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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; Waagemann, 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 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; Asimwe 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; 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; Asimwe, 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 (Asimwe, 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; Asimwe, 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.,

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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Figure 11 The mHealth pathway

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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 1 Studies with main focus on input [(n=232)], papers [(n=232)]

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected Input factors	Selected Mechanism factors	Selected Outcomes
Barrington 2010	Data collection health worker	Malaria	Rural Tanzania	Mobile system for anti-malarial stock counts	Pilot study, quantitative	129 health facilities	S stock count data provided in 95% -response rate ≥ 93% -error rate for composition of SMS responses averaged 7.5% -data accuracy 94% -use of personal mobiles -mobile telephone coverage within an acceptable distance -free response number	-use of personal mobiles -free response number -effective training sessions -government commitment -mobile telephone coverage within an acceptable distance	-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 -artemether-lumefantrine AL stocks increased by 64% and quinine stock increased 36% across the three districts
Asiimwe 2011	Data collection health worker	Malaria	Rural Uganda	SMS-based malaria reporting system; RapidSMS™	Implementation evaluation, quantitative	140 clinics	-set-up cost \$100 USD/health facility, local technician support \$400 USD per month, and cost of \$0.53 USD/week/clinic -88.6% of health facilities reporting weekly -12.1% of the 104 clinics reported total medicine artemisinin-combination therapies ACT stock out for at least one week -district1; 23.4% of suspected malaria cases reported, 44.8% of these confirmed with rapid testing -district2; 47% of suspected malaria cases reported, 4.5% received rapid testing diagnosis, total stock-out of artemisinin-combination therapies ACT 54.3% -with exception of few clinics, all were within reliable coverage areas	-with exception of few clinics, all were within reliable coverage areas -familiarity of users -local expertise in programming and in mobile phone services -concerns about control of data -developing ministry of health guidelines and policies to involve district health officers	
Andreatta 2011	Data collection health worker	MNCH; postpartum haemorrhage	Rural Ghana	SMS-based	U	10 traditional birth attendants	-traditional birth attendant TBAs 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		
Alam 2010	Data collection	MNCH	Urban Bangladesh	Mobile application for	U	3 centerscent	-App was said to be more efficient than existing system; reducing interview time,	-easy training of health workers -acceptability by health workers and	

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	health worker		h	collecting health info about pregnant women		res,- 9 health workers	no time delays for input of data and no incomplete data input -module showed reduced cost than the automation card system (without data)	patients	
Svoronos 2011	Data collection health worker	MNCH	Rural, Tanzania	Mobile application 'CommCare' for managing health workers day and report data on pregnant women in real time-	U	5 community health workers	-pilot submission data <u>-problem of resubmitting forms that were not initially send due to network problems</u>	-problem of resubmitting forms that were not initially send due to network problems -broader supervisory structure -necessary for successful community health worker program, regardless of ICT	-anecdotal evidence longer and more comprehensive house visits, more consistent up of existing pregnant and more active identification of preg
<u>AuthorB 2012</u>	<u>Data collection health worker</u>	<u>MNCH</u>	<u>Rural China</u>	<u>Mobile application for collecting data on</u>	<u>Study comparing mobile phone and paper-and-pen methods</u>	<u>120 mothers of infants aged 0 to 23 months in four village clinics</u>	<u>-no significant difference in inter-rater reliability between the methods for the questionnaire pairs (P=0.32) or variables (P=0.45)</u> <u>-no data entry errors in mobile questionnaires, while 65% of paper questionnaires had data entry errors</u> <u>-mean duration of an interview was not significantly different between the methods (P=0.19)</u> <u>-mean costs per questionnaire were higher for the mobile questionnaires (\$23 USD) than for the paper questionnaires (\$13 USD)</u> <u>-mean costs per questionnaire were higher for the mobile questionnaires (23 USD) than for the paper questionnaires (13 USD)</u>	<u>-the mobile phone data collection method was acceptable to interviewers</u> <u>-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</u>	
<u>Rajatonirina 2012</u>	<u>Data collection health worker</u>	<u>Influenza-like illnesses</u>	<u>Madagascar</u>	<u>Innovative case reporting system based on the use of mobile phones</u>	<u>Lessons learnt evaluation</u>	<u>Data collected daily from 34 sentinel centres corresponding to 862585</u>	<u>-86.7% of the data were transmitted within 24 hours</u> <u>-95 401 cases (11.1%) presented with fever; a special form was completed for 80 691 of these patients (84.6%)</u> <u>-costs less than \$2 USD per month per sentinel centre, and each centre's mobile phone equipment costs a mere \$10 USD</u>	<u>-motivation has been maintained through the provision of medical equipment and training opportunities</u> <u>-high staff turnover problem; was addressed by training health district officers to train and supervise new staff</u>	<u>-daily syndromic surveillance using SMS can effectively enhance improve the traditional public surveillance systems in place;</u> <u>-combined biological surveillance and syndromic surveillance using SMS</u>

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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

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Comment [Shuyi2]:

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						patient visits			it 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
Ganesan 2011	Data collection health worker	Disease outbreak	Rural India	Mobile application 'mHealthSurvey' on mobile phone to collect and transmit patient health records	Pilot study	Unclear, health workers in primary health centres and health sub centres	-an average 217 health records were submitted each day through mobile phone, with 74% from the primary health centres -health workers were required to submit data during patient interaction but majority submitted records after completing their routine work -the costs were \$0.09 USD per 100 completed records		
Kaewkug wal 2010	Data collection health worker + patient appointment reminder	MNCH	Rural Thailand	Mobile application for collecting health info about pregnant women	Before-after design without control group	Health personnel in healthcare clinic at pilot testing site	-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	-improved antenatal and immunization coverage -numbers of antenatal and vaccination visit on-time as per schedule significantly increased -less delay of antenatal visits and immunizations
MOTECH 2011	Data collection health worker + health promotion	MNCH	Rural Ghana	Mobile application informing health workers and pregnant women -+ interactive voice calls for health information	Initial implementation evaluation	Pregnant women and nurses	-Nurse handset, SMS vs. 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	
Haberer 2010	Data collection	HIV	Uganda	Interactive voice response	Randomized trial, no	31 of the 121	-Weekly completion rates for adherence queries were low (0-33%)	-calls and SMSes served as an adherence reminder	

	patient			calls and SMS for automated collection of weekly individual-level ART adherence data	control but two intervention s were compared, qualitative interviews	caregivers in the CHARTA Study who had their own mobiles	-Technologies were acceptable	-misunderstanding of personal identification numbers -challenges in training	Formatted: Font: 9 pt
Skinner 2007 (Cell Life program)	Consultation between health workers – data collection	HIV	South Africa	Mobile pre designed menu ‘Cell life’ for communication between therapeutic counsellors and the health services.	Qualitative interviews	8 counsellors	-it was easy to learn how to use -mobiles easy to learn to use -improvements in technology gave additional security	-mobile did not interfere or distract with relationship between counsellor and patient -improvements in technology giving 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 -mobile phone use facilitated providing a good service	
LeMay 2012	Consultation between health workers – data collection	Family planning /reproductive health and HIV/AIDS	Malawi	SMS system to improve the exchange and use knowledge among health workers	Baseline evaluation with quantitative and qualitative methods	Mobile phones provided to 253 health workers, 35 focus group discussions	-a total of 1761 regular messages were sent and received -all participating CHWs sent at least one SMS, with an average of five messages per CHW per month -main reasons for sending messages include reporting stock outs, asking general information, reporting emergencies, confirming meetings and requesting technical support -health workers with mobiles; most common modes of communication	-health workers reported that their participation in the SMS network resulted in local recognition and improved status among their clients and communities -findings indicated that information exchange between the district and community levels can directly affect the quality of care patients receive	Formatted: Font: 9 pt

							<u>included SMSs (100%), phone calls (94.4%), and face to face (8%)</u> <u>-preliminary time and costs estimates</u>			
Cole-Ceesay 2010	Consultation between health workers	MNCH	The Gambia	Emergency ambulance service linking the community with the hospital through a mobile system.	U	Traditional birth attendants and village health workers	-mobiles- with a- longer - battery- life overcame charging difficulties	-t- Traditional birth attendants reported that villagers provided credit for mobile which facilitated them to use it until free-phone numbers could be negotiated with network providers		
Chandhan ayingyong 2006	Consultation between health workers	Orthopaedics	Thailand	Teleconsultation MMS in emergency orthopaedic patients	Case-control, age-matched	59 emergency orthopaedic cases, 34 normal patients visiting the emergency department	-t- 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%.			
Macrohon 2010	Consultation between health workers	General	Rural Philippines	Telecommunication, including mobiles, for referral	Survey	3 health officers and 39 patients	-generally satisfactory- , some concerns about -time taken for response after SMS referrals, and expense of <u>the</u> entire system	-generally satisfactory , preference (42% of consultations) for mobile use for referrals because: real-time response; easy to use; no need to 'boot up' equipment; does not depend on the variable speed of broadband; longer battery life than laptops		
Zolfo 2010	Consultation between health workers - Education health workers	HIV	Peru	Mobile educational platform supporting learning events and tracking participant learning progress	Survey	Twenty physicians	-overall satisfaction of using mobile tools was greater for the iPhone -a- Access to Skype and Facebook, screen/keyboard size, and image quality were cited as more troublesome for the Nokia N95 compared to iPhone	-overall satisfaction of using mobile tools was greater for the iPhone		
<u>Azfar 2012</u>	<u>Consultation between health workers and</u>	<u>HIV</u>	<u>Botswana</u>	<u>Mobile teledermatology consultation</u>	<u>Survey</u>	<u>75 people living with HIV</u>	<u>-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</u>	<u>-quality of care; 91% believed that they would receive the same treatment and quality of care via mobile teledermatology consultation as with a</u>		

	patients						representation of their skin or poor photograph quality - 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	face-to-face interaction -if 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 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 patients	Family Planning	Urban Tanzania and Kenya	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	Rural Uganda	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	Uganda	HIV prevention quiz by SMS	Analysis of quiz responses	10,000 mobile numbers in	- Pp articipation rates varied from a low of between 5% and 10% in general population to around 50% in the f actory gq uiz			

						general population, 2,494 participants enrolled at the start of the FactoryQuiz				
Chib Author 2011b	Health promotion	HIV	Uganda	HIV prevention quiz (13 questions) by SMS	Analysis of quiz responses	10.000 mobile numbers in general population	<ul style="list-style-type: none"> -one-fifth of mobile subscribers responded to any of the 13 questions 	<p>Discussed factors:</p> <ul style="list-style-type: none"> -making SMS part of an integrated mass-media communication campaign -stigmatization could be 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 		
Maharani 2012	Health information	General	Indonesia	<p>Two paid services:</p> <ol style="list-style-type: none"> 1. advice on affordable pharmaceutical drug options via SMS 2. personal health information via SMS 	<ol style="list-style-type: none"> 1. survey and in-depth interviews 	<ol style="list-style-type: none"> 1. 30 users 2. pregnant women and mothers who received a free one month prescription : 88 (survey), 8 (interview) 	<ol style="list-style-type: none"> 1. program provided accurate data, which participants said helped them with making decisions when selecting <ul style="list-style-type: none"> -price of subscribing to SMS Info program was affordable as it saved them money 2. health information is easy and fast to access <ul style="list-style-type: none"> -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 	<ol style="list-style-type: none"> 2. some reported behaviour changes after reading health tips <ul style="list-style-type: none"> -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 		
Curioso 2007	Medication adherence reminder	HIV	Peru	No intervention Aim; Access, use and perceptions regarding	In-depth interviews	31 -people living- with HIV at 2 clinics	<ul style="list-style-type: none"> -77% were using mobiles -6% used their mobiles -to -send and receive SMSes -23% were using the alarms to remind to take their medication 	<ul style="list-style-type: none"> -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- 		

				Internet, cell mobiles and PDAs				<p>recorded voice (74% of those willing) or by SMS (74% of those willing).</p> <p>-alarm-reminders most useful- for <u>antiretroviral treatment</u>ART-naïve patients</p> <p>-81%- expressed- their- interest- in receiving- SMSes about- their- sexual health- over- the mobile, including information about sexually transmitted infections</p> <p>-Of those, 88% would prefer sexual health messages via SMS 68% via calls with a pre-recorded voice.</p> <p>-many said they would like to receive general HIV information via mobiles</p>		
Curioso 2009	Medication adherence reminder	HIV	Peru	No intervention Aim; perspectives on reminder strategies to- improve <u>antiretroviral treatment</u> ART adherence <u>and</u> SMSs	Four- focus groups	26 -people living with HIV	<p><u>-anthropomorphic features: anthropomorphized the system with human characteristics</u></p>	<p>-Perceptions towards reminder messages: overall acceptable</p> <p>-Characteristics of reminder messages: motivational, conciseness, simple and shareable, spiritual tone, confidential</p> <p>-Frequency of change: some frequency in to prevent monotony and boredom with them; change weekly/daily</p> <p><u>-Anthropomorphic features: anthropomorphized the system with human characteristics</u></p> <p>-Confidentiality and privacy issues: keeping the- medication reminders confidential- was the most important concern, no "sensitive" words</p>		
Shet 2010	Medication adherence reminder	HIV	India	No intervention Aim; perspectives mobile intervention for <u>improving antiretroviral treatment</u> ART	Survey	322 persons participated at the three clinics, 81% were HIV- infected patients in	<p>-73.1% owned mobile, and 55% used mobiles for over 2 years</p> <p>-use of mobile; calls approximately 4 times a day, SMS used by 25%</p>	<p>-74% (95% CI: 69.2–78.8) thought SMS reminder feature would be helpful in maintaining adherence</p> <p>-89% did not perceive SMS reminders as an intrusion on privacy</p> <p>-79.5% (P<0.005) wanted to use their mobile to call health worker</p> <p>-62% wanted receive info on the</p>		

				adherence		care		availability of new drugs and HIV medicine and 68% on research via mobile -26% did not perceive benefits from reminders as they were unnecessary		
Mbuagba w 2012	Medication adherence reminder	HIV	Cameroon	No intervention Aim; perspectives on SMSs for improving antiretroviral treatment adherence	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	-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		
Sidney 2012	Medication adherence reminder	HIV	India	weekly interactive call and a non-interactive neutral pictorial SMS on mobile phones	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 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%)		
De-Renzi 2012	Appointment reminder health workers	Chronic conditions, mainly HIV	Tanzania	SMS reminders to improve the promptness of routine community health workers visits	Pilot study (1) and two (2,3) randomized 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		

[illegible]

Table 2 Studies with main focus on mechanism (n=6), papers (n=10), theories (n=10)

Paper (first author, year)	Health category	Health purpose	Location	Intervention	Evaluation	Target	Theory, framework, model	Selected input factors	Constructs in bold, findings in normal font	Selected output
Hwabamungu 2010	Potential in general for patients and health workers	HIV	South Africa	No intervention	Structured interviews	42 patients and 13 staff members or caregivers	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)	Appropriateness of chosen technology; A m mobile phones possession – for – example – is high mobile ownership (51/55) use their mobile as tool to improve service provision or access (46/55)	Constructs of models not given u Users' perception; importance of technology can impact technology acceptance, most are aware of mobile applications and would consider using them for health, but issues of privacy, mobile phone data storage capacities and mobile phone loss p Patients' -and- care -givers' willingness -to -use -the technology does -not mean preparedness <u>for</u> paying- costs g Government and donor support critical to ensure free service which people expect i mportance of financial sustainability model	
Hamilton 2010	Health promotion	General	Rural Kenya	No intervention	Survey + participant observation such as in-depth interviews	12 Kenyan-based experts and practitioners, 55 residents	Theory: Social marketing (Hastings 2007)	Survey findings (villagers) on: p Profile of the Village In-depth interview findings (experts): p Profile of Expert Respondents	1. Price - cost prohibitive 2. Promotion - text messages 3. Product - goal of changing health behaviour 4. Place - practicability of a mobile phone Survey findings (villagers) on: e Educational <u>A</u> ttainment's r ole in <u>m</u> obile <u>P</u> hone <u>o</u> wnership and <u>u</u> se i literacy in <u>R</u> elation to <u>M</u> obile <u>O</u> wnership and <u>u</u> se R elationship between <u>m</u> edia <u>C</u> onsumption and <u>M</u> obile <u>O</u> wnership and <u>u</u> se a ccess to <u>M</u> obile <u>P</u> hones by <u>g</u> ender In-depth interview findings (experts) on: g ender and <u>A</u> ccess to <u>M</u> obile <u>P</u> hones t he <u>i</u> mpact of <u>p</u> rice on <u>m</u> obile <u>P</u> hone <u>O</u> wnership and <u>u</u> se	

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									<div>-Cost of aAirtime</div> <div>-Cost to Hhealth Pprovider</div> <div>-Cost to uUser</div> <div>-Cost of Electricity</div> <div>-Psychological cCost</div> <div>-mMobile pPhones, Hhealth and</div> <div>bBehaviour Echange</div> <div>-Surveillance</div> <div>-Role of the hindigenous Leadership</div> <div>-Mmobile and mMedia Partnership</div> <div>-Literacy rRates vis-à-vis Amobile</div> <div>pPhone Ownership and Use</div>				
<div>AuthorC 2012 cChib (in review 2011)</div>	Consultatio n between health workers	MNCH	Rural Nepal	No intervention	Focus groups and qualitative interviews	22 communit y healthcar e workers, 10 profession al managem ent represent atives and 19 patients and villagers	Spatio-temporal perspectives on mHealth (Castells 1989, 2007)	<div>1.Perspectives on Time</div> <div>-health workers need information made available immediately by phone but economic, network and infrastructural barriers</div> <div>-need for communication for administration but barrier of late information</div> <div>-importance of training but barrier of time and distance</div> <div>2.Perspectives on Space</div> <div>-remote areas led to gaps in information retrieval, and delivery of services</div> <div>-inconvenience of time lost and perceived emotional distance</div> <div>3.1.Communicative practices</div> <div>-sharing fixed line and mobile phone access</div> <div>-use of combination fixed- mobile community phone in larger villages</div>	<div>2.Perspectives on time</div> <div>-health workers need information made available immediately by phone but economic, network and infrastructural barriers</div> <div>-need for communication for administration but barrier of late information</div> <div>-importance of training but barrier of time and distance</div> <div>3.Perspectives on space</div> <div>-remote areas led to gaps in information retrieval, and delivery of services</div> <div>-inconvenience of time lost and perceived emotional distance</div>			Formatted: Font: Not Bold	
<div>Chib AuthorC 2012a (in review)</div>	Consultatio n between health workers	MNCH	Rural India	-	Qualitative in-depth interviews	Rural healthcar e workers (communi ty health workers 27; of which Accredite d Social Health Activists were 13), 18 doctors,	Framework: ICTs for healthcare development (Banuri 2003)		<div>Barriers:</div> <div>1.Infrastructure</div> <div>-widespread coverage mobile connectivity</div> <div>2.Economic</div> <div>-most owned mobiles, despite government only providing handful of them</div> <div>3.Technological</div> <div>-initial difficulties when learning to use the mobile phone</div> <div>4.Socio-cultural</div> <div>-role of gender was complex, acting as a supporting factor as well as a hindrance</div>	<div>Benefits:</div> <div>1.Opportunity producer</div> <div>-greater time efficiency and savings, as opposed to generating income, for community health workers</div> <div>2.Capabilities enhancer</div> <div>-mobiles greatly improved flow of communication within the healthcare infrastructure, especially during emergencies.</div> <div>3.Social enabler</div> <div>-broadening their social and professional circles</div> <div>4.Knowledge generator</div> <div>-rural healthcare workers</div>			Formatted: Font: Not Bold

						and 11 patients				rapidly and easily accessed healthcare information, through the usage of mobiles
AuthorC 2008, 2009, 2010, 2011a 2011b,										
AuthorC Chib 2008	Consultatio n between health workers	MNCH	Rural Indonesia	Mobile phones and free monthly call credits were distributed to midwives SMS-based application using -GPRS preloaded -on mobiles for uploading patient info	Focus groups and in-depth interviews	123 midwives in an experime ntal group; 101 in control group	Framework: ICTs for healthcare development (Banuri 2003)		Barriers 1.Infrastructure -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	Benefits 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
AuthorC Chib 2011a							Theory: dialectical perspective on gender arising from technology introduction		Autonomy vs. - sSubordination -c Constraints: denial of women's needs, masked inequalities -r Resolution: used strategies to legitimatize benefits and acknowledge constraints Personal growth vs. lLimited technological competency -c Constraints: domestic role limits time for training, low access to technology, fear to speak up -r Resolution: attempted to work around the limitations of time, used informal learning groups Economic independence vs. c Constraints earning capabilities -b Benefits: generalized poverty,	Autonomy vs. - sSubord -b Benefits: opportunity to make decisions, realization of usefulness of mobiles Personal growth vs. lLimited technological competency -b Benefits: mobile phones provide learning material, d Discuss and share knowledge Economic independence vs. c Constraints earning capabilities -b Benefits: increased efficiency in profession Appropriation of power vs. h Hierarchical control -b Benefits: access to power at top, recognition of

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								lack of appreciation for profession by outsiders, increased expenditure r Resolution: Potential long-term gains, Economic gain put aside for gain in dignity and self-respect Appropriation of power vs. hierarchical control c Constraints: difficulty to appropriate power, reluctance to even out hierarchical power r Resolution: self-empowerment	power by outsiders
AuthorC Chib 2009					Baseline and follow up survey	122 midwives in an experimental group; 101 in control group	Model: Technology acceptance model (TAM; Davis, 1986)	TAM could explain 40% of variation in health information-seeking via mobile phones 1.Value perception of mobile phone; marginally significant predictor for perceived usefulness ($pP = .10$) 2.Mobile phone efficacy; significant predictor for perceived ease of use ($pP < .01$), significant improvement in self-efficacy in experimental group 3.Perceived Ease of Use; significant predictor for perceived ease of use ($pP < .01$) 4.Perceived usefulness; perceived usefulness was significant predictors for health information-seeking behaviour ($pP < .01$)	5.Health information-seeking with mobile; significant decrease in using health information services via mobile phones over time in experimental group
AuthorC Chib 2010							Framework: ICTs for healthcare development (Banuri 2003)	Baseline Benefits: 1.Opportunity producer: -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%) 2.Capabilities enhancer -accomplish goals and resolve situations (90.2%); handling of unexpected situations (64.6%) and remaining calm when facing difficulties (75.3%) -reliance on support from colleagues, 69.2% accessing health information from people at work, 43.5% from their health organizations 3.Social enabler -ability to use social resources for work problems, such as midwives (87.9%) and midwife	Follow up compared to baseline for intervention group: Benefits: 1.Opportunity producer: M mobiles decreased usage of line phones ($Pp=0.04$). -inexpensive to use the mobile phone ($Pp=0.03$), and intend to increase usage ($Pp= 0.04$). 2.Capabilities enhancer r increased confidence to solve difficult problems ($p=0.07$) -increased confidence that facilities and equipment provided were adequate to deal with birth complications ($pP=0.09$) -confidence to store health data for patients effectively ($Pp=0.09$) -mobile was a well-known resource ($Pp=0.09$). r easy to use the mobile in general ($pP= 0.06$)

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								<p>colleagues (83.9%).</p> <p>-collective ties between the midwife for trust (94.2%) and support (83.4%).</p> <p>-90.2% were heavily relied on to help in medical situations, compared to obstetrician-gynaecologists $\downarrow$ (63.7%), corresponding to the degree of satisfaction with the information gained from them (midwives, 76.7%; obstetrician-gynaecologists $\downarrow$ -66.6%).</p> <p>-both midwife (91.9%) and obstetrician-gynaecologists $\downarrow$ (88.8%) are seen as fairly equal in terms of the relevancy of information that midwife seek during work.</p> <p>-social contacts and written material functioned as most common modes of obtaining information, with electronic means lagging behind</p> <p>-traditional methods, where accessibility, approachability and trust play a major role in shaping the efficacy of assimilating information</p> <p>4. Knowledge generator</p> <p>-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)</p> <p>-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</p>		<p>-complaints about telecom connectivity</p> <p>3. Social enabler</p> <p>-more likely to turn to health centre personnel for medical information needed ($Pp=0.09$) and access health information from the health centre using their mobiles ($Pp=0.09$).</p> <p>-improved relationship across the levels of the healthcare system hierarchy</p> <p>-quicker access to midwife for patients</p> <p>4. Knowledge generator</p> <p>-easier to search for numbers in mobile lists ($Pp=0.02$), and get the mobile to do what they wanted it to do ($pP=0.00$).</p> <p>-increased in their trust of obtaining health information from the cinema ($Pp < 0.06$) and brochures ($pP=0.04$)</p> <p>-medical question scores increased for standard procedures in childbirth process, decrease in medical question score ($pP=0.03$)</p> <p>postpartum mother to be referred to a hospital</p>
AuthorC Lee 2011b9					Baseline survey	223 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	

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Table 3 Studies with main focus on outcomesput [(n=125)], papers [(n=2147)]

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected Input factors	Selected Mechanism factors	Selected Outcomes	Formatted Table
Chang 2011, 2010, 2008										Formatted: Font: Bold
Chang 2011	Consultation between health workers	HIV	Rural Uganda	Peer health workers were given a mobile and were asked to send a SMS reporting adherence and clinical data after during home visits.	Quantitative and qualitative analysis of cluster randomised controlled trial + survey of 38 clinic staff	Mobile arm, 4 clusters, 13 health workers, 446 patients Control Arm, 6 clusters, 16 health workers, 524 patients	<u>Qualitative themes:</u> -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	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) <u>Qualitative themes:</u> -confidentially concerns; privacy concerns when using others phones -challenges with phones; challenges with phone maintenance, primarily with keeping them charged, theft	<u>Quantitative</u> -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.' <u>Qualitative themes:</u> -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	Formatted Table
Chang 2010					Quantitative analysis of cluster RCT					
Chang 2008					Survey of 39 clinical staff		-direct start-up costs were \$115- USD with monthly maintenance costs approximately \$15 USD per		-44% (17/39) strongly agreed and 56% (22/39) agreed that the peer worker and mobile intervention improved overall health of patients;	

							peer worker program -mobile intervention per health worker start-up costs were an additional \$100 USD with monthly maintenance costs of \$10 USD		20% (8/39) strongly agreed and 49% (19/39) agreed it had improved patient adherence
<u>Zurovac 2011, Jones 2012</u>									
Zurovac 2011	Consultation between health workers	Malaria	Rural Kenya	One-way SMS about paediatric malaria case-management for adhering to guidelines health workers	Cluster randomised trial	107 rural health facilities, 119 health workers		Qualitative findings on way (end 2011), suggested factors: -SMS addressing forgetfulness -SMS emphasise the clinical importance of doing tasks -increase 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
<u>Jones 2012</u>					<u>Qualitative study</u>	<u>24 health workers</u>		<u>The construct of stages of change (based on Prochaska & Di Clemente's 1983 stages of change model)</u> <u>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 kept 'up to date'</u> <u>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'</u>	
Jareethum 2008	Health promotion	MNCH	Thailand	Two SMSes per week (one	Randomised controlled	68 pregnant women; 32		-feeling of taken cared by -satisfaction levels were significantly	No significant differences in pregnancy outcomes between groups; gestational

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				way communicatio n) contained information and warnings	trial	intervention group, 29 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.	age at birth ($P = 0.34$), infant birth weight ($P = 0.35$), preterm delivery ($P = 0.22$) and route of delivery ($P = 1.00$)
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 motivation SMSs, 3 and 10 information SMSs), 801 in control group			-proportions of participants tested: 3 motivational SMSs 49%, 10 motivational SMSs 69%, 3 information SMSs 55%, 10 information SMSs 58%, control 57% -10 motivational SMSs; 1.7-fold increased odds of testing (CI 95%; P = 0.0036) compared to the control group -no significant effect for the other intervention groups -use of 10 MOTI SMSs yielded a per-tester of \$2.41 USD
-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	-Intervention group 97.6% (1132 patients) vs. control group 19.2% (42 patients) kept appointments
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		-HbA1c levels improved from an average of 10.0% at baseline to 8.9% at follow-up ($P = 0.01$) -Self-reported improvements of

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				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
<u>Lester 2010, 2009, 2008, 2006</u>									
<u>Lester 2010</u> <u>Lester 2006</u>	Medication adherence reminder	HIV	Nairobi, Kenya	SMS for ART adherence	<u>Randomized controlled trial</u> <u>Survey</u>	<u>Patients initiating ART, 273 received the intervention</u> <u>and 265 standard care</u> <u>patients</u>	<u>-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</u> <u>-many patients in the intervention group also reported that they thought the SMS support service was valuable-89% nine per cent had access to a phone</u> <u>-12% had ever called or been called by healthcare worker</u>	<u>-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</u> <u>-54% said they would be comfortable receiving HIV-related information by telephone</u> <u>-logistical issues</u>	<u>-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)</u> <u>-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)</u>
<u>Lester 2009</u>					<u>Randomised controlled trial</u> <u>protocol</u>				

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Lester 2008 Lester 2010					Description of crisis situation Randomized controlled trial	Patients initiating ART, 273 received the intervention ; and 265 standard care	-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 "top up" 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	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)
<u>Lester 2006</u>					<u>Survey</u>	<u>111 patients</u>	<u>-89% nine per cent had access to a phone -12% had ever called or been called by healthcare worker</u>	<u>-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</u>	
Pop-Eleches 2011	Medication adherence reminder 	HIV	Kenya	SMS for ART adherence	Randomized controlled trial	Patients initiating ART, 4 intervention groups (70,72,73,74 patients respectively), 139 patients control group		-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	-53% of participants receiving v 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<0.03)
Kunutsor 2010	Appointment and	HIV	Uganda	Voice calls or SMS for	Ce combinati on- cross-	Survey 276 patients,		-forgetfulness major reason for missed visit	-in 79% of missed appointments patients presented for treatment

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	medication adherence reminder			improving clinic attendance and ultimately adherence	sectional and prospective cohort	cohort 176 patients		-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	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)
Chen 2008	Appointment reminder	Health promotion clinic	China	SMS and phone reminder for attendance	Randomized controlled trial	3- groups: SMS reminder (n=620) telephone contact (n=620), control group (n=619)			-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<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)
Da Costa 2009	Appointment reminder	General	Brazil	SMS attendance reminder		29,000 appointments in 4 clinics, in 7890 cases a SMS reminder was sent to the patient's cell phone			-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<0.001)
Leong 2006	Appointment reminder	Primary care clinics	Malaysia	SMS and phone reminder for attendance	Randomized controlled trial	SMS group (n=329) Mobile call group (n=329) Control group (n=335)			-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

									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).
Liew 2009	Appointment reminder	Primary care clinics	Malaysia	SMS and phone reminder for attendance	Randomized controlled trial	SMS group (n=308), call group (n=314), control group (n=309)			-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
Prasad 2012	Appointment reminder	Outpatient clinics at a dental centre	India	SMS reminder	Intervention and control group comparison study	SMS group (n=96) Control group (n=110)			-rate of on time attendance was significantly higher in the test group (79.2%) than in the control group (35.5%)
Seidenberg 2012	Test result notification	HIV	Zambia	Texting of the results of infant HIV tests to relevant health facilities and caregivers	Before after evaluation	10 health facilities	-only 0.5% of the texted reports investigated differed from the corresponding paper reports		-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

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Abbreviations

| Maternal Newborn and Child Health (MNCH), Antiretroviral ~~treatment~~therapy (ART), Relative Risk (RR), Odds ~~R~~ratio (OR), P-value (P), Standard Deviation (SD)

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