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mHealth adoption in low-resource environments: A review of the use of mobile healthcare in developing countries

Abstract

The acknowledged potential of using mobile phones for improving healthcare in low-resource environments of developing countries has yet to translate into significant mHealth policy investment. The low uptake of mHealth in policy agendas may stem from a lack of evidence of the scalable, sustainable impact on health indicators. The mHealth literature in low- and middle-income countries reveals a burgeoning body of knowledge; yet existing reviews suggest that the projects yields mixed results. This paper adopts a stage-based approach to understand the varied contributions to mHealth research. The heuristic of input-mechanism-outputs is proposed as a tool to categorize mHealth studies.

This review (63 papers comprising 53 studies) reveals that mHealth studies in developing countries tend to concentrate on specific stages, principally on pilot projects that adopt a deterministic approach to technological inputs \( n=2 \), namely introduction and implementation. Somewhat less studied research designs that demonstrate evidence of outputs \( n=15 \), such as improvements in healthcare processes and public health indicators. The review finds a lack of emphasis on studies that provide theoretical understanding of adoption and appropriation of technological introduction that produces measurable health outcomes. As a result, there is a lack of dominant theory, or measures of outputs relevant to making policy decisions. Future work needs to aim for establishing theoretical and measurement standards, particularly from social scientific perspectives, in collaboration with researchers from the domains of information technology and public health. Priorities should be
set for investments and guidance in evaluation disseminated by the scientific community to practitioners and policymakers.

**Background**

*Introduction*

The growing evidence for the use of mobile information and communication technologies and mobility of information in healthcare (called mobile health or mHealth) has attracted the attention of practitioners, researchers and policymakers globally (Free et al., 2010; Leslie, Sherrington, Dicks, Gray, & Chang, 2011; Vodafone, 2006; Waegemann, 2010). Mobile phones have the potential to revolutionize healthcare, particularly in low-resource settings of low- and middle-income countries where healthcare infrastructure and services are often insufficient (Kahn, Yang, & Kahn, 2010).

Pilot mHealth projects have shown that, particularly in developing countries, mobile phones improve communication and information-delivery and –retrieval processes over vast distances between healthcare service providers and patients (Tamrat & Kachnowski, 2012). Mobiles provide remote access to healthcare facilities, facilitate trainings for, and consultations among, health workers, and allow for remote monitoring and surveillance to improve public health programs. This phenomenon has the potential to lead to an overall increase in the efficiency and effectiveness of under-resourced health infrastructures, ultimately translating into benefits for patients (Bloch, 2010; Ranck, 2011).

In general, however, the scalability of mHealth projects from pilot projects to large-scale nationwide implantation has been low, (Ping, Wu, Yu, & Xiao, 2006; WHO, 2011b) with the available evidence proving insufficient to persuade key
policymakers and health practitioners (Mechael et al., 2010). Amongst the reasons for this state of affairs are firstly, the lack of an ample evidence base, which is understandable for a nascent discipline; secondly, a lack of clarity in organizing the evidence to distinguish particular investigative approaches to mHealth, chief amongst which are the broad domains of technology development, social science, and public health. To resolve these issues, this paper aims to investigate prior mHealth reviews and conduct a comprehensive literature review, organizing the studies in a logical framework. In the next paragraph of this Background section we will provide an overview of the prior mHealth reviews, and then in the Methods and Results section of this paper we will describe the assessment of individual studies.

**Review of literature**

Recent reviews of mHealth provide a range of analyses focusing on particular technological features, process improvements in healthcare service delivery, and behaviour change and healthcare outcomes. As background to this review, we examine these mHealth reviews, noting the number of studies included in brackets \( [n] \) as a measure of scope.

The mHealth literature focusing on developing countries has certainly flourished in recent years. While the mHealth field may no longer comprehensively suffer from Kaplan’s (2006) accusation of having “almost no literature on using mobile telephones as a healthcare intervention [in developing countries]” ; also see SMS literature cited below); more recent reviews point to similar concerns (Gurman, Rubin, & Roess, 2012) \( [n=16] \); (Mechael, et al., 2010) \( [n=145] \)

From a thematic perspective, overview studies and reviews of mHealth globally have developed lists of notable technological features of project implemention
(Fjeldsoe, Marshall, & Miller, 2009) [n=14]; (Gurman, et al., 2012) [n=16]; (Klasnja & Pratt, 2012) [n=unstated]; (Patrick, Griswold, Raab, & Intille, 2008) [n=unstated], or process improvements such as healthcare service delivery (Blynn & Aubuchon, 2009) [n=unstated]; (Mechael, et al., 2010) [n=145]. However, making the theoretical link to effectiveness, namely behaviour change or health outcomes, has been less explicit.

A sub-set of mHealth reviews focus on SMS (Short Message Service), or mobile texting; yet find little rigorous evidence of effectiveness (Fjeldsoe, et al., 2009) [n=14]; (Lim, Hocking, Hellard, & Aitken, 2008) [n=9], with a few more recent studies focusing on developing countries (Cole-Lewis & Kershaw, 2010) [n=12]; (Deglise, Suggs, & Odermatt, 2012) [n=34]. Despite lack of evaluation of effectiveness, these earlier reviews suggest partial positive evidence of the impact of text messages. Recent ones are more mixed, noting both substantial (Guy et al., 2012) [n=18]; (Krishna, Boren, & Balas, 2009) [n=25], and limited, effects on improving healthcare service delivery (AuthorA, 2012a) [n=4]; (AuthorA, 2012b) [n=1], and patient care (de Tolly, Skinner, Nembaware, & Benjamin, 2012) [n=2]; (AuthorB, 2012b) [n=21]. Overall, we conclude that technology introduction and implementation and healthcare process improvements have been emphasized in the scientific literature. Less well understood in comparison are mechanisms of adoption and appropriation of technology at individual and socio-cultural levels of analysis.

Researchers have regularly called for theoretically-based interventions, suggesting the increased likelihood of meeting success criteria (Krishna, et al., 2009), yet there are few reviews that examine the role of theory in mHealth projects. A majority of the reviews chose to use methodological standards as an exclusion criteria, limiting the reviews to randomized control trials (RCTs) found within the peer-
reviewed literature, mostly upheld as the gold standard, sometimes adding experimental/quasi-experimental research designs. Others employed broader inclusion criterion, including all methodologies, as well as drawing from the grey literature.

*Aim of this review*

Our overview of reviews showed that though the body of mHealth knowledge is growing and studies have shown potential to improve healthcare, the current evidence is not convincing enough for policy makers. The reviews found mixed results and lack the ability to show robust evidence. The main focus of studies has been on inputs, while research in mechanism factors and underlying theory is missing. Therefore, the fundamental aim of this review is to identify, define and examine factors of inputs, mechanisms, and outputs, of mobile phones for healthcare workers and patients in low- and middle-income countries. Our objectives were to determine the relative value of research approaches within this linear model, propose recommendations that allow for collaborative research, as well as foster discussion and debate about the relative value of specific approaches to influencing practice and policy. We will do this by investigating a large number of studies, covering inputs, mechanism, and outputs, and incorporate both quantitative and qualitative evidence.

**Methods**

*Approach*

This review paper used a deductive approach addressing some of the issues outlined. First, we demarcated the boundaries of the investigation to mHealth studies conducted within developing countries, aiming, however, to cover a broader spectrum of papers than those found previously. Secondly, we focussed on all aspects, inputs, mechanism and outputs, as we argued that the investigation of the mechanisms of
adoption and appropriation of technology using social scientific methods is equally important as evidence for effective technology introduction and implementation, and public health outputs, such as process improvements and patient healthcare indicators. Finally, given the call for more nuanced methodological approaches (Mechael, et al., 2010), we broadened the review to multiple methods of investigation of the mHealth phenomenon.

We propose a pathway of research focus for mHealth studies as a heuristic within which to situate this review (Klasnja & Pratt, 2012; Thomas & Harden, 2008). We categorized the studies under the input-mechanism-outputs pathway shown in Figure 1, mapping onto a linear system of investigation within the mHealth field, which are often conflated.

Inputs include factors such as technology access and use vital to technology developers and practitioners who implement mHealth projects within beneficiary communities. Mechanism factors such as psychosocial influences and individual preferences offer explanatory value to understand technology adoption. Finally, outputs include healthcare process factors, including efficiency measures within the health system such as data-management and treatment adherence; and effectiveness measures of patient healthcare factors, defined as behaviour change or public health indicators within the beneficiary population. While the silos of technology development-social science-public health domains introduced earlier might seem to map onto this categorization simplistically, such a framework does allow for determining the relative focus of prior research investigations in the field.

**Inclusion and exclusion criteria**

We included research papers fulfilling the following inclusion criteria: those that studied the use of mobile phones in healthcare, focused on patients or healthcare
workers, and were undertaken in low-income and low- and upper-middle-income countries (as categorized by the World Bank (WorldBank, 2012)). We included both peer-reviewed and non-peer reviewed literature. We considered papers in all languages, but we only found papers in the English language. We excluded research which studied other mobile devices then mobile phones, did not focus on health or was undertaken in high-income countries.

**Review methods**

We based our methods on the Cochrane Collaboration systematic review methodology (Higgins & Green, 2011) and qualitative review methodology (Ring, Ritchie, Mandava, & Jepson, 2010; Sandelowski & Barroso, 2002; Thomas & Harden, 2008). Briefly summarized this includes defining the review question and developing criteria for inclusion and exclusion of studies, a high sensitivity search for studies, selection and data extraction using a standardised form, and considering meta-analysis when appropriate or a narrative assessment.

**Search methods**

One author (XX) used mHealth related search terms (phon*, mobil*, mhealth, m-health, ‘m health’, ehealth, telemedicine and telehealth) to search a number of electronic databases (The Cochrane Central Register of Controlled Trials (CENTRAL, The Cochrane Library, latest issue), Pubmed, EMBASE, WHO Global Health Library regional index (latest issue), PsycINFO, Web of Science, Mobile Active (http://www.mobileactive.org/), KIT Information Portal; mHealth in Low-Resource Settings (http://www.mhealthinfo.org/). The author searched the databases from October 2010 onwards as extensive searches for our previous mHealth systematic reviews (including 32,399 citations) covered the literature before this date. Reference lists of relevant studies and personal collections of articles were also searched.
Documents published before 2000 were not included as mobile phones were then not widely available in low- or middle-income countries.

One strength of this review is the extensive search of references from which selected the studies. Due to limited resources a single author undertook the review process. We acknowledge that the typology is used as a heuristic. The review is intended to be an illustration of the pathway, and not a systematic review of all mHealth studies in developing countries.

Data extraction and analysis

The author merged search results across databases, removed duplicates and screened citations against inclusion criteria. Data were extracted using a standardized form including descriptives, inputs, mechanism factors and outputs. Statistical pooling of results was not possible due to extensive heterogeneity of the study methodologies.

The papers were further categorized according to the type of the main intervention. Certain studies focussed on factors falling under more than one category; we chose to concentrate on the main intent of each study. Where studies exhibited more than one category in a significant manner, we examined the linkages.

Results

We found 53 studies (represented by 63 papers) addressing one of the three stages of the pathway, input-mechanism-outputs, shown in Figure 1. The main types of interventions studied were related to data collection (Alam, Khanam, Khan, Raihan, & Chowdhury, 2010; Andreatta, Debpuur, Danquah, & Perosky, 2011; Asiimwe et al., 2011; AuthorB, 2012a; Barrington, Wereko-Brobby, Ward, Mwafongo, & Kungulwe, 2010; Ganesan et al., 2011; Haberer, Kiwanuka, Nansera,
Wilson, & Bangsberg, 2010; Kaewkungwal et al., 2010; MOTECH, 2011; Rajatonirina et al., 2012; T. Svoronos et al., 2010) [n=11], and consultation between health workers (AuthorC, 2011b, 2012a, 2012c; Chandhanayingyong, Tangtrakulwanich, & Kiriratnikom, 2007; Chang et al., 2011; Cole-Ceesay et al., 2010; Lemay, Sullivan, Jumbe, & Perry, 2012; Macrohon & Cristobal, 2011; Skinner, Rivette, & Bloomberg, 2007; Zolfo et al., 2010; Zurovac et al., 2011) [n=11].

We categorized the papers by the main type of intervention; data collection (Alam, et al., 2010; Andreatta, et al., 2011; Asiimwe, et al., 2011; AuthorB, 2012a; Barrington, et al., 2010; Ganesan, et al., 2011; Haberer, et al., 2010; Kaewkungwal, et al., 2010; MOTECH, 2011; Rajatonirina, et al., 2012; T. Svoronos, et al., 2010) [n=11], consultation between health workers (AuthorC, 2011b, 2012a, 2012c; Chandhanayingyong, et al., 2007; Chang, et al., 2011; Cole-Ceesay, et al., 2010; Lemay, et al., 2012; Macrohon & Cristobal, 2011; Skinner, et al., 2007; Zolfo, et al., 2010; Zurovac, et al., 2011) [n=11], appointment reminders for health workers (Derenzi et al., 2012) [n=1], and patients; health promotion (AuthorC, 2012b; Danis et al., 2010; de Tolly, et al., 2012; Hamilton, 2010; Jareethum et al., 2008; L’Engle & Vadhat, 2009; K. J. Mitchell, Bull, Kiwanuka, & Ybarra, 2011) [n=7], medication reminders (Curioso et al., 2009; Walter H. Curioso & Ann E. Kurth, 2007; R. T. Lester et al., 2010; Mbuagbaw, Bonono-Momnougui, & Thabane, 2012; Pop-Eleches et al., 2011; Shet et al., 2010; Sidney et al., 2012) [n=7], appointment reminders (Chen, Fang, Chen, & Dai, 2008; Crankshaw et al., 2010; da Costa, Salomão, Martha, Pisa, & Sigulem, 2010; Kunutstor et al., 2010; Leong, Chen, & Leong, 2006; Liew et al., 2009; Prasad & Anand, 2012) [n=7], and health information for patients (Ashraf, Ansari, Tahseen Malik, & Rashid, 2010; Azfar et al., 2011; Maharani, Rosanna, & Liesman, 2012; Odigie et al., 2011; Piette et al., 2011) [n=5], test reminders
(Seidenberg et al., 2012; Wolpaw et al., 2011) [n=2], while two studies did not focus on any specific intervention (Faisal, 2011; Hwabamungu & Williams, 2010).

**Inputs**

A number of studies (Alam, et al., 2010; Andreatta, et al., 2011; Asiimwe, et al., 2011; AuthorB, 2012a; AuthorC, 2012b; Azfar, et al., 2011; Barrington, et al., 2010; Chandhanatingyong, et al., 2007; Cole-Ceesay, et al., 2010; Crankshaw, et al., 2010; Curioso, et al., 2009; W. H. Curioso & A. E. Kurth, 2007; Danis, et al., 2010; Derenzi, et al., 2012; Faisal, 2011; Ganesan, et al., 2011; Haberer, et al., 2010; Kaewkungwal, et al., 2010; L’Engle & Vadhat, 2009; Lemay, et al., 2012; Macrohon & Cristobal, 2011; Maharani, et al., 2012; Mbuagbaw, et al., 2012; J. R. Mitchell et al., 2011; MOTECH, 2011; Rajatonirina, et al., 2012; Shet, et al., 2010; Sidney, et al., 2012; Skinner, et al., 2007; T. Svoronos, et al., 2010; Wolpaw, et al., 2011; Zolfo, et al., 2010) [n, =32] described technological inputs required for mHealth implementation, focusing on technology access and use and on the feasibility of the intervention in terms of satisfaction, response rates, data accuracy and error rates and set-up costs. These studies were mostly pilot studies, implementation evaluations, studies with undefined design or interviews. A detailed description can be found in Table 1.

The range of technologies employed for data collection ranged from mobile applications (Alam, et al., 2010; AuthorB, 2012a; Ganesan, et al., 2011; Kaewkungwal, et al., 2010; T. Svoronos, et al., 2010), SMS-based mobile applications (Asiimwe, et al., 2011; Barrington, et al., 2010), to interactive voice calls and SMS (Haberer, et al., 2010; Rajatonirina, et al., 2012). For consultation between health workers, SMS (Lemay, et al., 2012; Macrohon & Cristobal, 2011), or MMS (Azfar, et al., 2011; Chandhanayingyong, et al., 2007) was used. Other studies used
calls and SMS for reminding patients (Wolpaw, et al., 2011), or health workers (Derenzi, et al., 2012) of their appointments, and SMS quizzes for health promotion (AuthorC, 2012b; Danis, et al., 2010), providing health information (Maharani, et al., 2012), and an application for health worker’s learning (Zolfo, et al., 2010). A diverse set of standards was applied, with no evidence provided for inter-operability.

Other studies researched the possibility of a SMS intervention for family planning (L’Engle & Vadhat, 2009), HIV prevention (J. R. Mitchell, et al., 2011), or antiretroviral therapy reminders (Curioso, et al., 2009; Mbuagbaw, et al., 2012; Shet, et al., 2010). The use of mobiles was studied in general (Faisal, 2011), for clinic appointment reminders and adherence messages (Crankshaw, et al., 2010; Shet, et al., 2010), and the use of information and communication technology in general for people living with HIV (W. H. Curioso & A. E. Kurth, 2007).

Notably, this group of studies were more relevant to practitioners, yet lacked explicit theoretical support and largely failed to address outputs. However, we found factors for technology adoption in these papers such as perceived facilitators and barriers and preferences (Alam, et al., 2010; Asiimwe, et al., 2011; AuthorB, 2012a; AuthorC, 2012b; Azfar, et al., 2011; Barrington, et al., 2010; Cole-Ceesay, et al., 2010; Crankshaw, et al., 2010; Curioso, et al., 2009; W. H. Curioso & A. E. Kurth, 2007; Derenzi, et al., 2012; Faisal, 2011; Haberer, et al., 2010; Kaewkungwal, et al., 2010; L’Engle & Vadhat, 2009; Lemay, et al., 2012; Macrohon & Cristobal, 2011; Mbuagbaw, et al., 2012; J. R. Mitchell, et al., 2011; MOTECH, 2011; Rajatonirina, et al., 2012; Shet, et al., 2010; Skinner, et al., 2007; T. Svoronos, et al., 2010; Wolpaw, et al., 2011). Some of these studies provided some evidence of potential impact (Barrington, et al., 2010; Kaewkungwal, et al., 2010; Lemay, et al., 2012; Rajatonirina, et al., 2012; T. Svoronos, et al., 2010). Two studies in rural Tanzania
showed impact: increases in the numbers of antimalarial medicines stocks (Barrington, et al., 2010), and anecdotal evidence of improved management of antenatal care (T. Svoronos, et al., 2010). A study in rural Thailand reported improved antenatal and immunization coverage (Kaewkungwal, et al., 2010).

**Mechanism**

A second and smaller number of studies (Ashraf, et al., 2010; AuthorC, 2011b, 2012a, 2012c; Hamilton, 2010; Hwabamungu & Williams, 2010) [n=6] investigated the reasons for technology adoption, using theoretical models for explanation or validation of the findings. These studies are described in detail in Table 2.

Four of these studies (AuthorC, 2012a, 2012c; Hamilton, 2010; Hwabamungu & Williams, 2010) used theory to explain the potential for mobile phones in addressing health problems. The ICT4 healthcare development model, was used by community healthcare workers for accessing information by mobile phones in rural India (AuthorC, 2012a). Castells spatio-temporal arguments (Castells, 1989) were used in rural Nepal to structure the potential of mobile phones for rural communities (AuthorC, 2012c). The Technology Acceptance Model (F. D. Davis, 1986) was adapted to study views of people living with HIV and healthcare workers on usability of mobile phone applications for healthcare in South Africa. However, the exact constructs of the theories studied were not described (Hwabamungu & Williams, 2010). Social marketing theory (Hastings, 2007) was used in rural Kenya for studying the use of mobile phones for health promotion (Hamilton, 2010).

A study in rural Indonesia (represented by five papers (AuthorC, 2008, 2009, 2010, 2011a, 2011b) evaluated an intervention wherein midwives were provided with mobile phones. Four theories were tested: the ICT4 healthcare model (Banuri, Zaidi, Spanger-Siegfried, Ali, & Zaidi, 2003) in two papers (AuthorC, 2008, 2010),
dialectical perspectives on gender (Baxter & Montgomery, 1996) in one paper (AuthorC, 2011b), the technology acceptance model (Fred D Davis, 1985) in one paper (AuthorC, 2009), and a hypothesized model of midwifes mobile phone use, access to resources, self-efficacy, and health knowledge in the last paper (AuthorC, 2011a). The communication for development framework (Bertrand, O'Reilly, Denison, Anhang, & Sweat, 2006) was used to study a health help-line in rural Bangladesh (Ashraf, et al., 2010).

A simple healthcare communication diagram (the study authors came up with this diagram) showing that patients, family, friends and healthcare workers are interconnected, was developed from studying peer health worker’s use of mobile phones to help people living with HIV to adhere to antiretroviral therapy in rural Uganda (as this study is more focussing on outputs it is categorized accordingly) (Chang, et al., 2011). The construct of stages of change (Prochaska & DiClemente, 1983) was used in a study obtaining health worker’s perspectives on receiving SMSs which aimed to improve their malaria case management (as this study is more focussing on outputs it is categorized accordingly) (Jones et al., 2012; Zurovac, et al., 2011).

We found that studies based on theory overlapped more with input studies than with outputs studies. The mechanism studies aimed to explain the adoption of technology using existing theory, or in the rare cases, advancing theory (AuthorC, 2009, 2010, 2011a). However, the selection and contextualization of some theories was questionable, since these rationales were not explicitly stated in all papers (Ashraf, et al., 2010; Hwabamungu & Williams, 2010). In three studies, the theoretical investigation concluded with an emphasis on outputs such as improved communication or greater efficiency within the healthcare system (Ashraf, et al.,
2010; AuthorC, 2011b, 2012a). All these studies showed the potential of mobile phones but apart from two (Chang, et al., 2011; Zurovac, et al., 2011), (categorized in the outputs studies) did not address quantitative impacts on healthcare.

**Outputs**

The final set of outputs studies (Chang, et al., 2011; Chen, et al., 2008; da Costa, et al., 2010; de Tolly, et al., 2012; Jareethum, et al., 2008; Kunutsor, et al., 2010; Leong, et al., 2006; R. T. Lester, et al., 2010; Liew, et al., 2009; Odigie, et al., 2011; Piette, et al., 2011; Pop-Eleches, et al., 2011; Prasad & Anand, 2012; Seidenberg, et al., 2012; Zurovac, et al., 2011) [n=15] was most relevant to policy, providing some indications of improved patient health outputs, and healthcare process improvements. Table 3 describes these studies in detail. These studies mainly used a randomized (Chen, et al., 2008; da Costa, et al., 2010; de Tolly, et al., 2012; Leong, et al., 2006; R. T. Lester, et al., 2010; Liew, et al., 2009; Pop-Eleches, et al., 2011) or cluster-randomized (Chang, et al., 2011; Zurovac, et al., 2011) controlled trial study designs.

Patient outcomes were related to medication adherence (Kunutsor, et al., 2010; R. T. Lester, et al., 2010; Pop-Eleches, et al., 2011), HIV counselling and testing (de Tolly, et al., 2012; Seidenberg, et al., 2012), HIV virology (Chang, et al., 2011; R. T. Lester, et al., 2010), mortality (Chang, et al., 2011), retention (Chang, et al., 2011), diabetes (Piette, et al., 2011), and pregnancy (Jareethum, et al., 2008). The study (represented by three papers) (Chang, et al., 2011; Chang et al., 2008; Chang et al., 2010) using the healthcare communication (described earlier in mechanism section) found no significant impact on HIV virologic outcomes, adherence to antiretroviral therapy, mortality, or retention (Chang, et al., 2011). Two randomized controlled trials in Kenya sent antiretroviral therapy reminder SMSs to people living with HIV,
and concluded that recipients significantly improved antiretroviral therapy adherence (R. T. Lester, et al., 2010; Pop-Eleches, et al., 2011), with one study (represented by four papers) (R. Lester & Karanja, 2008; R. T. Lester, Gelmon, & Plummer, 2006; R. T. Lester et al., 2009; R. T. Lester, et al., 2010) also showing improvements in HIV viral load suppression (R. T. Lester, et al., 2010). Health promotion SMSs for prenatal support found no significant differences in pregnancy outcomes in Thailand (Jareethum, et al., 2008).

Organisational outputs were reported by three randomized controlled trials (Chen, et al., 2008; Leong, et al., 2006; Liew, et al., 2009; Zurovac, et al., 2011), and other studies used varied designs (da Costa, et al., 2010; Kunutsor, et al., 2010; Odigie, et al., 2011; Prasad & Anand, 2012; Seidenberg, et al., 2012), with evidence of higher appointment attendance rates in the group receiving SMS and/or calls. A cluster randomized controlled trial represented by two papers (Jones, et al., 2012; Zurovac, et al., 2011), sent SMSs on infant malaria case-management to health workers and found that medication management by health workers improved (Jones, et al., 2012; Zurovac, et al., 2011). Four studies (Chang, et al., 2008; Chen, et al., 2008; de Tolly, et al., 2012; Leong, et al., 2006) provided information on costs, but none of the studies reported a full economic cost-effectiveness analysis.

Discussion

This review found 53 mHealth studies in developing countries: 32 input studies, six mechanism studies, and 15 outputs studies. On the one hand, it is encouraging to see the growing body of evidence related to mHealth in developing countries. On the other, it is evident that social scientific studies explicating processes of technology adoption are less emphasized within this body of research, compared to technology introduction, and improvements in healthcare process and indicators. One
result of this emphasis is the relative paucity of critical studies discussing reasons for failure, leading to stances bordering on technological determinism.

We found several gaps in the understanding of mobile interventions in healthcare, as conceptualized by the input-mechanism-outputs model, for example, of explanatory theory, and of sociological determinants of health outcomes. Few studies used theory or methodological designs (Ashraf, et al., 2010; AuthorC, 2011b, 2012a, 2012c; Hamilton, 2010; Hwabamungu & Williams, 2010), to explain why people would use mobile phones for healthcare needs, or link technological inputs to outputs (Chang, et al., 2011). When evident, a cross-disciplinary approach led to borrowing of theory from different disciplines, with no dominant theory. The behaviour-change theories utilized failed to account for context (Hwabamungu & Williams, 2010), particularly sociological factors such as culture and gender, essential for evaluating factors influencing how and why interventions work (T. Svoronos & Mate, 2011). Studies mainly utilized academically oriented measures (e.g. response rate, data accuracy) rather than measures prescribed by trans-national organizations (United Nations or the World Health Organization) such as the Millennium Development Goals indicators.

Most studies reported one or two stages of the pathway. Three studies (Chang, et al., 2011; R. T. Lester, et al., 2010; Pop-Eleches, et al., 2011) attempted to provide information on the whole pathway, but could not satisfactorily explain the theoretical mechanisms for technology adoption. Not a single study was able to provide a theoretical explanation for technology adoption that resulted in a healthcare system outcome. While it might be too early to expect comprehensive studies dealing with the complexity of linking concepts across the entire pathway, we expect mHealth
scholars to bridge disciplinary boundaries to provide such compelling evidence in the future.

Literature reviews over the past years have shown a lack of data on the effectiveness of mHealth in low- and middle-income countries in general (Blaya, Fraser, & Holt, 2010; Kaplan, 2006), and for specific purposes such as behaviour change interventions (Cole-Lewis & Kershaw, 2010; Fjeldsoe, et al., 2009), diabetes control (Liang et al., 2011), sexual health (Lim, et al., 2008), maternal healthcare (Noordam, Kuepper, Stekelenburg, & Milen, 2011; Tamrat & Kachnowski, 2012), and smoking cessation (Whittaker et al., 2009). Reported improvements of mHealth interventions on established health indicators were very limited, as were descriptions of cost-effectiveness or adverse effects. Certainly policymakers would expect greater explication of financial feasibility and mitigating factors for possible failures prior to engaging with the discipline.

The literature suggests that some projects are being scaled up to a national level without the necessary evidence from high-quality evaluation (Jordan, Ray, Johnson, & Evans, 2011; Novartis, 2011). It might be too early to do so without a systemic review of the varied mHealth initiatives. Early selection and failure of the wrong initiative, by extension of association, harms the entire field. If policymakers invest in mHealth projects, a fair amount should be reserved for evaluation purposes. Groups such as the mHealth Alliance and World Health Organisation are organizing efforts to ensure mHealth projects are guided by evidence, and avoid duplication (WHO, 2011a).

We found an encouraging growing body of knowledge about mHealth in low-resource setting of developing countries. It is, nonetheless, the appropriate time to acknowledge that the current crop of studies is not delivering the results aimed for.
Future work needs to aim for establishing technological, theoretical, and measurement standards. There is a need to consider all aspects of the input-mechanisms-outputs pathway to produce a comprehensive picture of how mobile phones can improve healthcare in low- and middle-income countries.

Researchers at the input level, primarily information technologists, need to determine the precise problems to be addressed not just from the viewpoint of technological input, but rather from both sociological and healthcare needs perspectives. Social science researchers should make choices for evaluation in terms of appropriate study design, providing clear evidence of outputs. This group should aim to make their approach relevant to technologists interested in the sociological context within which mHealth projects are conducted. Finally, public health officials need to examine the specific measures identified by policymakers for inclusion in research designs. In conclusion, an obvious recommendation is greater collaboration across disciplinary boundaries, or risk fracturing into marginalized silos. The emergent field of mHealth in developing countries is slowly gaining traction, yet can gain credibility and the confidence of practitioners and policymakers with a more organized approach to dissemination of the results. This review offers one such early attempt.
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**Legend**

*Proposed pathway of research focus for mHealth studies as a heuristic within which this review is situated. The blue boxes indicate the three categories of the pathway; the white boxes give examples of factors belonging to those categories.*
<table>
<thead>
<tr>
<th>Paper (first author, year)</th>
<th>mHealth category</th>
<th>Health purpose</th>
<th>Location</th>
<th>Intervention</th>
<th>Evaluation</th>
<th>Target</th>
<th>Selected Input factors</th>
<th>Selected Mechanism factors</th>
<th>Selected Output factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrington 2010</td>
<td>Data collection health worker</td>
<td>Malaria</td>
<td>Rural Tanzania</td>
<td>Mobile system for anti-malarial-stock counts</td>
<td>Pilot study, quantitative</td>
<td>129 health facilities</td>
<td>- Stock count data provided in 95%</td>
<td>- Use of personal mobiles</td>
<td>- Proportion of health facilities with no stock of one or more anti-malarial medicine fell from 78% at week 1 to 26% at week 21</td>
</tr>
<tr>
<td>Asiimwe 2011</td>
<td>Data collection health worker</td>
<td>Malaria</td>
<td>Rural Uganda</td>
<td>SMS-based malaria reporting system; RapidSMS™</td>
<td>Implementation evaluation, quantitative</td>
<td>140 clinics</td>
<td>- Set-up cost $100 USD/health facility, local technician support $400 USD per month, and cost of $0.53 USD/week/clinic</td>
<td>- With exception of few clinics, all were within reliable coverage areas</td>
<td></td>
</tr>
<tr>
<td>Andreatta 2011</td>
<td>Data collection health worker</td>
<td>MNCH; postpartum haemorrhage</td>
<td>Rural Ghana</td>
<td>SMS-based</td>
<td>U</td>
<td>10 traditional birth attendants</td>
<td>- Traditional birth attendant EBIAs were able to use the specified reporting and SMS protocols; 425 births and 13 (3.1%) cases of postpartum haemorrhage were reported during the 90-day period after training</td>
<td>- With exception of few clinics, all were within reliable coverage areas</td>
<td></td>
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<tr>
<td>Alam 2010</td>
<td>Data collection</td>
<td>MNCH</td>
<td>Urban Bangladesh</td>
<td>Mobile application for U</td>
<td>3 centurient</td>
<td>10</td>
<td>- App was said to be more efficient than existing system; reducing interview time</td>
<td>- With exception of few clinics, all were within reliable coverage areas</td>
<td></td>
</tr>
<tr>
<td>Author: Svoronos</td>
<td>Data collection method</td>
<td>MNCH</td>
<td>Rural, Tanzania</td>
<td>Mobile application</td>
<td>‘CommCare’ for managing health workers day and report data on pregnant women in real time.</td>
<td>U</td>
<td>5 community health workers</td>
<td>Data collection method</td>
<td>patients</td>
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<tr>
<td>2011</td>
<td>health worker</td>
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<td>No time delays for input of data and no incomplete data input -module showed reduced cost than the automation card system (without data)</td>
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<td>-pilot submission data</td>
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<td>-problem of resubmitting forms that were not initially send due to network problems</td>
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<tr>
<td>Author:</td>
<td>Data collection method</td>
<td>MNCH</td>
<td>Rural, China</td>
<td>Mobile application</td>
<td>for collecting data on</td>
<td>Study comparing mobile phone and paper-and-pen methods</td>
<td>120 mothers of infants aged 0 to 23 months in four village clinics</td>
<td>No significant difference in inter-rater reliability between the methods for the questionnaire pairs (P=0.32) or variables (P=0.45)</td>
<td>-the mobile phone data collection</td>
</tr>
<tr>
<td>2012</td>
<td>health worker</td>
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<td></td>
<td>No data entry errors in mobile questionnaires, while 65% of paper questionnaires had data entry errors only minor problems were encountered (e.g. the system halted for a couple of seconds or it shut off), which did not result in data loss</td>
<td></td>
<td></td>
<td>-mean duration of an interview was not significantly different between the methods (P=0.19)</td>
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<td>-mean costs per questionnaire were higher for the mobile questionnaire ($23 USD) than for the paper questionnaires ($13 USD)</td>
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</tr>
<tr>
<td>Svoronos,</td>
<td>Data collection method</td>
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<td>-mean costs per questionnaire were higher for the mobile questionnaire ($23 USD) than for the paper questionnaires ($13 USD)</td>
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</tr>
<tr>
<td>Rajatonirina</td>
<td>Data collection method</td>
<td>MNCH</td>
<td>Rural, Madagascar</td>
<td>Innovative case reporting system based on the use of mobile phones</td>
<td>Lessons learnt: evaluation</td>
<td>Data collected: daily from 34 sentinel centres corresponding to 862585</td>
<td>36.7% of the data were transmitted within 24 hours: 95.401 cases (11.1%) presented with fever; a special form was completed for 80,691 of these patients (84.6%); -costs less than $2 USD per month per sentinel centre, and each centre’s mobile phone equipment costs a mere $10 USD</td>
<td>-motivation has been maintained through the provision of medical equipment and training opportunities</td>
<td>-daily syndromic surveillance using SMS can effectively enhance surveillance systems in place.</td>
</tr>
<tr>
<td>2012</td>
<td>health worker</td>
<td></td>
<td></td>
<td></td>
<td>-motivation has been maintained through the provision of medical equipment and training opportunities</td>
<td></td>
<td></td>
<td>-combined biological surveillance and syndromic surveillance using SMS</td>
<td></td>
</tr>
</tbody>
</table>

**Comment [Shuyi1]:**
The figure 143 Yuan to 45 USD is a mistake, with the exchange rate is about 6.5. Please see my comments in Table 5. 143 Yuan/23 USD is the cost for per questionnaire. 45 USD is the cost for per interview case of a pair of questionnaires.

**Comment [Shuyi2]:**
Because this is the...
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Data Collection</th>
<th>Disease</th>
<th>Region</th>
<th>Mobile Application</th>
<th>Pilot Study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ganesan</td>
<td>2011</td>
<td>Health worker + health promotion</td>
<td>Influenza</td>
<td>Rural India</td>
<td>mHealthSurvey on mobile phone to collect and transmit patient health records</td>
<td>Pilot study</td>
<td>It is possible to rapidly detect the circulation of the influenza virus in areas under surveillance by detecting unusual patterns of disease activity. Sentinel SMS surveillance using SMS can quicken the response to disease outbreaks.</td>
</tr>
<tr>
<td>Kaewkugwal</td>
<td>2010</td>
<td>Data collection + patient appointment reminder</td>
<td>MNCH</td>
<td>Rural Thailand</td>
<td>Mobile application for collecting health info about pregnant women</td>
<td>Before-after design without control group</td>
<td>10% of women received reminder for antenatal visit. 17% of the child’s parents received immunization reminders. 10% of health workers updated antenatal status on phones. 45% updated child’s immunization information. No change in work routine facilitated the intervention. Health workers seeing usefulness of data collection was important.</td>
</tr>
<tr>
<td>MOTECH</td>
<td>2011</td>
<td>Data collection + health promotion</td>
<td>MNCH</td>
<td>Rural Ghana</td>
<td>Mobile application informing health workers and pregnant women + interactive voice calls for health information</td>
<td>Initial implementation evaluation</td>
<td>Nurse handset, SMS, Java, Content creation process, 54% patients owned a mobile. Great demand for maternal and child health information and participants seemed very comfortable receiving this via mobile. Nurse policy, Nurse incentives, need for constant encouragement for nurses. Women preferred calls over SMS. Women wanted to receive information in their local languages.</td>
</tr>
<tr>
<td>Haberer</td>
<td>2010</td>
<td>Data collection</td>
<td>HIV</td>
<td>Uganda</td>
<td>Interactive voice response</td>
<td>Randomized trial, no</td>
<td>Weekly completion rates for adherence queries were low (0–33%). Calls and SMSes served as an adherence reminder.</td>
</tr>
<tr>
<td>Patient calls and SMS for automated collection of weekly individual-level ART adherence data</td>
<td>Control but two intervention studies were compared, qualitative interviews</td>
<td>Caregivers in the CHARTA Study who had their own mobiles</td>
<td>Technologies were acceptable</td>
<td>-misunderstanding of personal identification numbers -challenges in training</td>
<td></td>
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</tbody>
</table>

**Table**

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Setting</th>
<th>Mobile Technology</th>
<th>Client Feedback</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>LeMay 2012</td>
<td>Consultation between health workers – data collection</td>
<td>Family planning / reproductive health and HIV/AIDS</td>
<td>SMS system to improve the exchange and use of knowledge among health workers</td>
<td>Baseline evaluation with quantitative and qualitative methods</td>
<td>Mobile phones provided to 253 health workers, 35 focus group discussions</td>
</tr>
</tbody>
</table>

**Notes**

- Skinner 2007 (Cell Life program)
- Consultation between health workers – data collection

**Findings**

- Mobiles were acceptable
- Mobile did not interfere or distract with relationship between counsellor and patient
- Improvements in technology gave additional security
- Feeling good because their work integrated them better into the community
- Having mobiles, a status item, raised status
- No feeling of pressure at being on call 24-hours-a-day and keeping the mobile on all the time
- Fear of crime as the mobile meant counsellors were more at risk for theft
- Positive impact on record keeping
- Feel more effective and secure in role due to rapid help

**Summary**

- Information exchange between the district and community levels can directly affect the quality of care patients receive
<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Country</th>
<th>Implementation</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cole-Ceesay 2010</td>
<td>Consultation between health workers</td>
<td>The Gambia</td>
<td>Emergency ambulance service linking the community with the hospital through a mobile system.</td>
<td>Traditional birth attendants and village health workers. Mobiles with longer battery life overcame charging difficulties.</td>
</tr>
<tr>
<td>Chandhan Ayingyong 2006</td>
<td>Consultation between health workers</td>
<td>Thailand</td>
<td>Teleconsultation via MMS in emergency orthopaedic patients</td>
<td>Case-control, age-matched: 59 emergency orthopaedic cases, 34 normal patients visiting the emergency department. Teleconsultation via MMS demonstrated good reliability, but poor diagnostic accuracy; sensitivity, specificity and accuracy were 78%, 54% and 65%, respectively. Overall misdiagnosis rate of 40%, with over-diagnosis of 12% and under-diagnosis of 27%.</td>
</tr>
<tr>
<td>Macrophon 2010</td>
<td>Consultation between health workers</td>
<td>General Rural Philippines</td>
<td>Telecommunication, including mobiles, for referral</td>
<td>Survey: 3 health officers and 39 patients. Generally satisfactory, some concerns about time taken for response after SMS referrals, and expenses of the entire system. Overall satisfaction of using mobile tools was greater for the iPhone.</td>
</tr>
<tr>
<td>Zolfo 2010</td>
<td>Consultation between health workers - Education health workers</td>
<td>Peru</td>
<td>Mobile educational platform supporting learning events and tracking participant learning progress</td>
<td>Survey: Twenty physicians. Overall satisfaction of using mobile tools was greater for the iPhone.</td>
</tr>
<tr>
<td>Afzar 2012</td>
<td>Consultation between health workers and HIV</td>
<td>Botswana</td>
<td>Mobile teledermatology consultation</td>
<td>Survey: 75 people living with HIV. Concerns: 82% reported no concerns, 8% reported concerns over not having a face-to-face interaction with the physician and 8% reported concerns over an incomplete teledermatology consultation as a quality of care. 91% believed that they would receive the same treatment and quality of care via mobile teledermatology consultation as with a face-to-face interaction with the physician.</td>
</tr>
</tbody>
</table>
### Patients

- **L'Engle 2009**
  - **Health promotion**: Family Planning
  - **Urban**: Tanzania and Kenya
  - **No intervention**: No intervention
  - **Aim**: Perspectives on SMS for info on family planning
  - **Qualitative interviews**: 40 clients in family planning clinics
  - **-common use of SMS**
  - **-sharing of mobiles, possibility of others reading SMS**
  - **-privacy of service**
  - **-share SMS with family and friends**
  - **-SMS seen as trustworthy**
  - **-SMS reminder of information**
  - **-less costs than visiting clinic**

- **Mitchell 2011**
  - **Health promotion**: HIV
  - **Urban**: Rural Uganda
  - **No intervention**: No intervention
  - **Aim**: Perspectives on SMS for HIV prevention
  - **Survey**: 1523 students
  - **-27% percent owned mobile**
  - **-of adolescents owning mobile 93% had sent a SMS in the past 12 months**
  - **-19% of adolescents who had sent or received SMS in the past year said that they sent a SMS on their mobile to get information about health and disease in the last 12 months.**
  - **-51% said they were somewhat or extremely likely to access a health education program about HIV/AIDS prevention via SMS**

- **Danis 2010**
  - **Health promotion**: HIV
  - **Urban**: Uganda
  - **HIV prevention quiz by SMS**
  - **Analysis of quiz responses**: 10,000 mobile numbers in -Participation rates varied from a low of between 5% and 10% in general population to around 50% in the Factory Quiz

### Face-to-face interaction

- **91% believed that they would receive the same treatment and quality of care via mobile teledermatology consultation as with a face-to-face interaction**
- **-privacy was guaranteed, 99% were completely comfortable with a mobile teledermatology consultation**
- **-concerns: 82% reported no concerns, 8% reported concerns over not having a face-to-face interaction with the physician and 8% reported concerns over an incomplete representation of their skin or poor photograph quality**
- **-acceptability: 58% accepted photography of the face, 97% chest, 92% genitals, 96% legs and 95% body as a whole**
- **-preferences: 85% reported that reduced cost of travel and 66% reduced time away from home or work as the benefits that would make them prefer mobile teledermatology consultations, 13% would not prefer mobile teledermatology over face-to-face consultation**
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Health Prom</th>
<th>Country</th>
<th>Study Description</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Findings</th>
<th>Discussed Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chib</td>
<td>2011</td>
<td>Health promotion</td>
<td>Uganda</td>
<td>HIV prevention quiz (13 questions) by SMS</td>
<td>Analysis of quiz responses</td>
<td>10,000 mobile numbers in general population</td>
<td>One-fifth of mobile subscribers responded to any of the 13 questions</td>
<td>Discussed factors: - making SMS part of an integrated mass-media communication campaign - stigmatization could be a strong obstacle to participation in the program - lower likelihood of mobile ownership for certain groups, particularly for rural women - self-selection bias into incentive based quizzes</td>
</tr>
<tr>
<td>Maharani</td>
<td>2012</td>
<td>Health information</td>
<td>Indonesia</td>
<td>Two paid services: 1 advice on affordable pharmaceutical drug options via SMS 2 personal health information via SMS</td>
<td>1. survey 2. survey and in-depth interviews</td>
<td>130 users 2. pregnant women and mothers who received a free one month prescription 28 (survey), 8 (interview)</td>
<td>1. - program provided accurate data, which participants said helped them with making decisions when selecting price of subscribing to SMS info program was affordable as it saved them money 2. - health information is easy and fast to access; price of receiving the SMS is a big factor affecting their decisions to keep the subscriptions, many did not want to pay for the health information subscription 3. - health information received was relevant; detailed information rather than short summarized information was much preferred</td>
<td>Discussed factors: 2. - some reported behaviour changes after reading health tips; increased confidence among users in sharing health information with their families peers, and neighbors; some reported greater levels of assurance when their doctors provided the same information as in the SMSs; indication of increased information-seeking behaviors</td>
</tr>
<tr>
<td>Curioso</td>
<td>2007</td>
<td>Medication adherence reminder</td>
<td>Peru</td>
<td>No intervention Aim; Access, use and perceptions regarding</td>
<td>In-depth interviews</td>
<td>31 people living with HIV at 2 clinics</td>
<td>- 77% were using mobiles - 6% used their mobiles to send and receive SMSes - 23% were using the alarms to remind to take their medication</td>
<td>- 81% were interested in receiving health information by mobiles - 74% reported willingness to use mobiles to receive reminder messages for their HIV medication, by a pre-</td>
</tr>
<tr>
<td>Year</td>
<td>Study Type</td>
<td>Country</td>
<td>HIV Status</td>
<td>Study Description</td>
<td>Methods</td>
<td>Findings</td>
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<td>Curioso 2009</td>
<td>Medication adherence reminder</td>
<td>Peru</td>
<td>HIV</td>
<td>No intervention Aim; perspectives on reminder strategies to improve antiretroviral treatment adherence and SMSs</td>
<td>Four-focus groups</td>
<td>- Internet, cell mobiles and PDAs recorded voice (74% of those willing) or by SMS (74% of those willing). - Alarm reminders most useful for antiretroviral treatment naïve patients - 81% expressed their interest in receiving SMSes about their sexual health over the mobile, including information about sexually transmitted infections - Of those, 88% would prefer sexual health messages via SMS 68% via calls with a pre-recorded voice. - Many said they would like to receive general HIV information via mobiles</td>
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</tbody>
</table>
| Shet 2010 | Medication adherence reminder | India | HIV | No intervention Aim; perspectives mobile intervention for improving antiretroviral treatment | Survey | - 322 persons participated at the three clinics, 81% were HIV-infected patients in 73.1% owned mobile, and 55% used mobiles for over 2 years. - Use of mobile; calls approximately 4 times a day, SMS used by 25% - 74% (95% CI: 69.2–78.8) thought SMS reminder feature would be helpful in maintaining adherence - 89% did not perceive SMS reminders as an intrusion on privacy - 79.5% (P<0.005) wanted to use their mobile to call health worker - 62% wanted receive info on the
<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Population</th>
<th>Country</th>
<th>Methodology</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbuagba 2012</td>
<td>Medication adherence reminder</td>
<td>HIV</td>
<td>Cameroon</td>
<td>No intervention</td>
<td>Five focus groups; 30 people living with HIV - ten of 30 declared that they had some difficulty with medication adherence - preferred reminders varied but most preferred were beeps, alarms, SMSs, or personal verbal reminders - 50% (15 of 30) of the participants believed that the SMS could help them take their medication but that the value of the SMS would depend on the sender - no consensus on the content or number of the message issues; poor network, possibility of dependence on the SMS, and poor adherence in its absence</td>
</tr>
<tr>
<td>Sidney 2012</td>
<td>Medication adherence reminder</td>
<td>HIV</td>
<td>India</td>
<td>Weekly interactive call and a non-interactive neutral pictorial SMS on mobile phones</td>
<td>Survey; 139 people living with HIV - 86% owned a phone - sharing a phone was associated with being female (OR 5.97; 95% CI: 2.1-17.0) or unemployed (OR 4.4; 95% CI: 1.5-13.1) - 93% knew how to make and receive a call - 86% knew how to receive and 47% how to send a SMS - 744 calls were made, 545 (76%) of which were received - all participants received the weekly pictorial SMS reminder - 90% reported the intervention as being helpful as medication reminders, and did not feel their privacy was invaded - 87% reported that they preferred the call as reminders, 11% preferred SMS alone - 59% viewed all the SMSs that were delivered, 15% never viewed any at all - no discomfort or stigma was experienced despite that other persons sometimes received the participant’s call (20%) or SMS (13%)</td>
</tr>
</tbody>
</table>
| De-Renzi 2012 | Appointment reminder health workers | Chronic conditions, mainly HIV | Tanzania | Pilot study (1) and two (2-3) randomised controlled studies | 1.13 community health workers 2.87 health workers 3 same 87 health 1.intervention: increase in ‘closed referrals’ by 33.8%; control: decrease by 34.6% 2.intervention group: 86% reduction in the average number of days a community health worker’s clients were overdue (9.7 to 1.4 days); control: no significant change between baseline and after the intervention (8.2 days to 9.3 days) - comfortable with daily SMSs - personal relationships were an important factor of success - community health workers ‘understood what was happening and were comfortable enough to tell the supervisor’ - most common reasons for overdue
<table>
<thead>
<tr>
<th>Wolpaw 2010</th>
<th>Test result reminder</th>
<th>HIV</th>
<th>Urban South Africa</th>
<th>Reminding patients who do not return for HIV test results with text messages and phone calls</th>
<th>Face-to-face interview</th>
<th>902 high risk participants enrolled over 1 year</th>
<th>-40.6% came back for results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>results and counselling were delivered to 62.3% of participants and all six patients with AHI. Six (0.67%) were diagnosed with AHI.</td>
</tr>
</tbody>
</table>

| Crankshaw 2010 | Appointment and medication adherence reminder | HIV | Urban South Africa | No intervention; perspectives on mobiles for clinic appointment reminders and adherence messages. | Survey | 300 individuals who presented for treatment at the ART clinic | -28% shared mobile with one or more other people |
|               |                                                 |     |                   |                                                                                     |         |                      | -87% indicated that they usually answered calls that displayed ‘private number’ |
|               |                                                 |     |                   |                                                                                     |         |                      | -79% use of the mobile alarm function for remembering to take medication |
|               |                                                 |     |                   |                                                                                     |         |                      | visit were that health worker was travelling, busy or forgot |
|               |                                                 |     |                   |                                                                                     |         |                      | -escalation; health workers were not always available when called by supervisor, local ‘champion health workers’ were used to reach them |
|               |                                                 |     |                   |                                                                                     |         |                      | -fewer health workers required escalation calls over time |

<table>
<thead>
<tr>
<th>Faisal 2012</th>
<th>General</th>
<th>General</th>
<th>Bangladesh</th>
<th>No intervention; impact assessment on existing mobile healthcare support</th>
<th>Surveys, telephone interviews</th>
<th>Ten families and 5 doctors</th>
<th>-90% of families had a mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>-30% of families were aware of local mobile health services</td>
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<td>-40% of families rely on mobile health services</td>
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<tr>
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<td></td>
<td>-doctors receive about 10-20 calls a day</td>
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<td></td>
<td>-doctors experience difficulties in diagnosing patients over the telephone but are able to provide basic advice</td>
</tr>
</tbody>
</table>

- Wolpaw 2010: Test result reminder
- Crankshaw 2010: Appointment and medication adherence reminder
- Faisal 2012: General
<table>
<thead>
<tr>
<th>Paper (first author, year)</th>
<th>mHealth category</th>
<th>Health purpose</th>
<th>Location</th>
<th>Intervention</th>
<th>Evaluation</th>
<th>Target</th>
<th>Theory, framework, model</th>
<th>Constructs in bold, findings in normal fond</th>
<th>Constructs of models not given</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hwabamungu 2010</td>
<td>Potential in general for patients and health workers</td>
<td>HIV</td>
<td>South Africa</td>
<td>No intervention</td>
<td>Structured interviews</td>
<td>42 patients and 13 staff members or caregivers</td>
<td>Models: Extended TAM (Davis, 1989); Task Technology Fit (Goodhue 1995), Fit between Individuals, Tasks and Technology (Ammenwerth 2006), and Unified Theory of Acceptance and Use of Technology (Venkatesh 2003)</td>
<td>Appropriateness of chosen technology; mobile phones possession— for example—is high mobile ownership (51/55) use their mobile as tool to improve service provision access (46/55)</td>
<td>Patients’ and caregivers’ willingness to use the technology does not mean preparedness for paying costs Government and donor support critical to ensure free service which people expect Importance of financial sustainability model</td>
</tr>
<tr>
<td>Hamilton 2010</td>
<td>Health promotion</td>
<td>General</td>
<td>Rural Kenya</td>
<td>No intervention</td>
<td>Survey + participant observation such as in-depth interviews</td>
<td>12 Kenyan-based experts and practitioners, 55 residents</td>
<td>Theory: Social marketing (Hastings 2007)</td>
<td>Survey findings (villagers) on: Profile of the Village In-depth interview findings (experts): Profile of Expert Respondents</td>
<td>Price - cost prohibitive Promotion - text messages Product - goal of changing health behaviour Place - practicability of a mobile phone Survey findings (villagers) on: Educational Attainment’s Role in Mobile Phone Ownership and Use Literacy in Relation to Mobile Phone Ownership and Use Relationship between Media Consumption and Mobile Phone Ownership and Use Access to Mobile Phones by Gender In-depth interview findings (experts) on: Gender and Access to Mobile Phones The Impact of Price on Mobile Phone Ownership and Use</td>
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</tbody>
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**Cost of Airtime**
- Cost to Health Provider
- Cost to User
- Cost of Electricity
- Psychological Cost
- Mobile phones, health and behaviour change
- Surveillance
- Role of the indigenous leadership
- Mobile and media partnership
- Literacy rates vis-à-vis mobile phone ownership and use

**Cost to Health Provider**
- Need for communication for administration but barrier of late information
- Importance of training but barrier of time and distance

**Cost to User**
- Convenience of time lost and perceived emotional distance

**Spatio-temporal**
- Remote areas led to gaps in information retrieval, and delivery of services
- Convenience of time lost and perceived emotional distance

**Psychological Cost**
- Role of gender was complex, acting as a supporting factor as well as a hindrance

**Infrastructure**
- Widespread coverage mobile connectivity

**Economic**
- Most owned mobiles, despite government only providing handful of them

**Technological**
- Initial difficulties when learning to use the mobile phone

**Socio-cultural**
- Role of gender was complex, acting as a supporting factor as well as a hindrance

**Opportunity producer**
- Greater time efficiency and savings, as opposed to generating income, for community health workers

**Capabilities enhancer**
- Mobiles greatly improved flow of communication within the healthcare infrastructure, especially during emergencies

**Social enabler**
- Broadening their social and professional circles

**Knowledge generator**
- Rural healthcare workers

**Framework: ICTs for healthcare development (Banuiri 2003)**
and 11 patients

rapidly and easily accessed healthcare information, through the usage of mobiles

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Consultation</th>
<th>MNCH</th>
<th>Rural</th>
<th>Mobile</th>
<th>Focus</th>
<th>123</th>
<th>Framework:</th>
<th>Barriers</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author C</td>
<td>n between health workers</td>
<td>Indonesia</td>
<td>phones and free monthly call credits were distributed to midwives</td>
<td>SMS-based application using GPRS preloaded on mobiles for uploading patient info</td>
<td>midwives in an experimental group; 101 in control group</td>
<td>ICTs for healthcare development (Banuri 2003)</td>
<td>1. Infrastructural - uneven telecommunications 2. Economic - cost mobile and credit 3. Technological - midwives lacking technical knowledge - lack of relevant local content (English) 4. Socio-cultural - midwives were given equal opportunities to communicate with ICT - no religious resistance - barrier of organisations hierarchy</td>
<td>1. Opportunity producer: - increase patient numbers, not in higher income - patient easier getting hold of midwife - midwife greater time and cost efficiency 2. Capabilities enhancer - enhancing ability handling medical situations 3. Social enabler - enhance midwife relationship with village community - enhance midwife relationship with colleagues and superiors in health care 4. Knowledge generator - improved medical knowledge - midwives sharing medical knowledge with patients</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Theory:</th>
<th>Autonomy vs. Subordination</th>
<th>Autonomy vs. Subordination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author C</td>
<td>dialectical perspective on gender arising from technology introduction</td>
<td>Constraints: denial of women’s needs, masked inequalities Resolution: used strategies to legitimize benefits and acknowledge constraints Personal growth vs. Limited technological competency</td>
</tr>
<tr>
<td></td>
<td>Constraints: domestic role limits time for training, low access to technology, fear to speak up Resolution: attempted to work around the limitations of time, used informal learning groups Economic independence vs. Constraints earning capabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constraints: generalized poverty,</td>
<td>Constraints earning capabilities</td>
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<tr>
<td></td>
<td>Benefits: opportunity to make decisions, realization of usefulness of mobiles</td>
<td></td>
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<td></td>
<td>Personal growth vs. Limited technological competency</td>
<td></td>
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<tr>
<td></td>
<td>Benefits: mobile phones provide learning material, discuss and share knowledge</td>
<td></td>
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<td></td>
<td>Economic independence vs. Constraints earning capabilities</td>
<td></td>
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<tr>
<td></td>
<td>Benefits: increased efficiency in profession</td>
<td></td>
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<tr>
<td></td>
<td>Appropriation of power vs. Hierarchical control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Benefits: access to power at top, recognition of</td>
<td></td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Methodology</td>
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<tr>
<td>Chib</td>
<td>2009</td>
<td>and follow up survey</td>
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<td>Chib</td>
<td>2010</td>
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</table>
colleagues (83.9%).
- collective ties between the midwife for trust (94.2%) and support (83.4%).
- 90.2% were heavily relied on to help in medical situations, compared to obstetrician-gynaecologists (63.7%), corresponding to the degree of satisfaction with the information gained from them (midwives, 76.7%; obstetrician-gynaecologists (66.6%).
- both midwife (91.9%) and obstetrician-gynaecologists (88.8%) are seen as fairly equal in terms of the relevancy of information that midwife seek during work.
- social contacts and written material functioned as most common modes of obtaining information, with electronic means lagging behind.
- traditional methods, where accessibility, approachability and trust play a major role in shaping the efficacy of assimilating information.

4. Knowledge generator
- knowledge family planning moderate, knowledge of pregnancy related issues lower, 23.9% already used the mobile phone often for obtaining relevant information (compared with 2.2 internet).
- 90% confident to use mobile for information, 85% relevant to their needs, and 70.5% felt that it would influence the way seeking medical advice.

3. Social enabler
- more likely to turn to health centre personnel for medical information needed (p=0.09) and access health information from the health centre using their mobiles (p=0.09).
- improved relationship across the levels of the healthcare system hierarchy.
- quicker access to midwife for patients.

2. Access to institutional resources;
- access to institutional resources had a direct positive effect on midwives' health knowledge, access to institutional resources did not increase self-efficacy.

1. Mobile phone use; midwives' mobile phone use was positively associated with access to both institutional and peer-network resources.

Baseline survey midwives Hypothesized model of midwives’ mobile phone use, access to resources, self-efficacy, and health knowledge mobile phone use was positively associated with access to both institutional and peer-network resources.

Format: Font: Not Bold
<p>| Ashraf 2010 | Health information for patients | General Rural Bangladesh | Health help line service (Grameen Phone) via their mobile phone | Qualitative interviews with storytelling 4 patients and 1 doctor from three villages | Framework: ICT4D value chain model ‘Communications-for-Development’ (adapted from Bertrand 2006) | increased self-efficacy 4. Self-efficacy: self-efficacy was positively associated with health knowledge 5. Health knowledge | 1. Context 4↓-Distance barrier 3↓-Financial barrier 4↓-Language barrier 4↓-Lack of knowledgeable doctors 5↓-Lack of 24 hour service. 6↓-Lack of Health Care 2. Changes in Behavioural Precursors: 4↓-Changes in knowledge and behaviour of both doctors and patients. 3↓-More positive attitude of doctors and patients. 4↓-Reduction of distance and other barriers 3. Changes in behaviour: 4↓-Increase in awareness level 3↓-An efficient alternative for emergency treatment 2↓-More relief patients 4. Broader development impact: 4↓-An effective data base for research 3↓-An important tool for implementing millennium development goals 2↓-Efficient management and administration |</p>
<table>
<thead>
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<th>Location</th>
<th>Intervention</th>
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<th>Target</th>
<th>Selected Input Factors</th>
<th>Selected Mechanism factors</th>
<th>Selected Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang 2011</td>
<td>Consultation between health workers</td>
<td>HIV</td>
<td>Rural Uganda</td>
<td>Quantitative and qualitative analysis of cluster randomised controlled trial + survey of 38 clinic staff</td>
<td>Mobile arm, 4 clusters, 13 health workers, 446 patients Control Arm, 6 clusters, 16 health workers, 524 patients</td>
<td>Qualitative themes:</td>
<td>Health care communication diagram</td>
<td>- Improved but incomplete phone access; patient access - to - phones varied, most patients did not own phones themselves, many had access by phones in the communities (16% owned, phones - 79% previously used a phone) - call costs was a key factor limiting patient communication</td>
<td>- Qualitative themes:</td>
</tr>
</tbody>
</table>
|                            |                   |                |          |              |            |        | Pathways through which mobile phones expedited communication: | - Confidently | - Voice and SMS; patients, peer workers, and staff said that calls on mobiles expedited patient care, improved logistics, save travel time - SMS; may have encouraged patients to improve adherence, task shifting, in contrast to voice calls clinic staff had to first review SMSs on computer before responding - improved peer health worker morale, improve capabilities and job satisfaction, improve peer health worker-staff relationships
<p>| Chang 2010                 |                   |                |          |              |            |        |                      |                           | - Direct - start-up costs were $115 USD with monthly maintenance costs approximately $15 USD per |
| Chang 2008                 |                   |                |          |              |            |        |                      |                           | -44% (17/39) strongly agreed and 56% (22/39) agreed that the peer worker and mobile intervention improved overall health of patients; |</p>
<table>
<thead>
<tr>
<th>Zurovac 2011</th>
<th>Consultation between health workers</th>
<th>Malaria Rural Kenya</th>
<th>One-way SMS about paediatric malaria case-management for adhering to guidelines to health workers</th>
<th>Cluster randomised triial</th>
<th>107 rural health facilities, 119 health workers</th>
<th>Qualitative findings on way (end 2011), suggested factors: -SMS addressing forgetfulness -SMS emphasise the clinical importance of doing tasks -increased the priority of doing the tasks -enhancement of health workers’ feeling that someone is paying attention to their work -increased motivation from the famous quotes and sayings: -Medication management improved by 23.7% (95% CI 7.6–40.0; ( p = 0.004 )) immediately after intervention and by 24.5% (8.1–41.0; ( p = 0.003 )) 6 months follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones 2012</td>
<td>Qualitative study</td>
<td>24 health workers</td>
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<td>The construct of stages of change (based on Prochaska &amp; DiClemente’s 1983 stages of change model) -high acceptance of all components of the intervention, important factors influencing practice were the active delivery of information, the ready availability of new and stored SMSs and the perception of being ‘up to date’ -the SMSs were operating mainly at the action and maintenance stages of behaviour change and achieved their effect by ‘creating an enabling environment and providing a prompt to action for the implementation of case management practices that had already been accepted by the health workers’</td>
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<tr>
<td>Jareethum 2008</td>
<td>Health promotion MNCH Thailand</td>
<td>Two SMSes per week (one Randomised controlled</td>
<td>68 pregnant women; 32</td>
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<td>-feeling of taken cared by satisfaction levels were significantly</td>
</tr>
<tr>
<td>de Tolly 2012</td>
<td>Health promotion</td>
<td>HIV</td>
<td>South Africa</td>
<td>Informational or motivational SMSs to prompt people to go for HIV counseling and testing</td>
<td>Randomised controlled trial</td>
<td>2533 in total: 438 participants in each of the 4 intervention groups (3 and 10 motivational SMSs, 3 and 10 information SMSs), 801 in control group</td>
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<td>2533 in total: 438 participants in each of the 4 intervention groups (3 and 10 motivational SMSs, 3 and 10 information SMSs), 801 in control group</td>
</tr>
</tbody>
</table>

| Odigie 2011 | Health information and appointment arrangements | Cancer | Nigeria | Patients receiving telephone number of Oncologist | Structured interviews after 24 months of intervention | 1160 patients, 219 controls | over 80% found the number very useful, perceived it most valuable to obtain information, to arrange an appointment, as a ‘morale booster.’ Elimination of the cost of transportation and time spent to travel and waiting time -feeling of taken care of -easier for women to make appointment when they need permission from husband |

| Piette 2011 | Health information for patients | Diabetess Rural Honduras | Patients received recorded information in A single-group, pre–post study interviews | 85 patients | -53% of participants completed at least half of their IVR calls and 23% of participants completed 80% or more | -HbA1c levels improved from an average of 10.0% at baseline to 8.9% at follow-up ($p=0.01$) -Self-reported improvements of |
| Spanish during interactive voice calls about diabetes management at baseline and 6 week follow-up | patients: 56% blood sugar control, 66% diet improved, 64% medication adherence, and 89% foot care |

| Lester 2010, 2009, 2008, 2006 | Medication adherence reminder | HIV | Nairobi, Kenya | SMS for ART adherence | Randomized controlled trial protocol | Patients initiating ART, 273 received the intervention; and 265 standard care patients | -acceptance; 191 of 194 patients in the intervention group reported they would like the SMS programme to continue, of whom 188 (98%) said they would recommend it to a friend -many patients in the intervention group also reported that they thought the SMS support service was valuable: 82% nine per cent had access to a phone -12% had ever called or been called by healthcare worker |

| Lester 2010, Lester 2006 | Randomized controlled trial protocol | Patients initiating ART, 273 received the intervention; and 265 standard care patients | -forwarding weekly SMSs to non-intervention participants to share support; confidentiality barriers, preference to talk with clinic staff in person and issues regarding stigma or confidentiality -54% said they would be comfortable receiving HIV-related information by telephone -logistical issues |

<p>| Lester 2009 | Randomized controlled trial protocol | Patients initiating ART, 273 received the intervention; and 265 standard care patients | -adherence to ART reported in 273 patients receiving the SMS intervention compared with 132 of 265 in the control group (RR for non-adherence 0.81, 95% CI 0.69–0.94; P=0.006) -suppressed viral loads reported in 156 of 273 patients in the SMS group and 128 of 265 in the control group, (RR for virologic failure 0.84, 95% CI 0.71–0.99; P=0.04) |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Description of crisis situation</th>
<th>Patients initiating ART, and standard care</th>
<th>Randomized controlled trial</th>
<th>Study outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lester 2008</td>
<td>Description</td>
<td>Randomized controlled trial</td>
<td>Patients initiating ART, 273 received the intervention, and 265 standard care</td>
<td>Acceptance: 191 of 194 patients in the intervention group reported they would like the SMS programme to continue, of whom 188 (98%) said they would recommend it to a friend. Many patients in the intervention group also reported that they thought the SMS support service was valuable.</td>
<td>Adherence to ART reported in 168 of 273 patients receiving the SMS intervention compared with 132 of 265 in the control group (RR for non-adherence 0.81, 95% CI 0.69–0.94; p=0.006). Suppressed viral loads reported in 156 of 273 patients in the SMS group and 128 of 265 in the control group (RR for virologic failure 0.84, 95% CI 0.71–0.99; p=0.04).</td>
</tr>
<tr>
<td>Lester 2006</td>
<td>Survey</td>
<td>111 patients</td>
<td>-89% nine per cent had access to a phone</td>
<td>-54% said they would be comfortable receiving HIV-related information by telephone.</td>
<td>Confidentiality barriers: preference to talk with clinic staff in person and issues regarding stigma or confidentiality.</td>
</tr>
<tr>
<td>Pop-Eleches 2011</td>
<td>Medication adherence reminder</td>
<td>SMS for ART adherence</td>
<td>Patients initiating ART, 4 intervention groups (70, 72, 73, 74 patients respectively), 139 patients control group</td>
<td>-longer SMS reminders were not more effective than either a short reminder or no reminder. -weekly reminders improved adherence, whereas daily reminders did not. -patients losing their mobile and changing numbers</td>
<td>-53% of participants receiving SMS reminders achieved adherence of at least 90% during the 48 weeks of the study, compared with 40% of participants in the control group (p&lt;0.03).</td>
</tr>
<tr>
<td>Kunutsor 2010</td>
<td>Appointment and SMS for HIV</td>
<td>Uganda</td>
<td>Voice calls or SMS for</td>
<td>Combination</td>
<td>Survey 276 patients,</td>
</tr>
<tr>
<td>Medication adherence reminder</td>
<td>Improving clinic attendance and ultimately adherence</td>
<td>Sectional and prospective cohort</td>
<td>Cohort 176 patients</td>
<td>- no confidentiality problems - preference for voice calls as for SMS due to their inability to read because of illiteracy and language barriers. - patients preferring direct patient communication</td>
<td>Within a mean duration of 2.2 days (SD = 1.2 days) after mobile call or SMS - proportion achieving optimal adherence before and after intervention was 141 (80.1%) and 160 (90.0%) (P = 0.002)</td>
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<tr>
<td>Chen 2008</td>
<td>Appointment reminder</td>
<td>Health promotion clinic</td>
<td>China</td>
<td>SMS and phone reminder for attendance</td>
<td>Randomized controlled trial</td>
</tr>
<tr>
<td>Da Costa 2009</td>
<td>Appointment reminder</td>
<td>General practice</td>
<td>Brazil</td>
<td>SMS attendance reminder</td>
<td>29,000 appointments in 4 clinics, in 7890 cases a SMS reminder was sent to the patient’s cell phone</td>
</tr>
<tr>
<td>Leong 2006</td>
<td>Appointment reminder</td>
<td>Primary care clinics</td>
<td>Malaysia</td>
<td>SMS and phone reminder for attendance</td>
<td>Randomized controlled trial</td>
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</tbody>
</table>
rates between SMS and mobile phone reminder groups.
- cost of SMS (RM 0.45 per attendance) was lower than mobile call (RM 0.82 per attendance).
- non-attendance rates in the SMS group (odds ratio [OR] = 0.62, 95% CI = 0.41 to 0.93, \(P = 0.020\)) and the call group (OR = 0.53, 95% CI = 0.35 to 0.81), \(P = 0.003\) were significantly lower than the control group.
- absolute non-attendance rate for call reminders (\(P = 0.505\)) was non-significant between the groups.

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<table>
<thead>
<tr>
<th>Liew 2009</th>
<th>Appointment reminder</th>
<th>Primary care clinics</th>
<th>Malaysia</th>
<th>SMS and phone reminder for attendance</th>
<th>Randomized controlled trial</th>
<th>SMS group (n=308), call group (n=314), control group (n=309)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prasad 2012</td>
<td>Appointment reminder</td>
<td>Outpatient clinics at a dental centre</td>
<td>India</td>
<td>SMS reminder</td>
<td>Intervention and control group comparison study</td>
<td>SMS group (n=96) Control group (n=110)</td>
</tr>
<tr>
<td>Seidenberg 2012</td>
<td>Test result notification</td>
<td>HIV</td>
<td>Zambia</td>
<td>Texting of the results of infant HIV tests to relevant health facilities and caregivers</td>
<td>Before after evaluation</td>
<td>10 health facilities</td>
</tr>
</tbody>
</table>

**Abbreviations**
Maternal Newborn and Child Health (MNCH), Antiretroviral treatment (ART), Relative Risk (RR), Odds Ratio (OR), P-value (P), Standard Deviation (SD)