

Mobile health (mHealth) intervention in maternal and child health care: Evidence from resource-constrained settings: A review

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Abstract

Introduction: Introducing innovative approaches such as mHealth to an efficient delivery of health services is considered appropriate strategy to alter the current deplorable high maternal and child mortality figures in low-income countries. Recently implemented mHealth projects are either pilot or applied at a limited scale and thus the existing body of research based knowledge is limited. Review and summarizing the existing scientific evidence of mHealth interventions and its health impacts related to MNCH in low-income countries is thus vital and timely for policy makers, researchers and health practitioners.

Objective: To review and appraise the existing evidences of the impact of mHealth enabled interventions on maternal, newborn and child health in low-income countries.

Methods: A comprehensive electronic literature search for relevant published articles was conducted on PubMed database using different search terms. PLoS (Public Library of Science), Google Scholar and Web of Science Database were also checked for available articles in the area. Inclusion and exclusion criteria's were developed and appropriate articles were selected for detail analysis and review.

Results: Out of the 998 articles accessed, 12 were finally reviewed for the intended purpose. Among the 12 relevant articles that were reviewed, ten (83%) studies were based on projects implemented in Africa. About 75 % (9/12) of the interventions focused on issues related to improving maternal health (ANC/ PNC), and child immunization coverage. Most of the studies showed positive relation of mHealth intervention with improvement of ANC/PNC, health service utilization, skilled delivery attendance, reduction in prenatal mortality and improved childhood immunization coverage. Ordinary mobile phones were used in nine out of the twelve studies. The majority (66.6%) of the interventions applied SMS based information sharing using mobile phone.

Conclusion: The review demonstrated the presence of limited published studies on impact of mHealth on maternal and child health in resource limited settings. However, the findings verified that mHealth tools present an opportunity to influence maternal and child health service utilization by improving ANC/PNC attendance and delivery in health institutions. More research is needed to document use of technology for improved health service utilization. [*Ethiop. J. Health Dev.* 2015;29(3):140-153]

Key words: mHealth, maternal and child health, resource-constrained settings, Ethiopia

Introduction

Maternal and child mortality is considerably high among low-income countries. According to United Nation Children's Fund (UNICEF) report of 2014, for every 100, 000 live births around 240 women die in low-income countries, compared with only 16 women dying for every 100,000 live births (1, 2). In Africa alone, on average, 162,000 mothers die each year during pregnancy and childbirth. Moreover, Sub-Saharan Africa (SSA) is found harbor the highest maternal mortality rate in the globe (510 per 100,000 live births) (3, 4).

Currently, the health care environment is fast changing to meet new challenges and benefit from new opportunities. This can at least be seen from the use of mobile phone for health communications. The work of mHealth Alliance (5) and the Mobile Alliance for Maternal Action

(MAMA) (6) witnesses the role mobile phone plays to improve maternal and child health service utilization.

Mobile health (mHealth) is technology based health intervention and is a sub-segment of eHealth (Electronic Health) (7, 8, 9) mHealth refers to the use of mobile communication technologies designed to promote health by supporting healthcare practices through health data collection, delivery of health care information and/or patient observation and provision of care (10).

Mobile phone technologies can be applied across the continuum of care for maternal, newborn and child health (MNCH) (10). It can increase the coverage of tailored health messages and also convey an opportunity to develop health literacy, by enhancing peoples' knowledge and skills (11, 12, 13).

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Various Sub-Saharan African countries have introduced mHealth for maternal and child health interventions for data exchange, supply chain, consultation and decision support. The use of technology shows immense contribution such as: individual based data collection on services and activities, feeding accurate and timely reports on MNCH services; tracking medicine supply at community level to provide consumption data and prevent stock outs; provision of tools for community case management and referrals for MNCH care; creating electronic referral loop; sending reminders to reinforce critical services; and communicating with supervisors and focal persons and for education and training purposes. These show the huge potential of mHealth interventions and programs for having positive effects on health outcomes in low-income countries (12, 13).

Results from pilot and small scale mHealth intervention projects attest improvements in antenatal care attendance through SMS appointment reminders and use of health service for delivery. Yet, evidence are still meager as concern the impacts of such intervention on maternal and child health, mortality and morbidity (12, 13, 14).

The objective of this paper is therefore to review existing evidences of role of mHealth enabled interventions on maternal, newborn and child health in low income countries. The assessment has further summarized findings from mobile phone based interventions and provides directions for policy makers, researchers and practitioners.

Methods

Search Strategy: A comprehensive electronic literature search for relevant published articles on mHealth

intervention on maternal and child health care delivery using the PubMed database was conducted in March 2015 by two of the authors of this paper. Google Scholar, PLoS (Public Library of Science) and Web of Science Database – Thomson Reuters were also checked for available articles in the area.

The following Keywords were used in searching (MeSH and free text terms): mHealth and ICT OR Cell Phones*; cellular phone and mobile phone*; mobile health and Health Communication/methods*; OR wireless technology and Text messaging; SMS and Interactive Voice Response; Smart phone and maternal health OR child health OR maternal and child health OR maternal OR women*; OR child, infant and neonatal*; OR MNCH and Nutrition OR PMTCT; mobile phone and pregnancy OR Delivery OR Obstetric/standards*; antenatal care and Immunization OR Postnatal care and mHealth; developing country OR resource-limited OR low-income country OR resource poor OR Sub-Saharan Africa and mHealth or maternal health.

Identified articles were first screened on the basis of their titles, then abstract and finally full texts based on the developed inclusion and exclusion criteria.

The inclusion criterion comprises among others, all published data of mHealth intervention on maternal and child health care in countries listed by UN as low income countries. But technical reports, special reports, brief communications and presentation of hypothetical scenarios etc. were excluded from the review. The detailed inclusion and exclusion criteria applied in the process of article selection are illustrated in Table 1 below.

Table 1: **Lists of inclusion and exclusion criteria used for selection**

S. No	Inclusion Criteria	Exclusion Criteria
1	Study Design: All comparative epidemiological studies (cross-sectional, cohort, case-control) or presented baseline data from a randomized controlled trial (experimental as well as observational studies), Conference reports/proceedings	-Technical reports, special reports, brief communications and presentation of hypothetical scenarios or mHealth training workshops -Discussion of literature for the purpose of model and theory building or critique -Summaries of the literature for the purpose of information or commentary
2	Study Setting: Studies made in developing countries (Low and Middle income countries, Resource limited settings)	-An Editorial discussions -Non mHealth phone application, telemedicine & other eHealth implementation -Non full text materials
3	Study Participants: Women & Children	
4	Intervention: Mobile Health Ordinary mobile phone, smart phone, or tablet based approaches with either SMS based, Telephone based, web based applications or Interactive Voice Response System)	
5	Outcome measures: Maternal health (ANC/PNC), Child health, Immunization, Family planning	
6	Language: English language publications	
7	Publication Status: All published data and grey literatures	
8	Date of Publication: All Dates	
9	Material Availability: Full text availability	

References of articles which met the search criteria were checked for additional articles on mHealth intervention on maternal and child health care delivery. During the review process, e-mail request was made for authors of

articles whose full texts were missing, so that they could send us copies of their articles (detail search process as shown in flow chart 1 below).

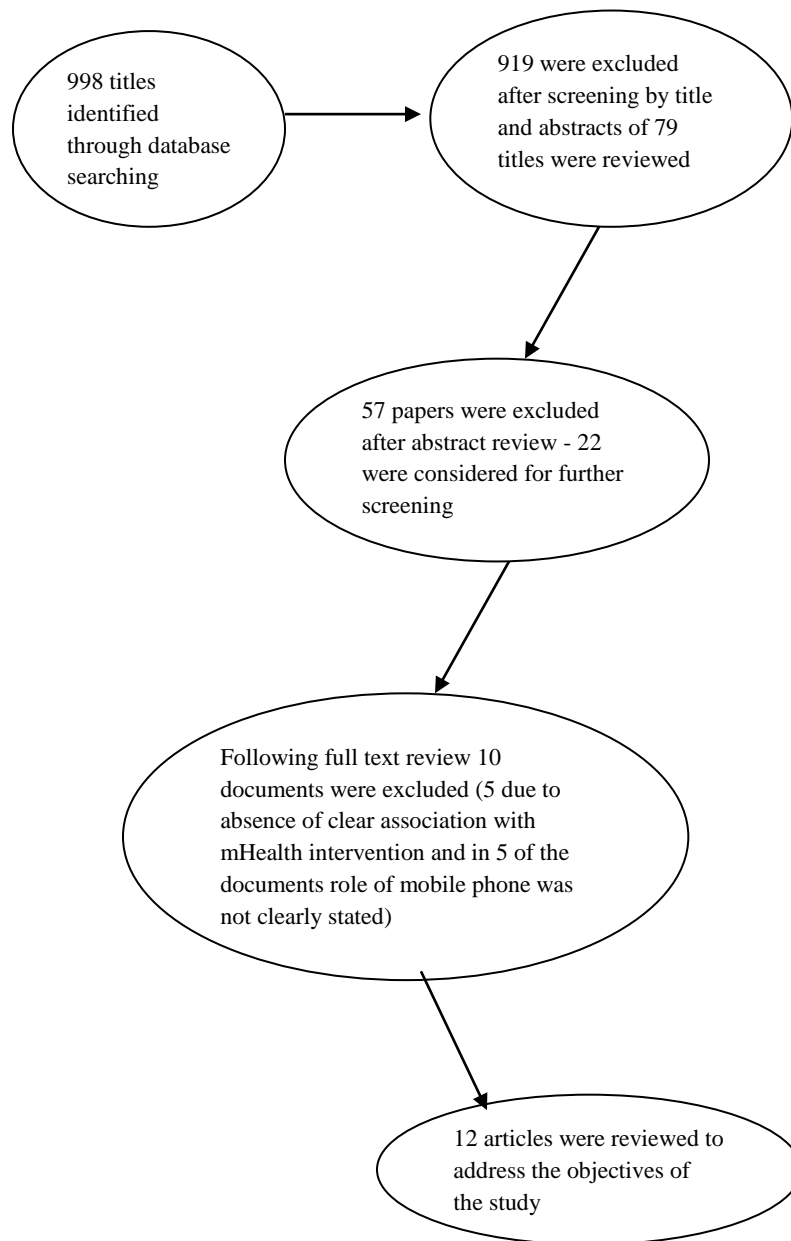


Figure 1: Flow chart of article selection process for review

Two authors of this paper independently scanned the electronic records to identify eligible publications based on the criterion. To minimize selection bias the remaining co-authors were involved in ascertaining selection. Any differences in selection were discussed and consented They shared eligible articles identified for

full text review and independently extracted data on the publication type, study characteristics, study participants, etc. using commonly agreed on data extraction form (Table 2). Findings were summarized and presented thematically.

Table 2: **Data Extraction Form for Systematic Review of Literature on mHealth intervention for maternal, newborn and child health**

1. GENERAL INFORMATION						
Study ID:		Report ID :		Date form completed:		
First author:		Year of study:		Data extractor:		
Citation:						
Publication type: Journal Article <input type="checkbox"/> Abstract <input type="checkbox"/> Other (specify e.g. book chapter) _____						
Country of study:						
Funding source of study:			Potential conflict of interest from funding? Y / N / unclear			
2. STUDY ELIGIBILITY						
2.1. Study Characteristics				Page/ Para/ Figure # _____		
Type of study	<input type="checkbox"/> Cohort <input type="checkbox"/> Case control <input type="checkbox"/> Cross-sectional <input type="checkbox"/> RCT		<i>Does the study design meet the criteria for inclusion?</i> Yes <input type="checkbox"/> No <input type="checkbox"/> Exclude Unclear <input type="checkbox"/>			
Time of the Study	<input type="checkbox"/> Prospective <input type="checkbox"/> Retrospective <input type="checkbox"/> N/A					
Type of intervention	<input type="checkbox"/> Text message <input type="checkbox"/> <input type="checkbox"/>		<i>Does the measurement of exposures meet the criteria for inclusion?</i> Yes <input type="checkbox"/> No <input type="checkbox"/> Exclude Unclear <input type="checkbox"/>			
Measurement of outcomes			<i>Do the outcome measures meet the criteria for inclusion?</i> Yes <input type="checkbox"/> No <input type="checkbox"/> Exclude Unclear <input type="checkbox"/>			
Study setting (eg. Rural, Urban)						
2.2. Study participants						Remark
Age of the study population						
Inclusion criteria					<i>Do the participants meet the criteria for inclusion?</i> Yes <input type="checkbox"/> No <input type="checkbox"/> <input type="checkbox"/> Exclude Unclear <input type="checkbox"/>	
Exclusion criteria						
Number of participants studied						
Number lost to follow up						
Final number of participants evaluated (n or %)						
3. METHODOLOGICAL QUALITY OF STUDIES (Newcastle /Ottawa Scale)						
	Cross-sectional studies	Mark	Case-control studies	Mark	Cohort studies	Mark
1. Selection	a) Outcome definition b) Representativeness of Sample		a) Case definition b) Representativeness of cases c) Selection of control d) Definition of controls		a) Representative ness of exposed cohort b) Selection of non exposed cohort c) Ascertainment of exposure d) Outcome occurred	

2. Comparability	a) Matching / adjustment for age b) Matching / adjustment for other factors Factors=.....		a) Matching / adjustment for age b) Matching / adjustment for other factors Factors=.....		a) Matching / adjustment for age b) Matching / adjustment for other factors Factors=..... ...	
3. Ascertainment	a) Ascertainment of exposure b) Same method of ascertainment for exposed and none exposed c) Non response rate		a) Ascertainment of exposure b) Same method of ascertainment for cases and controls c) Non response rate		a) Ascertainment of outcome b) Was follow up long enough for outcomes to occur c) Adequacy of follow up of cohort	
Grading scale		Max 7		Max 9		Max 9
4. SUMMARY OF ASSESSMENT FOR INCLUSION						
Include in review <input type="checkbox"/> Exclude from review <input type="checkbox"/>						
Independently assessed, and then compared? Yes <input type="checkbox"/> No <input type="checkbox"/>			Differences resolved Yes <input type="checkbox"/> No <input type="checkbox"/>			
Request further details? Yes <input type="checkbox"/> No <input type="checkbox"/>			Contact details of authors:			
Notes: Reason for exclusion						
5. RESULTS						
Primary outcomes	Adjusted and Crude (95%CI) OR, RR, HR and Raw data	Group=	N=	Group=	N=	
1						Reanalysis required? (specify)
2						Reanalysis possible? yes/no/unclear
3						Re analyzed results _____ -
Comment:						

Results

The initial search using the stated search terms identified 998 articles. All duplicated articles were removed automatically using EndnoteX6. A manual revision was done for verification and screened by title in which case 919 titles were excluded. 79 potential abstracts were screened and 57 were excluded. 22 studies were selected for full text review and 12 relevant studies met all the

eligibility criteria for this review as depicted in Figure 1. Among the 12 studies that were reviewed, four were Cross Sectional studies (15-18), three were pilot studies (19-21), one was Case-Control (22), one Cohort (23) and three were Randomized Control Trials (12, 24, 25). All studies were published between the years 2011 – 2015. Study characteristics and major outcomes of reviewed articles were summarized in Table 3.

Table 3: Summary of study characteristics and major outcomes of reviewed articles

First Author, Year, Country	Continuum of care	Phone Application Hardware/software format	Study Design	Population & Sample size	Outcome measures	Findings
1- Yan Kwan Lau 2014 -South Africa	-Pregnancy -Maternal health	SMS	Cross-Sectional	102 (Inter) 104 (Control)	Knowledge variables	-Text messages acted as a welcome reminder and a source of positive motivation, and were perceived as extended care from the health care provider -No significant difference in knowledge variable between intervention and control -Pregnancy related health behavior better in the intervention
2- Jaranit Kaewkungwal, 2015 -Thailand	Immunization -child health -BCC	Tablet based Data collection/transfer	Cross-Sectional	33 active VHVs	-immunization coverage -behavioral change communication	-Revealed potential benefits of the initiative for case identification; - improved immunization coverage -Prevention strategies successfully integrated into the routine health care workflows of immunization activities. -Awareness raised on child care.
3- Fidele Ngabo, 2012 -Rwanda	-Pregnancy -Delivery -Maternal & Child health	-Rapid SMS-MCH monitoring pregnancy and post-partum - Strengthen referral	Cross-Sectional	432 CHW	Text messaging to the central database	-35,734 SMS were sent by 432 CHW - A total of 11,502 pregnancies were monitored - A total of 362 SMS alerts for urgent and life threatening events were registered - 27% increase in facility based delivery from 72% twelve months before to 99% at the end of pilot phase which is significant - Major challenges were telephone maintenance and replacement
4- Dhiren M. 2015 -India, Gujarat	-MNCH -Training -Diagnosis -BCC	- job aid to ASHAs to assist with scheduling, BCC, diagnosis, and patient management	Cross-Sectional/Descriptive	-45 ASHAs (Accredited Social Health Activists)	-Improvement in performance of ASHAs	-low coverage of selected MNCH services and care received by complicated cases - the intervention and its delivery were found to be largely acceptable, feasible, and useful -few changes were made to the intervention and its delivery

Table 3 cont'd

<p>5-Wakadha H, 2013 -Kenya, Siaya district</p>	<p>Immunization -child health -</p>	<p>- SMS reminder conditional cash transfer</p>		<p>-72 mothers of children 0–3 weeks of age</p>	<p>Immunization service utilization</p>	<p>- Of the 63 children with known vaccination status at 14 weeks of age, 57 (90%) received pentavalent1 and 54 (86%) received pentavalent2 within 4 weeks of their scheduled date. -Of the 61 mothers with follow-up surveys administered at 14 weeks of age, 55 (90%) reported having received SMS reminders. -Of the 54 women who reported having received SMS reminders and answered the CCT questions on the survey, 45 (83%) reported receiving their CCT. -All mothers stated they preferred CCTs as cash via mobile phone rather than airtime.</p>
<p>6- Lund, S. 2014 -Zanzibar</p>	<p>-ANC -Maternal health</p>	<p>- automated short messaging service (SMS) -Linking pregnant women and their newborns to the health system with mobile phones - Text reminders for health care appointments/ANC and health education</p>	<p>RCT</p>	<p>-2550 pregnant women (1311 Int. and 1239 control)</p>	<p>-Four or more ANC visits during pregnancy. -Tetanus vaccination, preventive treatment for malaria, gestational age at last ANC visit and antepartum referral.</p>	<p>-More women in the intervention group (44%) received the recommended four or more antenatal care visits than in the control group (31%) -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).. -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) - 65% received two doses of preventive malaria treatment versus 52% in the control group (OR, 1.97; 95% CI, 0.98-3.94).</p>
<p>7- Sunday Oluwafemi, 2014 -Nigeria</p>	<p>-facility utilization -pregnancy -Maternal Health</p>	<p>- improving health facility utilization</p>	<p>Case control</p>	<p>-Registration records of 1429 women in Ifedore LGA and 1801 in Idanre LGA. -+ 231 women surveyed through questionnaire</p>	<p>-users' perceptions of benefits of the cell phone, effects on health facility utilization, the wish for the continuity of the cell phone initiative</p>	<p>-Out of the population of the pregnant women using the cell phone, 77% were using it to make calls only, and less than one quarter (23%) were using it for both calls and text messages. -Almost all the pregnant women (98%) believed that the number of women dying in pregnancy or shortly after delivery had been reduced drastically, -The majority (81%) rated the Abiye cell phone "very useful" - 59% found the easy and free communication linkage with the health workers the most important benefit of the cell phone, while 32% valued more the prompt response to emergency situations afforded by the cell phone. -80% of the women were "mostly satisfied" with the response they got each time they called or texted the health workers or the facility,</p>

Table 3 cont'd

8- Lund, S. 2012 -Zanzibar	-Skilled delivery -Maternal health	--An automated short messaging service (SMS) -Linking pregnant women and their newborns to the health system with mobile phones - Text reminders for health care appointments and health education	RCT	-2550 pregnant women (1311 inter. and 1239 controls) who attended antenatal care at one of the selected primary healthcare facilities	-Skilled delivery attendance amongst pregnant women	-60% of women in the intervention group versus 47% in the control group delivered with skilled attendance -a difference in the intervention effect between women of urban and rural residence; 82% of urban women in the intervention group delivered with skilled attendance versus 43% of rural women. -The intervention was highly significant amongst urban women who had odds five times higher (OR, 5.73; 95% CI, 1.51–21.81) for delivering with skilled attendance -the intervention did not improve skilled delivery attendance amongst women living in rural areas.
9- Lund, S. 2014 -Zanzibar	-prenatal care -Maternal & child health	- Data collection/ reporting -Linking pregnant women and their newborns to the health system - Text reminders for health care appointments/post natal care and health education	-RCT	2550 Pregnant women (1311 inter.& 1239 Control)	-Effect of a mobile phone intervention In reduction in prenatal mortality -stillbirth, and death of a child within 42 days after birth as a proxy of neonatal mortality	-Overall, 2482 children were live born, 54 were stillborn, and 36 died within the first 42 days of life. -Of these, 69 children were perinatal deaths. -The stillbirth rate was 17 per 1000 births in the intervention group versus 26 per1000 births in the control group. -The overall perinatal mortality rate 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. -The intervention was associated with a significant reduction in the outcome of perinatal mortality with an OR 0.50 (95% CI 0.27-0.93)
10- Marc Mitchell 2012 -Tanzania	-patient management/ Treatment -Child health	-Diagnostics and treatment support - guide the HCPs --improve adherence to IMCII protocol -Paper and pen method being replaced by treatment/diagnosis/data collection using PDAs	Cohort	-20 Care takers -12HCP from twelve HC	-Perceived improvement in IMCI	-The pilot results for e-IMCI were encouraging, suggesting that the technology employed is user-friendly enough for clinicians to use, and that both patient care and caregiver efficiency can be improved. -All HCPs stated that they preferred the PDA method over the paper method for administering IMCI. -HCPs Perceived the Electronic System as Faster and Simpler than the Paper System -All HCPs stated that the PDA simplified or reduced the work required during the IMCI appointment. -Nine (82%) HCPs noted that the PDA provided guidance through the IMCI protocol, -Eight HCPs (73%) believed the PDA enabled them to adhere more closely to IMCI guidelines

Table 3 cont'd

<p>11- Pamela A. 2011 Ghana</p>	<p>-Data collection/reporting -prenatal care -MCH</p>	<p>- -Data collection/transfer -SMS -evaluate use of cell phone by professional & TBA</p>	<p>10 PBA + 40 TBA</p>	<p>-cell phone usage for reporting and text messaging PPH via a specified protocol</p>	<p>-Data reported over the 90-day period indicate that both professional birth attendants and TBAs were able to use the specified reporting and text-messaging protocols to report clinical outcomes from their rural communities. -In total, 425 births were reported during the study period, with PPH occurring in 13 (3.1%) cases. -Prenatal care provided to 405 mothers (95.3%)</p>
<p>12- Van Heerden A. 2013 South Africa</p>	<p>-Data collection -Maternal health</p>	<p>- data collection to describe acceptability and feasibility</p>	<p>-16 interviewers -512 MLH</p>	<p>-phone based Face to face interview</p>	<p>-Acceptability of the method was found to be high among the 16 interviewers in group 1. -Perceived usefulness was reported to be slightly higher than perceived ease of use across the 3 time points. -After 3 months of field use, interviewer perceptions of both perceived ease of use and perceived usefulness were found to be higher than before training. -The feasibility of conducting MPAPI interviews in this setting was found to be high.</p>

The numbers of study participants vary from 2550 pregnant women in the intervention by Lund et al (12, 24, 25) to the smallest that involved 20 care takers and 12 Health care practitioners (23). Ten (83%) of the studies were implemented in rural settings of Africa and two in Asia. The intervention focused thoroughly on improving maternal health (ANC/ PNC), and child immunization coverage (Table 2).

Mobile based technological solutions employed:

Ordinary mobile phones were used in nine (75%) of twelve studies (12, 15, 16, 19-22, 24, 25); one used tablet based applications (18), one used PDA application (23) whereas the other one used Smart phone application (17). 66.6% (n=8) of the intervention used SMS based technology. The utility strategy is variable and were in the form of disseminating text messages (SMS) about clinical procedures and health information at antenatal visits (15, 22), Sending text message using pre-programmed simple numeric protocol and applying voucher component as reminders of antenatal care by linking pregnant women to the health system (12, 18, 22, 24, 25); and mobile phone based SMS reminder and incentivizing mothers using mobile phone-based conditional cash transfer (21).

A smart phone based Stateless Vac Project (18), strategically used mobile phone for such purposes as: (1) case identification, and (2) disease prevention intervention. For case identification, phone-to-phone information sharing between the VHUs (local health workers) and the PHU helped to identify and follow children who required vaccination. Use of mobile phone for disease prevention applies behavior change focused information and messages by installing locally appropriate information and message on VHU smart phone. This has helped to raise awareness and concerns about child health, and promote the importance of child immunization to the mothers.

Fidele Ngabo et al. (16) in Rwanda used UNICEF developed open source SMS application, the Rapid SMS-MCH system, which was customized to allow interactive communication between community health workers (CHW) following mother-infant pairs in their community. Besides, the system links clients with national centralized database, the health facility and in case of an emergency with ambulance driver.

Web based integrated mobile technology (ImTeCHO) was found to be useful as: job aid for scheduling, diagnosis and patient management (17); integrated management of child illness (eIMIC) for diagnosis and treatment support (23); and data collection/reporting platform for what otherwise be clinic based face to face interview (19, 20).

Purpose and Intervention Results: Six (50%) of the studies were planned to evaluate the role of mobile

phone intervention in improving utilization of maternal health (ANC/PNC) services, facilitate attendance of skilled delivery and improving maternal and child health care services (12, 16, 17, 22, 24, 25). Two studies aimed to test mobile as a tool for reporting/collecting data on pregnancy and related health information (19, 20); while two studies focused on improving child immunization coverage (18, 21). Among the other two studies, one attempted at increasing antenatal health knowledge and awareness among pregnant women attending antenatal care in South Africa (15) while the other attempted on evaluating perception of care takers using the technology in diagnosing and treating childhood illnesses (23).

Among the studies which tried to test maternal health related issues, three articles by Lund et al has come from rural Zanzibar (12, 23, 24). The findings showed that mobile phone intervention was directly associated with an increase in antenatal care attendance among the intervention group where 44% of the women received four or more antenatal care visits against 31% in the control group (OR, 2.39; 95% CI, 1.03-5.55); and lower prenatal mortality in the intervention cluster, 19 per 1000 births. Furthermore, the intervention produced a significant increase in skilled delivery attendance amongst urban women (odds ratio, 5.73; 95% confidence interval, 1.51–21.81).

Olufawemi et al. (22) in Nigeria also revealed facility utilization rate by pregnant women was significantly higher due to mHealth intervention in the intervention area. Fiedel et al (16) found out that implementation of Rapid SMS-MCH resulted in 27% increase in facility based delivery.

The ImTeCHO application in India was developed to integrate mHealth strategies in the form of job aid to ASHAs (Accredited Social Health Activists) and was found to be acceptable, feasible, and useful technology (17). Moreover, Andreato, P et al, van Herden et al., and Mitchell et al. (18, 19, 22) demonstrated that mobile phone based data collection and transfer is preferred, acceptable, easily adaptable and better than the routine working process.

Kaewkungwal et al. and Wakadha et al. (18, 21) who investigated the potentials of mHealth on child-hood immunization also proved its potential benefits, specially its value for case identification and immunization coverage. It was also reported that the strategy can be successfully integrated into the routine health care workflows of immunization activities at point-of-care.

Yan Kwan Lau et al. (15) tested the attitude of mothers of antenatal care via short message, and they showed text messages acted as a welcome reminder, a source of positive motivation, and were perceived as extended care from the health care provider. However, their attempt to improve knowledge of mothers and pregnancy related

health behavior did not show statistically significant change; even though better than the control group.

Discussion

mHealth is one major component of eHealth, which refers to the utilization of information and communication technology for health including for sharing messages, information, data transmission and video telecommunication via the Internet (10, 13).

The current review tried to look the impact of mHealth on MCHC in depth so as to assess its potential benefits and related health impacts in resources limited set ups. The focus of these reviewed studies were varied including improving pregnancy related knowledge; increasing health facility utilization; reducing maternal and prenatal mortality by improving ANC/PNC attendance and professionally assisted delivery; examining perception of care takers on using the mobile technology; and improving child immunization coverage. A significant number of studies focused on improving communication gap between mother's, health workers and health facilities.

Although availability of evidences on mHealth interventions on MCHC is still limited, studies included in this review have generated promising results regarding the positive impact of these interventions on maternal and child health issues. The strongest evidence exists for text message reminders and information delivered to pregnant women's through mobile phones (15).

In rural areas, where population densities are low and access to healthcare is limited, mHealth offers potential solutions for maximizing on limited resources and improve efficiency by facilitating work process in data collection and information communication (17, 19, 20, 23). Similar findings are reported by Free et al. (26) and Little et al. (27) who reviewed studies on the effectiveness of mobile health technologies in improving health care service delivery processes.

Studies demonstrated effectiveness of mobile messaging on maternal health in terms of increasing antenatal care attendance, attendance of skilled deliveries, and improvement of child vaccination (12, 18, 24, 25). Studies by Bonono (28), Ally (29), Fedha (30) and Noordam (31) also revealed similar findings and such outcomes offer hope to the lingering maternal health indicators in Sub-Saharan Africa.

Conclusion:

Unreliable mobile network in the rural set up was a universal concern and is believed to affect the level of outcome of the intervention and also the general mHealth frontier. Because of these methodological limitations and the small number of studies that fulfilled the inclusion criteria, large scale randomized controlled trials are suggested to be implemented. It is known that most

countries are currently recognizing the need for clear technology use strategy, clear roadmap to apply appropriate technology considering existing infrastructure and knowledge in the rural area, which further justify the need for further evidence of the technology.

Limitations

Despite the positive outcome reported from the reviewed literatures, there were limitations. Among the limitation methodological issue is found to be the major one. Some of the investigations were pilot/case studies and used small samples; other studies had issues related to short intervention period, lack of eloquent measurement method like measuring behavioral change and acceptance and clear outcome indicator (18-21, 24).

Studies by Andreato P et al (19) and Michel et al (23) have problems related to the reliability of the source of data (hospital based data), lacked baseline data to compare their results and clear selection bias which is also acknowledged by the authors. High attrition rate (43%) of the participants in a study done by Yan Kwan Lau et al (15), also questions the validity of the outcome.

Similarly, evidences presented in Nigabo (16) and Wakahada (21) studies are based on self-reported behavior change from health workers and patients, which is not sufficiently reliable to draw strong conclusions on the usefulness of mHealth interventions. In addition to this Wakahada's study (21) tried to combine multiple mHealth interventions which is text message reminders and conditional cash transfers via mobile phone, that makes difficult to find out to what extent each intervention contributed to the observed results.

The review identified that most of the studies did not include detail descriptions of their technical implementation, data security, confidentiality and scale-up plan. Difference in research design among the reviewed articles were identified but its implication on the findings were not discovered by the reviewers.

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