratio (AOR): 1.98 (95%CI 1.53–2.55)) and also utilized postnatal care service (41.2% versus 21.1%: AOR: 2.77 (95%CI 2.12–3.61)) compared to those in the control

group. Women who uses the in health facilities in the intervention area are significantly more likely to have delivery in the health center than the control group (43.1% versus 28.4%; AOR; 1.98 (95%CI 1.53–2.55)) [60].

**Table 25.** Results on effects of mHealth on facility delivery and PNC – Ethiopia.

| Study and country | Study design and setting | Study population | Intervention /Exposure | Outcomes | Results | Overall risk of bias |
|---|---|---|---|---|---|---|
| [60]Shiferaw (2016), Ethiopia | Clinical control trail | **Baseline:**933 pregnant women<br>Intervention= 477<br>Control=456<br><br>**Follow up: 1037**<br>Intervention=514<br>Control= 523 | Smartphone with an application to send SMS reminders and educational messages | Antenatal visits<br>Postnatal visits<br>Facility delivery | **<u>Interventions Vs. Control</u>**<br><br>*Antenatal visits:* (43.1% versus 28.4%; (AOR): 1.98 (95%CI 1.53–2.55))<br><br>*Postnatal visits*: (41.2% versus 21.1%: AOR: 2.77 (95%CI 2.12–3.61))<br><br>*Facility delivery:* (43.1% versus 28.4%; AOR; 1.98 (95%CI 1.53–2.55)) | Low risk of bias |

# Chapter Four

## 4.0 Discussion

### 4.1 Summary of evidence

This systematic review provides an overview of mHealth interventions conducted or implemented in Sub-Saharan Africa and Southern Asia targeting outcomes on target 3.1 and 3.2 of the United Nations' SDGs. The study aimed to determine the progress of mHealth towards agenda 2030 of the SDGs in terms of effects of mHealth interventions on maternal and child health reported by other studies. This systematic review identified 19 relevant studies published since 2010, demonstrating a growing keenness in the effects of mHealth interventions on maternal and child health outcomes such as neonatal deaths, antenatal and postnatal care attendance, access to skilled birth delivery and vaccination/immunization coverage. Almost all the studies included in this review exhibited an indication that mHealth interventions have the potential to change behavior of pregnant women, caretakers and health workers thus increasing ANC attendance, PNC attendance, childhood vaccination/immunization rates, and skilled delivery attendance. Overall, the quality of the included studies varied between strong and moderate based on the quality assessment tool for quantitative studies developed by the EPHPP.

Although only two studies reported results on neonatal mortality and none reporting on maternal and under-five year mortality, low usage of maternal health services, such as ANC, SBA at delivery and PNC, were identified in this review as secondary outcomes representing major causes of maternal mortality and neonatal mortality. The two studies presenting results on neonatal mortality found some level of proof that SMS reminders for pregnant women and smartphone-based applications for health workers are effective in lowering neonatal deaths in limited-resource countries. The evidence on neonatal mortality on this study is not enough due to the fact that is it based on only two studies, both conducted in the Eastern part of Sub-Saharan Africa. No study from Southern Asia reported results on primary outcomes. More studies reporting on neonatal mortality rate/ratio in both regions, and especially in Southern Asia, are still needed to support the limited evidence available. This will allow to know if there is divergence in the progress towards agenda 2030 of the United Nations SDGs between the two regions, and therefore put interventions in place to eliminate such divergence and ensure convergent progress to attain SDG 3.1 and 3.2. Generally, out of the 19 studies included in this review, only four were conducted in Southern Asia. Not only there were fewer studies

conducted in Southern Asia than in Sub-Saharan Africa, but also a number of studies from this region was excluded because of higher risk of bias.

Access to skilled birth personnel plays a very important role in reducing deaths among women, newborns during pregnancy, childbirth and the early postnatal period. A very vital indicator for harnessing the SDG 3.1 is the proportion of births or deliveries attended by a skilled birth personnel. The wired mothers mHealth intervention conducted in the Sub-Saharan region to enhance skilled delivery attendance showed a 60% skilled delivery rate in the intervention cluster compared to a 47% in the control cluster [95]. Findings from this study represent an indication of positive progress achieved as opposed to that stated in the MDG tracking report [102], where the proportion of births in the presence of a skilled attendant in Sub-Saharan Africa increased only by 7% between 1990 (41%) and 2008 (48%). Additionally, the wired mothers mHealth intervention supports the ability of mobile phones to induce behavioral change and influence women's choice of delivery attendance, as demonstrated by other studies on mHealth [103, 104].

Improvement in knowledge and skill acquisition of health care workers can be facilitated through mHealth interventions to provide quality care during emergencies in child birth, as demonstrated by the *Safe Delivery Application* interventional study conducted in Ethiopia [94]. In low-income countries, and for that matter limited-resource settings, findings from the Safe Delivery Application study are instrumental in addressing the challenges in the provision of quality care due to absence of continuing education programs. Findings from a study conducted in Ethiopia on the use of a mHealth intervention to improve delivery and postnatal care [60] supported an earlier study conducted in Zanzibar testing the ability of SMS reminders to improve skilled birth delivery at births [95]. Pursuant to the WHO recommendation of four ANC visits in the course of pregnancy, health workers were encouraged through SMS reminders to contact pregnant women to honor their appointments, which ultimately led to a higher ANC attendance. This study established an the connection between ANC, PNC and access to skilled delivery; attendance to four ANC visits was associated with a higher odds of postnatal care attendance and health facility delivery where there is a greater chance of having access to a skilled birth attendant [60].

Similarly, the SUSTAIN-MNCH mHealth intervention study in Tanzania focused on uptake of antenatal care among the factors associated with facility delivery, and indicated a positive impact of mHealth on attaining the WHO recommendation of at least four ANC visits and delivery at a health facility [90]. The *wired mothers* [95] and the *SUSTAIN-MNCH* [90] interventions are indicative that mHealth interventions delivered through smartphones are

useful in disadvantaged settings burdened with poverty and lower rate of delivery in health facilities. Additionally, the *SUSTAIN-MNCH* intervention and the *Safe Delivery Application* show the importance of training of health workers through smartphone applications to enhance uptake of health facility delivery and skills improvement on newborn resuscitation, thus supporting the global effort in attaining the SDG target on neonatal mortality (SDG 3.2). The results from the safe delivery application support the findings from a review showing that neonatal resuscitation improves neonatal and perinatal mortality [105]. Moreover, ensuring that every child delivery is done in the presence of skilled health personnel is a key to reduce the global maternal deaths [106] as captured in the SDG 3.1. According to findings from this study, access to skilled birth delivery and health facility delivery, as part of mHealth interventional strategies in the continuum of care, contributes to reducing the mortality targets expressed by SDG 3.1 and 3.2.

The utilization of smartphone applications by trained health workers can increase knowledge acquisition [94] and enhance communication [60] with pregnant women and caretakers, hence encouraging an increase in access to care in limited-resource settings, especially in Sub-Saharan Africa and Southern Asia where an acceleration of progress is needed to address the burden of maternal mortality and neonatal mortality. Simple mHealth interventions like the *wired mothers* can be used to facilitate appointment reminders through text messages [65, 95, 96]. At the primary health care level, mHealth interventions based on SMS or text support can be relied on to play a pivotal role in increasing accessibility in a decentralized health care system through appointment reminders on immunization schedules [18, 65, 68, 86, 87, 89, 91], antenatal and postnatal schedules [60, 62, 65, 90, 99], and applications to facilitate data collection [60, 62, 67] of pregnant women, caretakers and newborns. The burden of maternal deaths and neonatal deaths targeted by SDG 3 can be alleviated through the use of voice calls and SMS to increase communication and provision of health education, support behavioral change and encourage adherence with regards to having skilled birth delivery, utilization of antenatal care and postnatal care, immunization /vaccination schedules.

The results from the studies included in this systematic review are indicative of how SMS-based interventions can support pregnant women and care takers in promoting maternal, neonatal and child health. Findings from this study provided some understanding on the types of mHealth interventions that can promote maternal and infant health and also some proof that mHealth interventions delivered through SMS and voice calls can effectively work in Sub-Saharan Africa [60-62, 88, 90, 95, 100] and Southern Asia [18, 67, 68, 85].

### 4.2 Limitations

This systematic review has its strengths and weaknesses. To achieve a thorough search strategy, specific terms were added under the 4 components (population/participants, intervention, outcomes, study setting). Access to the Ovid search platform through the university library allowed access to commercial databases and relevant full-text articles which otherwise would have been excluded due to challenges regarding accessibility. The inclusion of these papers in the systematic review is a strength. Even though only papers published in peer-reviewed journals were included to enhance the quality of the review, this might have led to the exclusion of external reports from non-profit organizations, white or grey literature, or papers published in technology journals. Another possible weakness is the inclusion of only papers published in English. It is also worth noting that there was a program overlap among few of the studies included in this review. In particular, three papers reporting on use of SMS reminders were linked to the same program in Zanzibar, Tanzania [65, 95, 96]. The generalizability of the findings from this review is affected by the quality of the included studies as well as the variation of programs and research groups.

### 4.3 Policy implication

This systematic review provides a contribution towards the role of mHealth interventions in attaining the SDG 3.1 and 3.2. Results showed an increasing number of evidence-based interventions aimed to make pregnancy and childbirth safe for both mother and child by alleviating the burden of maternal deaths and neonatal deaths. Findings from this study can serve as a basis to provide and inform health policy recommendations on the implementation of mHealth interventions, especially delivered through SMS messages, to improve maternal health-seeking behavior, and as reminders to caretakers in the health delivery structure in countries in Southern Asia and Sub-Saharan Africa. The experiences in improving maternal and neonatal health in Sub-Saharan Africa and Southern Asia showed in this study will help in achieving the SDG 3.

# Chapter Five

## 5.0 Conclusions and Recommendations

With most maternal, neonatal and child deaths taking place in Sub-Saharan Africa and Southern Asia, a need for action is required to achieve United Nations' SDG 3.1 and 3.2. If interventions supporting maternal, neonatal and child health, such as mHealth interventions, are utilized in the healthcare delivery system, more than half of the global 56 million deaths under-five year can be potentially prevented between 2018 and 2030 in Sub-Saharan Africa and Southern Asia. The potential presented by mHealth interventions directed towards the agenda 2030 on maternal and child health as enshrined in the SDG 3.1 and 3.2 is promising and offers new hope for the future. Progress demonstrated in the two SDG regions included in this systematic review shows that the SDGs on maternal and child survival can be harnessed through focused health system interventions like mHealth in priority areas that most likely will improve access to skilled delivery attendance and increase vaccination coverage/ immunization uptake, postnatal care visits as well as antenatal care attendance, according to the WHO recommendation of at least four ANC visits prior to delivery. This ultimately contributes to a growing evidence that mHealth can support the SDGs and contribute to reduce maternal mortality and neonatal mortality in the post 2015 agenda of the United Nations.

### 5.1 Additional Information

#### 5.1.2 Funding

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# Appendices

This sections gives an overview of the appendices (attached in subsequent pages ) referred to in the conduct of this systematic review for easy identification and reference.

# The post-2015 development agenda: progress towards sustainable development goal target on maternal mortality and child mortality in limited resource settings with mHealth interventions: a systematic review in Sub-Saharan Africa and Southern Asia

*Elvis Bossman, Paolo Zanaboni, Monika Johansen*

## Citation

Elvis Bossman, Paolo Zanaboni, Monika Johansen. The post-2015 development agenda: progress towards sustainable development goal target on maternal mortality and child mortality in limited resource settings with mHealth interventions: a systematic review in Sub-Saharan Africa and Southern Asia. PROSPERO 2019 CRD42019109434 Available from: http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42019109434

## Review question

1. What is the contribution of mHealth interventions at reducing the global maternal mortality to less than 70 per 100000 live births by 2030?

2. How mHealth interventions contribute to end preventable deaths of new-borns 2030?

3.How mHealth interventions contribute to end preventable deaths of children under five by 2030?

## Searches

MEDLINE, EMBASE and Web of Science are the electronic bibliographic databases that will be searched for relevant articles in the area under study bordering on terms that describe or relate to mHealth interventions. Grey literature including World Health Organisation(WHO) and United Nations(UN) reports will be sought for relevant publications. The articles to be considered will be restricted to those published in English. Literature published from 2010 to the date of the formal screening will be considered. Based on the global strategy for women's and children's health, year 2010 was chosen as baseline as we expect that most relevant studies are published after that date. In developing the search terms for this study, PICOS will be used to group the search terms into categories based on the research questions: population , intervention, outcome and study setting. Where appropriate Medical Subject Headings (MeSH) will be used to make uniform search terms. The search strategy will be tested before the formal screening.

## Types of study to be included

Studies on mHealth interventions conducted in Sub-Saharan Africa and Southern Asia within primary , secondary and tertiary care level will be included in this review. Only quantitative studies will be eligible for this review. Quantitative studies will not be restricted to randomized control trails (RCTs).

## Condition or domain being studied

Although the Millennium Development Goals(MDGs) made significant progress in terms of maternal mortality and child mortality , it fell short of the global target after the 2015 deadline. This necessitated the post-2015 agenda through the Sustainable Development Goals(2016-2030). There is a need for an average of 7.5% annual reduction between 2016-2030 which is three times the observed rate in the MDG(1990-2015) era.The focus of this review will be directed on the contribution of mHealth interventions in the effort to harness the Sustainable Development Goal 3. Main emphasis will be on target 3.1 and 3.2 which duel on improving maternal health and neonatal/ child health respectively. With the proliferation of mobile phones in Africa and for that matter Sub-Saharan Africa, mHealth interventions have the potential to make a very significant contribution to close the gap of unmet maternal and child mortality target by 2030 as captured in SDG target 3.1 and 3.2. The review will look at interventions using mHealth technology to improve health behavior and health outcomes in pregnant patients or child health. In Sub Saharan Africa mHealth has emerged as a technological innovative tool aim at improving maternal and child health as well as maternal mortality and child mortality.

## Participants/population

Maternal health encompasses the various stages of women's health ranging from pregnancy to postpartum.

Child health for the purpose of this review will be concentrating on interventions to improve children in the neo-natal stages and children under five years. Interventions targeting young adolescents(11-15 years) and children between 5 and 10 years will be excluded in this study.Taking into account the aim of this review, studies will be included according to the following criteria:

1) studies on pregnant women or women in their post/natal period and/or children under five years including new-borns.
2) studies on interventions implemented in health care facilities or for health care workers with outcomes on maternal and child health.

3) studies conducted in the sustainable development goal region of sub-Saharan Africa and Southern Asia.

## Intervention(s), exposure(s)

This review will be mainly directed on mHealth interventions for maternal health and child health in Sub-Saharan Africa and Southern Asia. For the purpose of this review, mHealth will be defined as the use in medicine and public health of mobile communication devices such as mobile phones, patient monitoring devices, personal digital assistant (PDAs), and other wireless devices, to enhance access to health information, improve distribution of routine and emergency health services, or provide diagnostic services(WHO, 2014). The following eligibility criteria will be used to select interventions for this review : a) studies related to the use of mobile health (mHealth) interventions;- b) studies which assess and examine the impact of mHealth on maternal mortality , neo-natal mortality and under five mortality. Studies reporting other indicators that impact on maternal or child mortality will be also included to evaluate secondary outcomes. Additionally, mHealth interventions will be classified according to the service level (primary , secondary or the tertiary) when appropriate. mHealth interventions in health care facilities and /for health care workers to addressing maternal mortality, neonatal mortality and their related outcomes implemented in sub-Saharan Africa or Southern Asia will be eligible also for this review.

## Comparator(s)/control

This review is not restricted to comparator studies only. Where comparators are present these may comprise usual care control or another implementation process. Also where comparators are present, they should not have different characteristics from the intervention group prior to its introduction.

## Context

Between 1990 and 2017, the global neonatal mortality rate decreased by 51% . Notwithstanding this observed decline in mortality levels, there is a significantly huge difference in neonatal mortality across the SDG regions. Sub-Saharan Africa experienced the highest neonatal mortality rate in 2017 at 27 deaths per 1, 000 live births. Comparatively, a child born in Sub-Saharan Africa is nine times more likely to die in the first month than a child in a high-income country. According to 2017 report, Sub-Saharan Africa (39%) together with Southern Asia (38%) accounted for 80% of the newborn deaths. In the face of the 41 percent decline neonatal mortality seen between 2000 to 2017 in Sub-Saharan Africa, the burden of neo-natal deaths still stagnated. Geographically, two SDG regions with the highest under five mortality in 2017 were Sub-Saharan Africa (accounting for about 50%) and Southern Asia(accounting for 30%). In the year 2017, 4.4million under five deaths would have been saved globally if all countries had under five mortality as low as the region with lowest mortality. Projections show that 56 million children under five will die between 2018 and 2030 based on current trends. Developing regions accounted for approximately 99%(302 000) of the global maternal deaths in 2015, with Sub-Saharan Africa alone accounting for roughly 66%(201 000). To harness the SDG target on maternal mortality ratio will require an accelerated effort to triple annual global reduction rate of maternal mortality rate to an average of 7.5% as against the current 2.5% annual reduction.

## Main outcome(s)

The primary outcomes of this review will be centered on:

1.) Maternal mortality(deaths): 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 (from direct or indirect obstetric death), but not from accidental or incidental causes.

2.) Neonatal mortality(deaths): neonatal deaths (deaths among live births during the first 28 completed days of life) may be subdivided into early neonatal deaths, (occurring during the first 7 days of life) and late neonatal deaths (occurring after the 7th day but before the 28th completed day of life.)

3.) Under-five mortality (deaths): under-five mortality is related to the probability of a child born in a specific year or period dying before reaching the age of 5.

## Additional outcome(s)

In addition to the primary outcomes, the following secondary outcomes will be considered in this review.

1.) Skilled Delivery Attendance: in limited resource settings, accessibility to a skilled attendant at the time of delivery is a vital lifesaving intervention for both mothers and babies. Not having access to this key assistance is detrimental to women's health because it could lead to the demise of the mother .

2) Antenatal and postnatal visits as outcomes: studies show that antenatal and postnatal visits have impact on maternal and child mortality.

3) Vaccination Coverage:in spite of the recent success, more than 3million people die from vaccine-preventable disease each year. About half of these deaths are in children under 5 years.

4) Civil registration and vital statistics: taking effective actions to prevent future deaths requires knowing who died and why they died . This is vital to support measurement efforts and also help track progress towards reaching SDG target 3.1 and 3.2.

## Data extraction (selection and coding)

An Excel table will be used to capture descriptive characteristics of the studies included in the review. These features include: title, main author, year of publication, main goal of the study, study methods, sampling strategy and study participants, main results. Additionally, study setting, details of intervention, study design, outcomes measured and columns for risk assessment component rating will also be extracted from individual studies onto the data extraction form. This will enable the review team to have an overview on the eligible studies included.
Titles and abstracts of the papers retrieved using the search strategy will be screened independently by the review team members to identify studies that potentially meet the inclusion criteria. Full text of these potentially eligible studies will be retrieved and assessed for eligibility by the review team members. Any disagreement over eligibility of particular studies will be resolved through discussion among team members.

## Risk of bias (quality) assessment

A review of quantitative studies will be conducted . A quantitative systematic review encompasses studies that have numerical data. In order to harness a standardized study quality of the studies included in this review, the "*Quality Assessment Tool for Quantitative Studies"* will be utilized. This quality appraisal tool can be used for knowledge synthesis of articles of any public health topic area to support decision making process. This includes design, implementation and assessment of public health programs such as mHealth interventions. The "Quality Assessment Tool for Quantitative Studies" developed by the Effective Public Health Practice Project(EPHPP) has a checklist comprising of eight main thematic areas upon which a methodological rating of strong, moderate or weak will be scored. These sections include selection bias, study design, confounders, blinding, data collection methods, withdrawal and dropouts, intervention integrity and analysis. Two independent reviewers will assess the quality of the articles included in this review. A third reviewer will help resolve discrepancies before an overall quality score will be assigned. A summary of the articles included will be created based on the components of the "Quality Assessment Tool for Quantitative Studies".

## Strategy for data synthesis

A report summarizing the characteristics of the included studies will be presented in form of a table. From the data extracted from the eligible studies for inclusion, synthesis will be organised based on the type of intervention, purpose of intervention, outcomes measured. Findings from the data synthesis will be analysed and structured around the study designs and indicators for measuring the outcomes of the mHealth interventions to answer the research questions. Meta-analysis might be conducted if the outcomes from the

included studies are sufficiently homogenenous.

## Analysis of subgroups or subsets

If feasible, sub-group analyses of the results related to the effects may be undertaken for the different kinds of interventions. Additionally, if possible sub-group analyses will be conducted on the study settings (primarily, secondary and tertiary level), intervention types (e.g SMS, application, phone calls), aim (e.g education and behavior change, utilization of health service, remote monitoring, communication and training of healthcare workers, diagnostic and treatment, remote data collection)

## Contact details for further information

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## Organisational affiliation of the review

UiT, The Arctic University of Norway, Faculty of Health Sciences

## Review team members and their organisational affiliations

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Monika Johansen. Norwegian Centre for E-Health Research, University Hospital of North Norway, and UiT, The Arctic University of Norway, Faculty of Health Sciences

## Anticipated or actual start date

01 December 2018

## Anticipated completion date

15 May 2019

## Funding sources/sponsors

Study initiated and managed by UiT, The Arctic University of Norway as part of a masters degree programme

## Conflicts of interest

None known

## Language

English

## Country

Norway

## Stage of review

Review_Ongoing

## Subject index terms status

Subject indexing assigned by CRD

## Subject index terms

Africa South of the Sahara; Asia; Child; Child Mortality; Conservation of Natural Resources; Goals; Health Resources; Humans; Maternal Mortality; Telemedicine

## Date of registration in PROSPERO

17 January 2019

## Date of publication of this version

17 January 2019

## Details of any existing review of the same topic by the same authors

## Stage of review at time of this submission

The review has not started

| Stage | Started | Completed |
|---|---|---|
| Preliminary searches | No | No |
| Piloting of the study selection process | No | No |
| Formal screening of search results against eligibility criteria | No | No |
| Data extraction | No | No |
| Risk of bias (quality) assessment | No | No |
| Data analysis | No | No |

## Versions

17 January 2019

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| | 22 | exp Child, Preschool/ | 869143 | Advanced | Display Results \| More | |
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All Range Clear 100 Per Page 1 Go Next ›

1. **Randomized controlled trial on effectiveness of mHealth (mobile/smartphone) based Preterm Home Care Program on developmental outcomes of preterms: Study protocol.**

Nayak BS; Lewis LE; Margaret B; Bhat Y R; D'Almeida J; Phagdol T.

*Journal of Advanced Nursing. 75(2):452-460, 2019 Feb.*

*[Journal Article]*

**UI:** 30375032

**Authors Full Name**
Nayak, Baby S; Lewis, Leslie Edward; Margaret, Binu; Bhat Y, Ramesh; D'Almeida, Joslin; Phagdol, Tenzin.

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2. **Effect of an interactive text-messaging service on patient retention during the first year of HIV care in Kenya (WelTel Retain): an open-label, randomised parallel-group study.**

van der Kop ML; Muhula S; Nagide PI; Thabane L; Gelmon L; Awiti PO; Abunah B; Kyomuhangi LB; Budd MA; Marra C; Patel A; Karanja S; Ojakaa DI; Mills EJ; Ekstrom AM; Lester RT.

*The lancet. Public Health. 3(3):e143-e152, 2018 03.*

*[Journal Article. Research Support, N.I.H., Extramural. Research Support, Non-U.S. Gov't]*

**UI:** 29361433

**Authors Full Name**
van der Kop, Mia Liisa; Muhula, Samuel; Nagide, Patrick I; Thabane, Lehana; Gelmon, Lawrence; Awiti,

Abstract Reference
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|---|---|---|---|---|---|---|
| ☐ | 41 | neonatal mortality.mp. | 7617 | Advanced | Display Results \| More | |
| ☐ | 42 | (neonatal mortalit* or neonatal death* or infant death* or perinatal death* child* death*).ti,ab,kw. | 22935 | Advanced | Display Results \| More | |
| ☐ | 43 | (under five mortalit* or under five death* or U5MR).ti,ab,kw. | 849 | Advanced | Display Results \| More | |
| ☐ | 44 | 37 or 38 or 39 or 40 or 41 or 42 or 43 | 93996 | Advanced | Display Results \| More | |
| ☐ | 45 | maternal mortality.mp. or exp Maternal Mortality/ | 21085 | Advanced | Display Results \| More | |
| ☐ | 46 | maternal deaths.mp. or exp Maternal Death/ | 5673 | Advanced | Display Results \| More | |
| ☐ | 47 | 45 or 46 | 22847 | Advanced | Display Results \| More | |
| ☐ | 48 | (mortalit* or Death*).ti,ab,kw. | 1691839 | Advanced | Display Results \| More | |
| ☐ | 49 | 44 or 47 or 48 | 1728739 | Advanced | Display Results \| More | |
| ☐ | 50 | exp Pregnancy Outcome/ or exp Prenatal Care/ or antenatal visits.mp. or exp Pregnancy Complications/ | 242682 | Advanced | Display Results \| More | |
| ☐ | 51 | antenatal attend*.ti,ab,kw. | 204 | Advanced | Display Results \| More | |
| ☐ | 52 | exp Postnatal Care/ or postnatal visit*.mp. | 95482 | Advanced | Display Results \| More | |
| ☐ | 53 | exp Vaccination/ or vaccinat*.mp. or exp Immunization Programs/ | 212210 | Advanced | Display Results \| More | |
| ☐ | 54 | (immuniz* or Civil registration or vital statistics).ti,ab,kw. | 122413 | Advanced | Display Results \| More | |
| ☐ | 55 | ((skilled birth attend* or skill*) adj3 birth attend*).ti,ab,kw. | 955 | Advanced | Display Results \| More | |
| ☐ | 56 | 50 or 51 or 52 or 53 or 54 or 55 | 611846 | Advanced | Display Results \| More | |
| ☐ | 57 | 49 or 56 | 2255436 | Advanced | Display Results \| More | |
| ☐ | 58 | 8 and 30 | 32040 | Advanced | Display Results \| More | |
| ☐ | 59 | 57 and 58 | 3341 | Advanced | Display Results \| More | |
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1. **Characterizing exposure to household air pollution within the Prospective Urban Rural Epidemiology (PURE) study.**

Arku R.E., Birch A., Shupler M., Yusuf S., Hystad P., Brauer M.

*Environment International. 114 (pp 307-317), 2018. Date of Publication: May 2018.*

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2. **A prospective observational pilot study to test the feasibility of a smartphone enabled uChek© urinalysis device to detect biomarkers in urine indicative of preeclampsia/eclampsia.**

Wirth M., Biswas N., Ahmad S., Nayak H.S., Pugh A., Gupta T., Mahmood I.

*Health and Technology. 9 (1) (pp 31-36), 2019. Date of Publication: 24 Jan 2019.*

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| | 8 | 1 or 2 or 3 or 4 or 5 or 6 or 7 | 104772 | Advanced | Display Results \| More | |
| | 9 | exp Pregnant Women/ | 73058 | Advanced | Display Results \| More | |
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| | 13 | (pregnant women or gestation).ti,ab,kw. | 391907 | Advanced | Display Results \| More | |
| | 14 | (matern* or mother).ti,ab,kw. | 682715 | Advanced | Display Results \| More | |
| | 15 | women.mp. or exp WOMEN/ | 8641872 | Advanced | Display Results \| More | |
| | 16 | 9 or 10 or 11 or 12 or 13 or 14 or 15 | 9607891 | Advanced | Display Results \| More | |
| | 17 | exp INFANT/ | 1835361 | Advanced | Display Results \| More | |
| | 18 | exp INFANT, NEWBORN/ | 967975 | Advanced | Display Results \| More | |
| | 19 | exp INFANT HEALTH/ | 23961 | Advanced | Display Results \| More | |
| | 20 | exp PERINATAL CARE/ | 60904 | Advanced | Display Results \| More | |
| | 21 | exp Delivery, Obstetric/ | 194470 | Advanced | Display Results \| More | |
| | 22 | exp Child, Preschool/ | 1271900 | Advanced | Display Results \| More | |
| | 23 | (newborn* or infant*).ti,ab,kw. | 950025 | Advanced | Display Results \| More | |
| | 24 | (neonat* or perinat*).ti,ab,kw. | 627324 | Advanced | Display Results \| More | |
| | 25 | (child* adj3 under five year*).mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, ui, sy] | 3286 | Advanced | Display Results \| More | |
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| | 27 | Health Facilities/ or health facilit*.mp. | 105447 | Advanced | Display Results \| More | |
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| | 29 | 27 or 28 | 2085530 | Advanced | Display Results \| More | |
| | 30 | 16 or 26 or 29 | 13028434 | Advanced | Display Results \| More | |
| | 31 | sub-saharan africa.mp. or exp "Africa South of the Sahara"/ | 404957 | Advanced | Display Results \| More | |
| | 32 | exp bangladesh/ or exp bhutan/ or exp india/ or exp afghanistan/ or exp iran/ or exp nepal/ or exp pakistan/ or exp sri lanka/ | 369401 | Advanced | Display Results \| More | |
| | 33 | maldives.mp. | 629 | Advanced | Display Results \| More | |
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| | 36 | 31 or 32 or 33 or 34 or 35 | 1149707 | Advanced | Display Results \| More | |
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| | 38 | exp CHILD MORTALITY/ | 13464 | Advanced | Display Results \| More | |
| | 39 | exp FETAL MORTALITY/ or exp PERINATAL MORTALITY/ | 24980 | Advanced | Display Results \| More | |
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|---|---|---|---|---|---|
| 41 | neonatal mortality.mp. | 14386 | Advanced | Display Results \| More | |
| 42 | (neonatal mortalit* or neonatal death* or infant death* or perinatal death* child* death*).ti,ab,kw. | 43130 | Advanced | Display Results \| More | |
| 43 | (under five mortalit* or under five death* or U5MR).ti,ab,kw. | 1575 | Advanced | Display Results \| More | |
| 44 | 37 or 38 or 39 or 40 or 41 or 42 or 43 | 164345 | Advanced | Display Results \| More | |
| 45 | maternal mortality.mp. or exp Maternal Mortality/ | 35623 | Advanced | Display Results \| More | |
| 46 | maternal deaths.mp. or exp Maternal Death/ | 10004 | Advanced | Display Results \| More | |
| 47 | 45 or 46 | 38978 | Advanced | Display Results \| More | |
| 48 | (mortalit* or Death*).ti,ab,kw. | 2942452 | Advanced | Display Results \| More | |
| 49 | 44 or 47 or 48 | 3007838 | Advanced | Display Results \| More | |
| 50 | exp Pregnancy Outcome/ or exp Prenatal Care/ or antenatal visits.mp. or exp Pregnancy Complications/ | 677275 | Advanced | Display Results \| More | |
| 51 | antenatal attend*.ti,ab,kw. | 377 | Advanced | Display Results \| More | |
| 52 | exp Postnatal Care/ or postnatal visit*.mp. | 100748 | Advanced | Display Results \| More | |
| 53 | exp Vaccination/ or vaccinat*.mp. or exp Immunization Programs/ | 383195 | Advanced | Display Results \| More | |
| 54 | (immuniz* or Civil registration or vital statistics).ti,ab,kw. | 255681 | Advanced | Display Results \| More | |
| 55 | ((skilled birth attend* or skill*) adj3 birth attend*).ti,ab,kw. | 1693 | Advanced | Display Results \| More | |
| 56 | 50 or 51 or 52 or 53 or 54 or 55 | 1307005 | Advanced | Display Results \| More | |
| 57 | 49 or 56 | 4139634 | Advanced | Display Results \| More | |
| 58 | 8 and 30 | 38849 | Advanced | Display Results \| More | |
| 59 | 57 and 58 | 4171 | Advanced | Display Results \| More | |
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1. **Characterizing exposure to household air pollution within the Prospective Urban Rural Epidemiology (PURE) study.**

Arku R.E., Birch A., Shupler M., Yusuf S., Hystad P., Brauer M.

*Embase*
*Environment International. 114 (pp 307-317), 2018. Date of Publication: May 2018.*

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Wirth M., Biswas N., Ahmad S., Nayak H.S., Pugh A., Gupta T., Mahmood I.

*Embase*
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| | 13 | (pregnant women or gestation).ti,ab,kw. | 391907 | Advanced | Display Results \| More | |
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| | 25 | (child* adj3 under five year*).mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, px, rx, ui, sy] | 3286 | Advanced | Display Results \| More | |
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| | 27 | Health Facilities/ or health facilit*.mp. | 105447 | Advanced | Display Results \| More | |
| | 28 | Health Knowledge, Attitudes, Practice/ or exp Child Health Services/ or exp Health Personnel/ or exp Community Health Workers/ or health worker*.mp. | 2009792 | Advanced | Display Results \| More | |
| | 29 | 27 or 28 | 2085530 | Advanced | Display Results \| More | |
| | 30 | 16 or 26 or 29 | 13028434 | Advanced | Display Results \| More | |
| | 31 | sub-saharan africa.mp. or exp "Africa South of the Sahara"/ | 404957 | Advanced | Display Results \| More | |
| | 32 | exp bangladesh/ or exp bhutan/ or exp india/ or exp afghanistan/ or exp iran/ or exp nepal/ or exp pakistan/ or exp sri lanka/ | 369401 | Advanced | Display Results \| More | |
| | 33 | maldives.mp. | 629 | Advanced | Display Results \| More | |
| | 34 | (afghanistan or Bangladesh or Bhutan or India or Iran or Maldives or Nepal or Pakistan or Sri lanka).ti,ab,kw. | 361258 | Advanced | Display Results \| More | |
| | 35 | (Subsaharan africa or Angola or Benin or Botswana or Burkina Faso or Burundi or cameroon or Cape verde or Central Africa Republic or Chad or Comoros or Congo or Ivory coast or Djibouti or Equitorial Guinea or Guinea or Ethiopia or Gabon or Gambia or Ghana or Guinea Bissau or Kenya or Lesotho or Liberia or Madagascar or Malaswi or Mali or Mauritania or Mauritius or Mozambique or Namibia or Niger or Nigeria or Rwanda or Sao Tome or Senegal or Seychelles or Sierra leon or Somali or South Africa or Sudan or Swaziland or Tanzania or Togo or Uganda or Zaire or Zambia or Zimbabwe or zanzibar).ti,ab,kw. | 544424 | Advanced | Display Results \| More | |
| | 36 | 31 or 32 or 33 or 34 or 35 | 1149707 | Advanced | Display Results \| More | |
| | 37 | exp INFANT MORTALITY/ | 44126 | Advanced | Display Results \| More | |
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| | 39 | exp FETAL MORTALITY/ or exp PERINATAL MORTALITY/ | 24980 | Advanced | Display Results \| More | |
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|---|---|---|---|---|---|
| 41 | neonatal mortality.mp. | 14386 | Advanced | Display Results \| More | |
| 42 | (neonatal mortalit* or neonatal death* or infant death* or perinatal death* child* death*).ti,ab,kw. | 43130 | Advanced | Display Results \| More | |
| 43 | (under five mortalit* or under five death* or U5MR).ti,ab,kw. | 1575 | Advanced | Display Results \| More | |
| 44 | 37 or 38 or 39 or 40 or 41 or 42 or 43 | 164345 | Advanced | Display Results \| More | |
| 45 | maternal mortality.mp. or exp Maternal Mortality/ | 35623 | Advanced | Display Results \| More | |
| 46 | maternal deaths.mp. or exp Maternal Death/ | 10004 | Advanced | Display Results \| More | |
| 47 | 45 or 46 | 38978 | Advanced | Display Results \| More | |
| 48 | (mortalit* or Death*).ti,ab,kw. | 2942452 | Advanced | Display Results \| More | |
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| 51 | antenatal attend*.ti,ab,kw. | 377 | Advanced | Display Results \| More | |
| 52 | exp Postnatal Care/ or postnatal visit*.mp. | 100748 | Advanced | Display Results \| More | |
| 53 | exp Vaccination/ or vaccinat*.mp. or exp Immunization Programs/ | 383195 | Advanced | Display Results \| More | |
| 54 | (immuniz* or Civil registration or vital statistics).ti,ab,kw. | 255681 | Advanced | Display Results \| More | |
| 55 | ((skilled birth attend* or skill*) adj3 birth attend*).ti,ab,kw. | 1693 | Advanced | Display Results \| More | |
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| # 10 | 353 | #8 AND #7<br>**Refined by: PUBLICATION YEARS:** ( 2018 OR 2017 OR 2016 OR 2015 OR 2014 OR 2013 OR 2012 OR 2011 OR 2010 )<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=Auto* | ☐ | ☐ |
| # 9 | 358 | #8 AND #7<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |
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| # 6 | 1,364,190 | TS=mortality OR TS=deaths OR TS=" Antenatal visits" OR TS= "Antenatal attendance" OR TS= "postnatal care" OR TS="postnatal visits" OR TS= vaccination OR TS= Immunization OR TS=civil registration OR TS="vital statistics" OR TS= "Skilled delivery attendance" OR TS= "Maternal health" OR TS = "child health" OR TS= " Maternal mortality" OR TS= "Maternal deaths" OR TS= "Neonatal mortality" OR TS= "Infant mortality" OR TS= "under five mortality"<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |
| # 5 | 2,335,152 | #4 OR #3 OR #2<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |
| # 4 | 203,029 | TS= Health facilit* OR TS= "health workers" OR TS="Health personnel"<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |
| # 3 | 1,330,041 | TS= infants OR TS= newborns OR TS= neonates OR TS= "under five years" OR TS=children<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |
| # 2 | 1,051,252 | TS= pregnan* OR TS="pregnant women" OR TS="pregnant mother" OR TS=matern* OR TS="gestational | ☐ | ☐ |

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*Search language=English*

| | | | | |
|---|---|---|---|---|
| # 1 | 56,303 | TS= "mobile health" OR TS= mHealth OR TS= SMS OR TS= " text message" OR TS= "mobile phone" OR TS= smartphone<br>*Databases= WOS, BCI, KJD, MEDLINE, RSCI, SCIELO, ZOOREC Timespan=2010-2019*<br>*Search language=English* | ☐ | ☐ |

AND OR Combine Select All ✖ Delete

# QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES


## COMPONENT RATINGS

### A) SELECTION BIAS

**(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?**

1 Very likely
2 Somewhat likely
3 Not likely
4 Can't tell

**(Q2) What percentage of selected individuals agreed to participate?**

1 80 - 100% agreement
2 60 – 79% agreement
3 less than 60% agreement
4 Not applicable
5 Can't tell

| RATE THIS SECTION | STRONG | MODERATE | WEAK |
|---|---|---|---|
| See dictionary | 1 | 2 | 3 |

### B) STUDY DESIGN

**Indicate the study design**

1 Randomized controlled trial
2 Controlled clinical trial
3 Cohort analytic (two group pre + post)
4 Case-control
5 Cohort (one group pre + post (before and after))
6 Interrupted time series
7 Other specify _____
8 Can't tell

**Was the study described as randomized? If NO, go to Component C.**

No Yes

**If Yes, was the method of randomization described? (See dictionary)**

No Yes

**If Yes, was the method appropriate? (See dictionary)**

No Yes

| RATE THIS SECTION | STRONG | MODERATE | WEAK |
|---|---|---|---|
| **See dictionary** | 1 | 2 | 3 |

## C) CONFOUNDERS

**(Q1) Were there important differences between groups prior to the intervention?**

1 Yes
2 No
3 Can't tell

**The following are examples of confounders:**

1 Race
2 Sex
3 Marital status/family
4 Age
5 SES (income or class)
6 Education
7 Health status
8 Pre-intervention score on outcome measure

**(Q2) If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?**

1 80 – 100% (most)
2 60 – 79% (some)
3 Less than 60% (few or none)
4 Can't Tell

| RATE THIS SECTION | STRONG | MODERATE | WEAK |
|---|---|---|---|
| **See dictionary** | 1 | 2 | 3 |

## D) BLINDING

**(Q1) Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?**

1 Yes
2 No
3 Can't tell

**(Q2) Were the study participants aware of the research question?**

1 Yes
2 No
3 Can't tell

| RATE THIS SECTION | STRONG | MODERATE | WEAK |
|---|---|---|---|
| **See dictionary** | 1 | 2 | 3 |

## E) DATA COLLECTION METHODS

**(Q1) Were data collection tools shown to be valid?**

1 Yes
2 No
3 Can't tell

**(Q2) Were data collection tools shown to be reliable?**

1 Yes
2 No
3 Can't tell

| RATE THIS SECTION | STRONG | MODERATE | WEAK |
|---|---|---|---|
| **See dictionary** | 1 | 2 | 3 |

## F) WITHDRAWALS AND DROP-OUTS

**(Q1) Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?**

1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

**(Q2) Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).**

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

| RATE THIS SECTION | STRONG | MODERATE | WEAK | |
|---|---|---|---|---|
| See dictionary | 1 | 2 | 3 | Not Applicable |

## G) INTERVENTION INTEGRITY

**(Q1) What percentage of participants received the allocated intervention or exposure of interest?**

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

**(Q2) Was the consistency of the intervention measured?**

1 Yes
2 No
3 Can't tell

**(Q3) Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?**

4 Yes
5 No
6 Can't tell

## H) ANALYSES

**(Q1) Indicate the unit of allocation (circle one)**

community organization/institution practice/office individual

**(Q2) Indicate the unit of analysis (circle one)**

community organization/institution practice/office individual

**(Q3) Are the statistical methods appropriate for the study design?**

1 Yes
2 No
3 Can't tell

**(Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?**

1 Yes
2 No
3 Can't tell

**GLOBAL RATING**

**COMPONENT RATINGS**
Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

| | | | | | |
|---|---|---|---|---|---|
| **A** | **SELECTION BIAS** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | |
| **B** | **STUDY DESIGN** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | |
| **C** | **CONFOUNDERS** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | |
| **D** | **BLINDING** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | |
| **E** | **DATA COLLECTION METHOD** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | |
| **F** | **WITHDRAWALS AND DROPOUTS** | **STRONG** | **MODERATE** | **WEAK** | |
| | | 1 | 2 | 3 | Not Applicable |

**GLOBAL RATING FOR THIS PAPER (circle one):**

| | | |
|---|---|---|
| 1 | STRONG | (no WEAK ratings) |
| 2 | MODERATE | (one WEAK rating) |
| 3 | WEAK | (two or more WEAK ratings) |

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-F) ratings?

No Yes

If yes, indicate the reason for the discrepancy

| | |
|---|---|
| 1 | Oversight |
| 2 | Differences in interpretation of criteria |
| 3 | Differences in interpretation of study |

**Final decision of both reviewers (circle one):**

| | |
|---|---|
| **1** | **STRONG** |
| **2** | **MODERATE** |
| **3** | **WEAK** |

# Quality Assessment Tool for Quantitative Studies Dictionary


The purpose of this dictionary is to describe items in the tool thereby assisting raters to score study quality. Due to under-reporting or lack of clarity in the primary study, raters will need to make judgements about the extent that bias may be present. When making judgements about each component, raters should form their opinion based upon information contained in the study rather than making inferences about what the authors intended. Mixed methods studies can be quality assessed using this tool with the quantitative component of the study.

## A) SELECTION BIAS

(Q1) Participants are more likely to be representative of the target population if they are randomly selected from a comprehensive list of individuals in the target population (score very likely). They may not be representative if they are referred from a source (e.g. clinic) in a systematic manner (score somewhat likely) or self-referred (score not likely).

(Q2) Refers to the % of subjects in the control and intervention groups that agreed to participate in the study before they were assigned to intervention or control groups.

## B) STUDY DESIGN

In this section, raters assess the likelihood of bias due to the allocation process in an experimental study. For observational studies, raters assess the extent that assessments of exposure and outcome are likely to be independent. Generally, the type of design is a good indicator of the extent of bias. In stronger designs, an equivalent control group is present and the allocation process is such that the investigators are unable to predict the sequence.

### Randomized Controlled Trial (RCT)

An experimental design where investigators randomly allocate eligible people to an intervention or control group. A rater should describe a study as an RCT if the randomization sequence allows each study participant to have the same chance of receiving each intervention and the investigators could not predict which intervention was next. If the investigators do not describe the allocation process and only use the words 'random' or 'randomly', the study is described as a controlled clinical trial.

See below for more details.

*Was the study described as randomized?*

Score YES, if the authors used words such as random allocation, randomly assigned, and random assignment.

Score NO, if no mention of randomization is made.

*Was the method of randomization described?*

Score YES, if the authors describe any method used to generate a random allocation sequence.

Score NO, if the authors do not describe the allocation method or describe methods of allocation such as alternation, case record numbers, dates of birth, day of the week, and any allocation procedure that is entirely transparent before assignment, such as an open list of random numbers of assignments.
If NO is scored, then the study is a controlled clinical trial.

*Was the method appropriate?*

Score YES, if the randomization sequence allowed each study participant to have the same chance of receiving each intervention and the investigators could not predict which intervention was next. Examples of appropriate approaches include assignment of subjects by a central office unaware of subject characteristics, or sequentially numbered, sealed, opaque envelopes.

Score NO, if the randomization sequence is open to the individuals responsible for recruiting and allocating participants or providing the intervention, since those individuals can influence the allocation process, either knowingly or unknowingly.

If NO is scored, then the study is a controlled clinical trial.

Controlled Clinical Trial (CCT)
An experimental study design where the method of allocating study subjects to intervention or control groups is open to individuals responsible for recruiting subjects or providing the intervention. The method of allocation is transparent before assignment, e.g. an open list of random numbers or allocation by date of birth, etc.

Cohort analytic (two group pre and post)
An observational study design where groups are assembled according to whether or not exposure to the intervention has occurred. Exposure to the intervention is not under the control of the investigators. Study groups might be non-equivalent or not comparable on some feature that affects outcome.

Case control study
A retrospective study design where the investigators gather 'cases' of people who already have the outcome of interest and 'controls' who do not. Both groups are then questioned or their records examined about whether they received the intervention exposure of interest.

Cohort (one group pre + post (before and after)
The same group is pretested, given an intervention, and tested immediately after the intervention. The intervention group, by means of the pretest, act as their own control group.

Interrupted time series
A study that uses observations at multiple time points before and after an intervention (the 'interruption'). The design attempts to detect whether the intervention has had an effect significantly greater than any underlying trend over time. Exclusion: Studies that do not have a clearly defined point in time when the intervention occurred and at least three data points before and three after the intervention

Other:
One time surveys or interviews

C) CONFOUNDERS

By definition, a confounder is a variable that is associated with the intervention or exposure and causally related to the outcome of interest. Even in a robust study design, groups may not be balanced with respect to important variables prior to the intervention. The authors should indicate if confounders were controlled in the design (by stratification or matching) or in the analysis. If the allocation to intervention and control groups is randomized, the authors must report that the groups were balanced at baseline with respect to confounders (either in the text or a table).

D) BLINDING

(Q1) Assessors should be described as blinded to which participants were in the control and intervention groups. The purpose of blinding the outcome assessors (who might also be the care providers) is to protect against detection bias.

(Q2) Study participants should not be aware of (i.e. blinded to) the research question. The purpose of blinding the participants is to protect against reporting bias.

## E) DATA COLLECTION METHODS

Tools for primary outcome measures must be described as reliable and valid. If 'face' validity or 'content' validity has been demonstrated, this is acceptable. Some sources from which data may be collected are described below:

Self reported data includes data that is collected from participants in the study (e.g. completing a questionnaire, survey, answering questions during an interview, etc.).

Assessment/Screening includes objective data that is retrieved by the researchers. (e.g. observations by investigators).

Medical Records/Vital Statistics refers to the types of formal records used for the extraction of the data.

Reliability and validity can be reported in the study or in a separate study. For example, some standard assessment tools have known reliability and validity.

## F) WITHDRAWALS AND DROP-OUTS

Score YES if the authors describe BOTH the numbers and reasons for withdrawals and drop-outs.

Score NO if either the numbers or reasons for withdrawals and drop-outs are not reported.

Score NOT APPLICABLE if the study was a one-time interview or survey where there was not follow-up data reported.

The percentage of participants completing the study refers to the % of subjects remaining in the study at the final data collection period in all groups (i.e. control and intervention groups).

## G) INTERVENTION INTEGRITY

The number of participants receiving the intended intervention should be noted (consider both frequency and intensity). For example, the authors may have reported that at least 80 percent of the participants received the complete intervention. The authors should describe a method of measuring if the intervention was provided to all participants the same way. As well, the authors should indicate if subjects received an unintended intervention that may have influenced the outcomes. For example, co-intervention occurs when the study group receives an additional intervention (other than that intended). In this case, it is possible that the effect of the intervention may be over-estimated. Contamination refers to situations where the control group accidentally receives the study intervention. This could result in an under-estimation of the impact of the intervention.

## H) ANALYSIS APPROPRIATE TO QUESTION

Was the quantitative analysis appropriate to the research question being asked?

An intention-to-treat analysis is one in which all the participants in a trial are analyzed according to the intervention to which they were allocated, whether they received it or not. Intention-to-treat analyses are favoured in assessments of effectiveness as they mirror the noncompliance and treatment changes that are likely to occur when the intervention is used in practice, and because of the risk of attrition bias when participants are excluded from the analysis.

Component Ratings of Study:

For each of the six components A – F, use the following descriptions as a roadmap.

A) SELECTION BIAS

Good: The selected individuals are very likely to be representative of the target population (Q1 is 1) and there is greater than 80% participation (Q2 is 1).

Fair: The selected individuals are at least somewhat likely to be representative of the target population (Q1 is 1 or 2); and there is 60 - 79% participation (Q2 is 2). 'Moderate' may also be assigned if Q1 is 1 or 2 and Q2 is 5 (can't tell).

Poor: The selected individuals are not likely to be representative of the target population (Q1 is 3); or there is less than 60% participation (Q2 is 3) or selection is not described (Q1 is 4); and the level of participation is not described (Q2 is 5).

B) DESIGN

Good: will be assigned to those articles that described RCTs and CCTs.

Fair: will be assigned to those that described a cohort analytic study, a case control study, a cohort design, or an interrupted time series.

Weak: will be assigned to those that used any other method or did not state the method used.

C) CONFOUNDERS

Good: will be assigned to those articles that controlled for at least 80% of relevant confounders (Q1 is 2); or (Q2 is 1).

Fair: will be given to those studies that controlled for 60 – 79% of relevant confounders (Q1 is 1) and (Q2 is 2).

Poor: will be assigned when less than 60% of relevant confounders were controlled (Q1 is 1) and (Q2 is 3) or control of confounders was not described (Q1 is 3) and (Q2 is 4).

D) BLINDING

Good: The outcome assessor is not aware of the intervention status of participants (Q1 is 2); and the study participants are not aware of the research question (Q2 is 2).

Fair: The outcome assessor is not aware of the intervention status of participants (Q1 is 2); or the study participants are not aware of the research question (Q2 is 2).

Poor: The outcome assessor is aware of the intervention status of participants (Q1 is 1); and the study participants are aware of the research question (Q2 is 1); or blinding is not described (Q1 is 3 and Q2 is 3).

E) DATA COLLECTION METHODS

Good: The data collection tools have been shown to be valid (Q1 is 1); and the data collection tools have been shown to be reliable (Q2 is 1).

Fair: The data collection tools have been shown to be valid (Q1 is 1); and the data collection tools have not been shown to be reliable (Q2 is 2) or reliability is not described (Q2 is 3).

Poor: The data collection tools have not been shown to be valid (Q1 is 2) or both reliability and validity are not described (Q1 is 3 and Q2 is 3).

F) WITHDRAWALS AND DROP-OUTS - a rating of:

Good: will be assigned when the follow-up rate is 80% or greater (Q1 is 1 and Q2 is 1).

Fair: will be assigned when the follow-up rate is 60 – 79% (Q2 is 2) OR Q1 is 4 or Q2 is 5.

Poor: will be assigned when a follow-up rate is less than 60% (Q2 is 3) or if the withdrawals and drop-outs were not described (Q1 is No or Q2 is 4).

Not Applicable: if Q1 is 4 or Q2 is 5.