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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 implementation
(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 than 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, Werekobrobby, 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; Kunutsor 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; Chandhanayingyong, 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 midwives 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.,
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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**Figure 1** The mHealth pathway

**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.

1. **Input**
   - Technology access and use
   - Response rate
   - Data quality

2. **Mechanism**
   - Individual preferences
   - Adoption factors

3. **Outcomes**
   - Patient health outcomes
   - Efficiency measures
   - Broader development impacts
### Table 1: Studies with main focus on input (n=222), papers (n=222)

<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</td>
<td>Health worker</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>Asimwe 2011</td>
<td>Data collection</td>
<td>Health worker</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>- Familiarity of users</td>
<td>- With exception of few clinics, all were within reliable coverage areas</td>
</tr>
<tr>
<td>Andreatta 2011</td>
<td>Data collection</td>
<td>Health worker</td>
<td>Rural Ghana</td>
<td>SMS-based</td>
<td>U</td>
<td>10 traditional birth attendants</td>
<td>- Traditional birth attendant used to use the specified reporting and SMS protocols</td>
<td>- Concerns about control of data</td>
<td>- Development of ministry of health guidelines and policies to involve district health officers</td>
</tr>
<tr>
<td>Alam 2010</td>
<td>Data collection</td>
<td>MNCH</td>
<td>Urban Bangladesh</td>
<td>Mobile application for</td>
<td>U</td>
<td>3</td>
<td>- App was said to be more efficient than existing system; reducing interview time</td>
<td>- Easy training of health workers</td>
<td>- Acceptability by health workers</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Data collection method</td>
<td>Country</td>
<td>Health Workers</td>
<td>Data Collection Methods</td>
<td>Findings</td>
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<tr>
<td>Svoronos</td>
<td>2011</td>
<td>Mobile application “CommCare”</td>
<td>Rural, Tanzania</td>
<td>Health worker</td>
<td>No time delays for input of data and no incomplete data input</td>
<td>-Module showed reduced cost than the automation card system (without data)</td>
<td>Patients</td>
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<td>(res) 9 health workers</td>
<td>-Pilot submission data</td>
<td>-Problem of resubmitting forms that were not initially send due to network problems</td>
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<tr>
<td>Author8</td>
<td>2012</td>
<td>Mobile application for collecting data on mobile phones and paper and pen methods</td>
<td>Rural China</td>
<td>MNCH</td>
<td>Study comparing mobile phone and paper-and-pen methods</td>
<td>No data entry errors in mobile questionnaires, while 65% of paper questionnaires had data entry errors</td>
<td>-The mobile phone data collection method was acceptable to interviewers for a couple of seconds or it shut off; which did not result in data loss</td>
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<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>-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>
<td>Rajatonirena</td>
<td>2012</td>
<td>Innovative case reporting system based on the use of mobile phones</td>
<td>Rural Madagascar</td>
<td>MNCH</td>
<td>Lessons learnt evaluation</td>
<td>-Data collected daily from 34 sentinel centres corresponding to 862585</td>
<td>-Motivation has been maintained through the provision of medical equipment and training opportunities -High staff turnover problem was addressed by training health district officers to train and supervise new staff</td>
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<td>Data collected daily from 34 sentinel centres corresponding to 862585</td>
<td>-86.7% of the data were transmitted within 24 hours</td>
<td>-Daily syndromic surveillance using SMS can effectively enhance the traditional public health surveillance systems in place -Combined biological and syndromic surveillance using SMS</td>
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<tr>
<td>Study</td>
<td>Data collection</td>
<td>Disease outbreak</td>
<td>Disease</td>
<td>Pilot study</td>
<td>Description</td>
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<tr>
<td>Ganesan 2011</td>
<td>Data collection health worker</td>
<td>Rural India</td>
<td>Mobile application <code>mHealthSurvey</code> 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>
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<td>Kaewkugwal 2010</td>
<td>Data collection health worker + patient appointment reminder</td>
<td>MNCH 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.</td>
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<tr>
<td>MOTECH 2011</td>
<td>Data collection health worker + health promotion</td>
<td>MNCH 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>No change in work routine facilitated the intervention. Health workers seeing usefulness of data collection was important.</td>
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<tr>
<td>Haberer 2010</td>
<td>Data collection</td>
<td>HIV Uganda</td>
<td>Interactive voice response randomized trial, no</td>
<td>Randomized trial, no</td>
<td>-31 of the 121 Weekly completion rates for adherence queries were low (0–33%). Calls and SMSes served as an adherence reminder.</td>
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<td>Patient calls and SMS for automated collection of weekly individual-level ART adherence data</td>
<td>control but two interventions were compared, qualitative interviews</td>
<td>- technologies were acceptable</td>
<td>- misunderstanding of personal identification numbers</td>
<td>- challenges in training</td>
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<td>Skinner 2007 (Cell Life program) Consultation between health workers – data collection</td>
<td>HIV South Africa Mobile pre-designed menu ‘Cell life’ for communication between therapeutic counsellors and the health services. Qualitative interviews 8 counsellors</td>
<td>- It was easy to learn how to use mobiles easy to learn to use</td>
<td>- improvements in technology gave additional security</td>
<td>- mobile did not interfere or distract with relationship between counsellor and patient</td>
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<td>- improvements in technology giving additional security</td>
<td>- feeling good because their work integrated them better into the community</td>
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<td>- no feeling of pressure at being on call 24-hours-a-day and keeping the mobile on all the time</td>
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<td>- fear of crime as the mobile meant counsellors were more at risk for theft</td>
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<td>- positive impact on record keeping</td>
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<td>- feel more effective and secure in role due to rapid help</td>
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<td>- mobile phone use facilitated providing a good service</td>
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<td>LeMay 2012 Consultation between health workers – data collection</td>
<td>Family planning / reproductive health and HIV/AIDS Malawi SMS system to improve the exchange and use knowledge among health workers Baseline evaluation with quantitativ e and qualitative methods Mobile phones provided to 253 health workers, 35 focus group discussions</td>
<td>- a total of 1761 regular messages were sent and received</td>
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<td>- all participating CHWs sent at least one SMS, with an average of five messages per CHW per month</td>
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<td>- main reasons for sending messages include reporting stock outs, asking general information, reporting emergencies, confirming meetings and requesting technical support</td>
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<td>- health workers with mobiles; most common modes of communication</td>
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<td>- health workers reported that their participation in the SMS network resulted in local recognition and improved status among their clients and communities</td>
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<td>- findings indicated that information exchange between the district and community levels can directly affect the quality of care patients receive</td>
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<td>Author</td>
<td>Year</td>
<td>Study Description</td>
<td>Location</td>
<td>Methodology</td>
<td>Findings</td>
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<td>Cole-Ceesay</td>
<td>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 overcame charging difficulties.</td>
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<tr>
<td>Chandhanayingyong</td>
<td>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>
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<tr>
<td>Macrohon</td>
<td>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.</td>
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<tr>
<td>Zolfo</td>
<td>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. Access to Skype and Facebook, screen/keyboard size, and image quality were cited as more troublesome for the Nokia N95 compared to iPhone.</td>
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</tbody>
</table>
| Asfar | 2012 | Consultation between health workers and HIV | Botswana | Mobile teledermatology consultation | 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 quality of care. 91% believed that they would receive the same treatment and quality of care via mobile teledermatology consultation as with a
| Patients | Patient representation of their skin or poor photograph quality | 91% believed that they would receive the same treatment and quality of care via mobile teledermatology consultation as with a face-to-face interaction | Patients 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 65% 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 |

| L’Engle 2009 | Health promotion | Family Planning | Urban Tanzania and Kenya | No intervention | Qualitative interviews | 40 clients in family planning clinics | -common use of SMS -sharing of mobiles, possibility of others reading SMS |

| Mitchell 2011 | Health promotion | HIV | Rural Uganda | No intervention | Aim; perspectives on SMS for info on family planning | 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 |

<p>| Danis 2010 | Health promotion | HIV | 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 |</p>
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Country</th>
<th>Intervention</th>
<th>Population</th>
<th>Methodology</th>
<th>Findings</th>
<th>Discussed Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chib</td>
<td>2011b</td>
<td>Uganda</td>
<td>HIV prevention quiz (13 questions) by SMS</td>
<td>General population, 2,494 participants enrolled at the start of the FactoryQuiz</td>
<td>Analysis of quiz responses</td>
<td>10,000 mobile numbers in general population, one-fifth of mobile subscribers responded to any of the 13 questions</td>
<td>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>Indonesia</td>
<td>Two paid services: 1. advice on affordable pharmaceutical drug options via SMS, 2. personal health information via SMS</td>
<td>HIV</td>
<td>1 survey, 2 survey and in-depth interviews, 1.30 users, 2. pregnant women and mothers who received a free one month prescription, 88 (survey), 8 (interview)</td>
<td>1. program provided accurate data, which participants said helped them with making decisions when selecting prices 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, health information received was relevant; detailed information rather than short summarized information was much preferred</td>
<td>Reported behaviour changes after reading health tips, increased confidence among users in sharing health information with their families, peers, and neighbours, some reported greater levels of assurance when their doctors provided the same information as in the SMSs, indication of increased information-seeking behaviours</td>
</tr>
<tr>
<td>Curioso</td>
<td>2007</td>
<td>Peru</td>
<td>Medication adherence reminder</td>
<td>HIV</td>
<td>In-depth interviews, 31 people living with HIV at 2 clinics</td>
<td>77% were using 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>Participant Information</td>
<td>Methods</td>
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</table>
| 2009 Curioso | Medication adherence reminder | HIV Peru | No intervention: Aim; perspectives on reminder strategies to improve antiretroviral treatment ART adherence and SMSs | Four-focus groups 26 people living with HIV                              | - alarm reminders most useful for antiretroviral treatment ART-naive 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.  
- anthropomorphic features: anthropomorphized the system with human characteristics.  
- Perceptions towards reminder messages: overall acceptable  
- Characteristics of reminder messages: motivational, conciseness, simple and shareable, spiritual tone, confidential  
- Frequency of change: some frequency in to prevent monotony and boredom with them; change weekly/daily  
- Anthropomorphic features: anthropomorphized the system with human characteristics  
- Confidentiality and privacy issues: keeping the medication reminders confidential was the most important concern, no "sensitive" words  
- Curioso 2009 Medication adherence reminder HIV Peru No intervention: Aim; perspectives on reminder strategies to improve antiretroviral treatment ART adherence and SMSs Four-focus groups 26 people living with HIV - anthropomorphic features: anthropomorphized the system with human characteristics - Perceptions towards reminder messages: overall acceptable - Characteristics of reminder messages: motivational, conciseness, simple and shareable, spiritual tone, confidential - Frequency of change: some frequency in to prevent monotony and boredom with them; change weekly/daily - Anthropomorphic features: anthropomorphized the system with human characteristics - Confidentiality and privacy issues: keeping the medication reminders confidential was the most important concern, no "sensitive" words |
| 2010 Shet | Medication adherence reminder | HIV India | No intervention: Aim; perspectives mobile intervention for improving antiretroviral treatment ART | Survey 322 persons participated at the three clinics, 81% were HIV-infected patients | - 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>Author</th>
<th>Year</th>
<th>Scenario</th>
<th>Country</th>
<th>Methods</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Mbuagba w 2012</td>
<td></td>
<td>Medication adherence reminder</td>
<td>Cameroon</td>
<td>Aims: perspectives on SMSs for improving antiretroviral treatment adherence</td>
<td>Five focus groups of 30 people living with HIV - 10% of 30 people 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 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>
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<td>Medication adherence reminder</td>
<td>India</td>
<td>Survey</td>
<td>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 intruded; - 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>
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<tr>
<td>DeRenzi 2012</td>
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<td>Appointment reminder health workers</td>
<td>Tanzania</td>
<td>Pilot study (1) and two (2,3) randomized controlled studies</td>
<td>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</td>
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<tr>
<td>Study</td>
<td>Intervention</td>
<td>Country</td>
<td>Aim</td>
<td>Method</td>
<td>Findings</td>
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<tr>
<td>Crankshaw 2010</td>
<td>Appointment and medication adherence reminder</td>
<td>South Africa</td>
<td>No intervention; preliminary costs</td>
<td>Survey; 300 individuals who presented for treatment at the ART clinic</td>
<td>-28% shared mobile with one or more other people&lt;br&gt;-87% indicated that they usually answered calls that displayed ‘private number’&lt;br&gt;-79% use of the mobile alarm function for remembering to take medication</td>
</tr>
<tr>
<td>Wolpaw 2011</td>
<td>Test result reminder</td>
<td>South Africa</td>
<td>Reminding patients who do not return for HIV test results with text messages and phone calls</td>
<td>Face-to-face interview; 902 high risk participants enrolled over 1 year</td>
<td>-40.6% came back for results&lt;br&gt;-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>
<tr>
<td>Faisal 2012</td>
<td>General</td>
<td>Bangladesh</td>
<td>No intervention; impact assessment on existing mobile health care services</td>
<td>Surveys, telephone interviews; Ten families and 5 doctors</td>
<td>-90% of families had a mobile&lt;br&gt;-30% of families were aware of local mobile health services&lt;br&gt;-40% of families rely on mobile health services&lt;br&gt;-doctors receive about 10-20 calls a day&lt;br&gt;-doctors experience difficulties in diagnosing patients over the telephone but are able to provide basic advice</td>
</tr>
<tr>
<td>Paper (first author, year)</td>
<td>mHealth category</td>
<td>Health purpose</td>
<td>Location</td>
<td>Intervention</td>
<td>Evaluation</td>
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<tr>
<td>Hwaba mungu 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>
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<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>
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<tr>
<td>Author</td>
<td>Consultation</td>
<td>MNCH</td>
<td>Rural</td>
<td>No</td>
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1. **Perspectives on Time**
   - Health workers need information made available immediately by phone but economic, network and infrastructural barriers
   - Need for communication for administration but barrier of late information
   - Importance of training but barrier of time and distance

2. **Perspectives on Space**
   - Remote areas led to gaps in information retrieval and delivery of services
   - Inconvenience of time lost and perceived emotional distance

3. **Communicative practices**
   - Sharing fixed line and mobile phone access
   - Use of combination fixed-mobile community phone in larger villages

- 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

| Chib, 2012 (in review) | Consultation between health workers | India | - | Qualitative | Rural | Framework: ICTs for healthcare development (Banuri 2003) | Barriers: | Benefits: |

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

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

3. **Social enabler**
   - Broader their social and professional circles

4. **Knowledge generator**
   - Rural healthcare workers
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>Framework:</th>
<th>Barriers</th>
<th>Benefits</th>
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</thead>
<tbody>
<tr>
<td>Chib 2008</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>
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<thead>
<tr>
<th>Theory:</th>
<th>Autonomy vs. Subordination</th>
<th>Autonomy vs. Hierarchical control</th>
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<tr>
<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</td>
<td>- Constraints: opportunity to make decisions, realization of usefulness of mobiles</td>
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<td>Personal growth vs. Limited technological competency</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</td>
<td>- Benefits: mobile phones provide learning material, discuss and share knowledge</td>
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<td>Economic independence vs. Constraints earning capabilities</td>
<td>- Constraints: generalized poverty,</td>
<td>- Benefits: increased efficiency in profession</td>
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<td>Appropriation of power vs. Hierarchical control</td>
<td>- Constraints earning capabilities</td>
<td>- Benefits: access to power at top, recognition of</td>
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<td>- Constraints: sharing knowledge,</td>
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<td>Author</td>
<td>Year</td>
<td>Baseline and follow up survey</td>
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<tr>
<td>Chib</td>
<td>2009</td>
<td>122 midwives in experimental group; 101 in control group</td>
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<tr>
<th>Framework: ICTs for healthcare development (Banuri 2003)</th>
<th>Baseline Benefits:</th>
<th>Follow up compared to baseline for intervention group: Benefits:</th>
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</thead>
<tbody>
<tr>
<td>1. Opportunity producer:</td>
<td>- save time for work (92.4%), provide up-to-date information related to work (91.4%), increase productivity (93.2%), and improve the quality of work (95%)</td>
<td>1. Opportunity producer:</td>
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<td>2. Capabilities enhancer</td>
<td>- accomplish goals and resolve situations (90.2%); handling of unexpected situations (64.6%) and remaining calm when facing difficulties (75.3%);</td>
<td>2. Capabilities enhancer</td>
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<td>- reliance on support from colleagues, 69.2% accessing health information from people at work, 43.5% from their health organizations</td>
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<td>3. Social enabler</td>
<td>- ability to use social resources for work problems, such as midwives (87.9%) and midwife</td>
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<td>Chib</td>
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<td>Framework:</td>
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<td>Benefits:</td>
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<td>3. Social enabler</td>
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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

Author C
Lee
2011b
Baseline survey midwives
Hypothesized model of midwives' mobile phone use, access to resources, self-efficacy, and health knowledge
1. Mobile phone use; midwives' mobile phone use was positively associated with access to both institutional and peer-network resources
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
3. Access to peer resources; access to peer resources had no direct positive effect on midwives' health knowledge, access to peer resources

- complaints about telecom connectivity
3. Social enabler
- more likely to turn to health centre personnel for medical information needed (Pa = 0.09) and access health information from the health centre using their mobiles (Pa = 0.09).
- improved relationship across the levels of the healthcare system hierarchy
- quicker access to midwife for patients
4. Knowledge generator
- easier to search for numbers in mobile lists (Pa = 0.02), and get the mobile to do what they wanted it to do (Pa = 0.00).
- increased in their trust of obtaining health information from the cinema (Pa < 0.06) and brochures (Pa = 0.04) medical question scores increased for standard procedures in childbirth process, decrease in medical question score (Pa = 0.03) postpartum mother to be referred to a hospital

Formatted: Font: Not Bold
| 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) | 1. Context: 
- Distance barrier 
- Financial barrier 
- Language barrier 
- Lack of knowledgeable doctors 
- Lack of 24 hour service. 
- Lack of Health Care 
2. Changes in Behavioural Precursors: 
- Changes in knowledge and behaviour of both doctors and patients. 
- More positive attitude of doctors and patients. 
- Reduction of distance and other barriers | 1. Increased self-efficacy: self-efficacy was positively associated with health knowledge 
2. Health knowledge 
3. Changes in behaviour: 
- Increase in awareness level 
- An efficient alternative for emergency treatment 
- More relief patients 
4. Broader development impact: 
- An effective data base for research 
- An important tool for implementing millennium development goals 
- Efficient management and administration |
<table>
<thead>
<tr>
<th>Paper (first author, year)</th>
<th>nHealth 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>
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<tbody>
<tr>
<td>Chang 2011</td>
<td>Consultation between health workers</td>
<td>HIV</td>
<td>Rural Uganda</td>
<td>Peer health workers were given a mobile and were asked to send a SMS reporting adherence and clinical data after during home visits.</td>
<td>Mobile arm, 4 clusters, 13 health workers, 446 patients Control Arm, 6 clusters, 16 health workers, 524 patients</td>
<td>Qualitative themes: 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>Health care communication diagram Pathways through which mobile phones expedited communication: -formal (peer worker- clinic Staff) -informal (patient- family) -other (patient – clinic and peer worker, family and friends – peer worker and clinic) Qualitative themes: Confidentially Concerns; privacy concerns when using others phones -Challenges with phones; challenges with -phone-maintenance, primarily with keeping them charged, theft</td>
<td>Quantitative -no significant differences in virologic adherence, mortality, or retention outcomes -clinic staff agreed strongly/agreed (89%) that ‘Mobile phones used by peer workers improved overall care of patients’ agreed strongly/agreed (89%) that ‘All peer worker should be given mobile phones to use for patient care.’ Qualitative themes: -Voice Calls; 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. SMSes on computer before responding -improved peer health worker morale, improve capabilities and job satisfaction, improve peer health worker-staff relationships</td>
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<tr>
<td>Chang 2010</td>
<td>Quantitative analysis of cluster RCT</td>
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<td>Chang 2008</td>
<td>Survey of 39 clinical staff</td>
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<td>-Direct- start-up -costs were $115-USD with monthly maintenance costs approximately $15 USD per</td>
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<td>-44% (17/39) strongly agreed and 56% (22/39) agreed that the peer worker and mobile intervention improved -overall health of patients;</td>
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<tr>
<td>Year</td>
<td>Study Title</td>
<td>Country</td>
<td>Population</td>
<td>Methodological Design</td>
<td>Findings</td>
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<td>2011</td>
<td>Zurovac</td>
<td>Kenya</td>
<td>Rural health workers</td>
<td>Consultation between health workers</td>
<td>Medication management improved by 23.7% (95% CI 7.6–40.0; pP=0.004) immediately after intervention and by 24.5% (8.1–41.0; pP=0.003) 6 months follow-up</td>
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<td>2012</td>
<td>Jones</td>
<td>Kenya</td>
<td>107 rural health facilities, 119 health workers</td>
<td>Qualitative findings on way (end 2011), suggested factors: SMS addressing forgetfulness, SMS emphasises the clinical importance of doing tasks, enhancement of health workers’ feeling that someone is paying attention to their work, increased motivation from the famous quotes and sayings</td>
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<td>2008</td>
<td>Jareethum</td>
<td>Thailand</td>
<td>107 rural health facilities, 119 health workers</td>
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Medication management improved by 23.7% (95% CI 7.6–40.0; pP=0.004) immediately after intervention and by 24.5% (8.1–41.0; pP=0.003) 6 months follow-up.
### de Tolly 2012

**Health promotion**

HIV South Africa

**Informational or motivational SMSs to prompt people to go for HIV counseling and testing**

**Randomised controlled trial**

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

Higher in intervention vs. control group in antenatal period (9.25 vs. 8.00, \( P < 0.001 \)) and during labour (9.09 vs. 7.90, \( P = 0.007 \)). Intervention group, the confidence level was higher (8.91 vs. 7.79, \( P = 0.001 \)) and the anxiety level was lower (2.78 vs. 4.93, \( P = 0.002 \)) than the control group in antenatal period, but not in postnatal period.

- Proportions of participants tested: 3 motivational SMSs 49%, 10 motivational SMSs 69%, 3 information SMSs 55%, 10 information SMSs 58%.
- 10 motivational SMSs: 1.7-fold increased odds of testing (C.I. 95%; \( P = 0.0036 \)) compared to the control group.
- No significant effect for the other intervention groups.
- Use of 10 MOTI SMSs yielded a cost per tester of $2.41 USD.

### Piette 2011

**Health information for patients**

Diabetes 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

- \( \text{HbA1c levels improved from an average of 10.0% at baseline to 8.9% at follow-up (} \( P = 0.01 \)) \)
- \( \text{Self-reported improvements of} \)

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- \( \text{Self-reported improvements of} \)
Spanish during interactive voice calls about diabetes management at baseline and 6 week follow-up

<table>
<thead>
<tr>
<th>Year</th>
<th>Study Type</th>
<th>Location</th>
<th>Intervention</th>
<th>Acceptance</th>
<th>Forwarding Weekly SMS to Non-intervention Participants</th>
<th>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)</th>
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<tbody>
<tr>
<td>2010</td>
<td>Randomised controlled trial</td>
<td>Nairobi, Kenya</td>
<td>Patients initiating ART, 273 received the intervention; 265 standard care patients</td>
<td>191 of 194</td>
<td>Patients in the intervention group reported they would like the SMS programme to continue, of whom 186 (98%) said they would recommend it to a friend</td>
<td>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>
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<tr>
<td>2009</td>
<td>Randomised controlled trial</td>
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<td>-82% had access to a phone</td>
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<td>-All patients in the intervention group also reported that they thought the SMS support service was valuable. 89% had access to a phone. 12% had never called or been called by healthcare worker</td>
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<td>2008</td>
<td>Randomised controlled trial</td>
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<td>-54% said they would be comfortable receiving HIV-related information by telephone</td>
<td>98%</td>
<td>-Logistical issues</td>
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<tr>
<td>2006</td>
<td>Randomised controlled trial</td>
<td></td>
<td>-Preference to talk with clinic staff in person and issues regarding stigma or confidentiality</td>
<td>98%</td>
<td>-Logistical issues</td>
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Patients: 56% blood sugar control, 66% diet improved, 64% medication adherence, and 89% foot care.
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<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th>Patients</th>
<th>Description of crisis situation</th>
<th>Randomized controlled trial</th>
<th>Patients initiating ART, 273 received the intervention, and 265 standard care</th>
<th>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)</th>
<th>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)</th>
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<th>Patients</th>
<th>Description of crisis situation</th>
<th>Randomized controlled trial</th>
<th>Patients initiating ART, 4 intervention groups (70, 72, 73, 74 patients respectively), 139 patients control group</th>
<th>-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</th>
<th>-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)</th>
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<th>Study</th>
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<th>Patients</th>
<th>Description of crisis situation</th>
<th>Randomized controlled trial</th>
<th>Patients initiating ART, 273 received the intervention, and 265 standard care</th>
<th>-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. -nurses were able to connect patients to new dispensaries. -support for emotional distressed patient whose home had been burned. during previous three patients losing mobile phones -access denied to air time &quot;top up&quot; by poor security or economic fallout or were forced to remain in remote areas without network coverage -forwarding weekly SMSs to non-intervention participants to share support.</th>
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<td>Chen 2008</td>
<td>Appointment reminder</td>
<td>China</td>
<td>SMS and phone reminder for attendance</td>
<td>Control group</td>
<td>Attendance rates were significantly higher in SMS and telephone groups than that in the control group, with odds ratio 1.698, 95% confidence interval 1.224 to 2.316, ( P = 0.001 ) in the SMS group, and OR 1.829, 95% CI 1.333 to 2.509, ( P &lt; 0.001 ) in the telephone group. No difference between the SMS group and telephone group (( P = 0.670 )). Cost per attendance for the SMS group (0.31 Yuan) was significantly lower than that for the telephone group (0.48 Yuan).</td>
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<tr>
<td>Da Costa 2009</td>
<td>Appointment reminder</td>
<td>Brazil</td>
<td>SMS and phone reminder for attendance</td>
<td>Control group</td>
<td>Nonattendance reduction rates for appointments at the four outpatient clinics studied were 0.82% (( P = 0.590 )), 3.55% (( P = 0.009 )), 5.75% (( P = 0.022 )), and 14.49% (( P &lt; 0.001 )).</td>
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<tr>
<td>Leong 2006</td>
<td>Appointment reminder</td>
<td>Malaysia</td>
<td>SMS and phone reminder for attendance</td>
<td>Control group</td>
<td>Attendance rates of control, SMS and mobile call groups were 48.1, 59.0 and 59.6%, respectively. Attendance rate of the SMS group was significantly higher compared with that of the control group (OR 1.59, 95% CI 1.17 - 2.17, ( P = 0.005 )). No significant difference in attendance.</td>
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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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<th>Results</th>
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<td>Liew 2009</td>
<td>Appointment reminder</td>
<td>Malaysia</td>
<td>SMS and mobile phone reminder for attendance</td>
<td>Randomized controlled trial, SMS group (n=308), call group (n=314), control group (n=309)</td>
<td>Non-attendance rates in the SMS group (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.</td>
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<td>Prasad 2012</td>
<td>Appointment reminder</td>
<td>India</td>
<td>SMS reminder</td>
<td>Intervention and control group comparison study, SMS group (n=96), Control group (n=110)</td>
<td>Rate of on time attendance was significantly higher in the test group (79.2%) than in the control group (35.5%).</td>
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<tr>
<td>Seidenberg 2012</td>
<td>Test result notification</td>
<td>Zambia</td>
<td>Texting of the results of infant HIV tests to relevant health facilities and caregivers</td>
<td>Before after evaluation, 10 health facilities, only 0.5% of the texted reports investigated differed from the corresponding paper reports</td>
<td>Mean turnaround time for result notification to a health facility fell from 44.2 days pre-implementation to 26.7 days post-implementation. Reduction in turnaround time was statistically significant in nine (90%) facilities. The mean time to notification of a caregiver also fell significantly, from 66.8 days pre-implementation to 35.0 days post-implementation.</td>
</tr>
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**Abbreviations**
Maternal Newborn and Child Health (MNCH), Antiretroviral therapy (ART), Relative Risk (RR), Odds Ratio (OR), P-value (P), Standard Deviation (SD)