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## MHealth adoption in low-resource environments

**Published in:**

Journal of Health Communication

**Publication status and date:**

Published: 02/01/2015

**DOI (link to publisher):**

[10.1080/10810730.2013.864735](https://doi.org/10.1080/10810730.2013.864735)

**Document Version**

Publisher's PDF, also known as Version of record

**Document License/Available under:**

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**Citation for the published version (APA):**

Chib, A., Van Velthoven, M. H., & Car, J. (2015). MHealth adoption in low-resource environments: A review of the use of mobile healthcare in developing countries. *Journal of Health Communication*, 20(1), 4-34.  
<https://doi.org/10.1080/10810730.2013.864735>

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To cite this article: Arul Chib , Michelle Helena van Velthoven & Josip Car (2015) mHealth Adoption in Low-Resource Environments: A Review of the Use of Mobile Healthcare in Developing Countries, Journal of Health Communication, 20:1, 4-34, DOI: [10.1080/10810730.2013.864735](https://doi.org/10.1080/10810730.2013.864735)

To link to this article: <https://doi.org/10.1080/10810730.2013.864735>



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# mHealth Adoption in Low-Resource Environments: A Review of the Use of Mobile Healthcare in Developing Countries

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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 yield mixed results. This article adopts a stage-based approach to understand the varied contributions to mHealth research. The heuristic of inputs-mechanism-outputs is proposed as a tool to categorize mHealth studies. This review (63 articles 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 ( $n = 32$ ), namely introduction and implementation. Somewhat less studied were 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 ( $n = 6$ ) 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.

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 health care 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 information-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 implementation has been low (Ping, Wu, Yu, & Xiao, 2006; World Health Organization, 2011b) with the available evidence proving insufficient to persuade key policymakers and health practitioners (Mechael et al., 2010). Among the reasons for this state of affairs are first, the lack of an ample evidence base, which is understandable for a nascent discipline; and second, a lack of clarity in organizing the evidence to distinguish particular investigative approaches to mHealth, chief among which are the broad domains of technology development, social science, and public health. To resolve these issues, this article 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 section, we provide an overview of the prior mHealth reviews, and then in the Methods and Results section of this article, we describe the assessment of individual studies.

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## Review of Literature

Recent reviews of mHealth provide a range of analyses focusing on particular technological features, process

improvements in healthcare service delivery, and behavior change and healthcare outcomes. As background to this review, we examine these mHealth reviews, noting the number of studies included in parentheses (*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 subsequently cited); 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 [total number unstated]; Patrick, Griswold, Raab, & Intille, 2008 [total number unstated]), or process improvements such as healthcare service delivery (Blynn & Aubuchon, 2009 [total number unstated]; Mechael et al., 2010 [*n* = 145]). However, making the theoretical link to effectiveness, namely behavior change or health outcomes, has been less explicit.

A subset of mHealth reviews focus on SMS, 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 effect 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 (de Jongh, Gurol-Urganci, Vodopivec-Jamsek, Car, & Atun, 2012 [*n* = 4]; Gurol-Urganci, de Jongh, Vodopivec-Jamsek, Car, & Atun, 2012 [*n* = 1]), and patient care (de Tolly, Skinner, Nembaware, & Benjamin, 2012 [*n* = 2]; van Velthoven, Brusamento, Majeed, & Car, 2013 [*n* = 21]). Overall, we conclude that technology introduction and implementation and health care 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 sociocultural levels of analysis.

Researchers have regularly called for theoretically based interventions, suggesting the increased likelihood of meeting success criteria (Krishna et al., 2009), yet few reviews 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 found within the peer-reviewed literature, mostly upheld as the gold standard, sometimes adding experimental/quasi-experimental research designs. Others used 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 policymakers. 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 do this by investigating a large number of studies, covering inputs, mechanism, and outputs, and incorporate both quantitative and qualitative evidence.

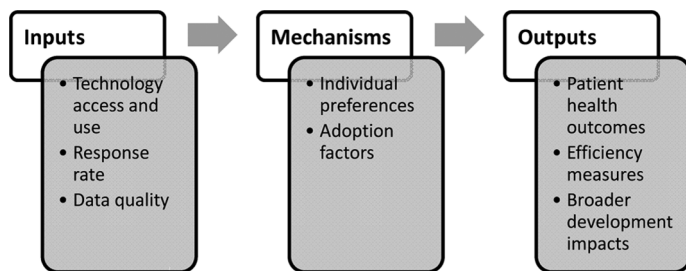
## Method

### Approach

This review article 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 articles than those found previously. Second, we focused 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. Last, 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 inputs-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. Last, 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 behavior change or public health



**Fig. 1.** The mHealth pathway: 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.

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 articles 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 (2012). We included peer-reviewed and non-peer reviewed literature. We considered articles in all languages, but we only found articles 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 standardized form, and considering meta-analysis when appropriate or a narrative assessment.

### Search Methods

One author (M. H. van Velthoven) used mHealth related search terms (phon\*, mobil\*, mhealth, m-health, 'mhealth,' 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, World Health Organization 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 not widely available in low- or middle-income countries at the time.

One strength of this review is the extensive search of references from which the studies were selected. Because of 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 methods.

The articles were further categorized according to the type of the main intervention. Certain studies focused 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 articles) addressing one of the three stages of the pathway, *inputs-mechanism-outputs*, shown in Figure 1. The main types of interventions studied were related to data collection (Alam, Khanam, Khan, Raihan, & Chowdhury, 2010; Andreatta, Debpur, Danquah, & Perosky, 2011; Asimwe et al., 2011; 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; Svoronos et al., 2010; Zhang et al., 2012 [ $n = 11$ ]), and consultation between health workers (Chandhanayingyong, Tangtrakulwanich, & Kiriratnikom, 2007; Chang et al., 2011; Chib & Chen, 2011; Chib, Cheong, et al., 2012; 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 articles by the main type of intervention; data collection (Alam et al., 2010; Andreatta et al., 2011; Asimwe et al., 2011; Barrington et al., 2010; Ganesan et al., 2011; Haberer et al., 2010; Kaewkungwal et al., 2010; MOTECH, 2011; Rajatonirina et al., 2012; Svoronos et al., 2010; Zhang et al., 2012 [ $n = 11$ ]), consultation between



health workers (Chandhanayingyong et al., 2007; Chang et al., 2011; Chib & Chen, 2011; Chib, Cheong, et al., 2012; Chib, Law, Ahmad, & Ismail, 2012; 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 (Chib, Wilkin, Leow, Hoefman, & van Beijma, 2012; 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; Curioso & Kurth, 2007; 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, Salomao, 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; Azfar et al., 2011; Barrington et al., 2010; Chandhanayingyong et al., 2007; Chib, Wilkin, et al., 2012; Cole-Ceesay et al., 2010; Crankshaw et al., 2010; Curioso et al., 2009; Curioso & 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; Mitchell et al., 2011; MOTECH, 2011; Rajatonirina et al., 2012; Shet et al., 2010; Sidney et al., 2012; Skinner et al., 2007; Svoronos et al., 2010; Wolpaw et al., 2011; Zhang et al., 2012; 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 setup costs. These studies were mostly pilot studies, implementation evaluations, and studies with undefined design or interviews. A detailed description can be found in Table 1.

The range of technologies used for data collection ranged from mobile applications (Alam et al., 2010; Ganesan et al., 2011; Kaewkungwal et al., 2010; Svoronos et al., 2010; Zhang et al., 2012), 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 (Chib, Wilkin, et al., 2012; 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 interoperability.

Other studies researched the possibility of an 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 (Curioso & Kurth, 2007).

It is worth noting that 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 articles such as perceived facilitators and barriers and preferences (Alam et al., 2010; Asimwe et al., 2011; Azfar et al., 2011; Barrington et al., 2010; Chib, Wilkin, et al., 2012; 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; Zhang et al., 2012). 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 (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; Chib & Chen, 2011; Chib, Cheong, et al., 2012; Chib, Law, et al., 2012; 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 (Chib & Chen, 2011; Chib, Law, et al., 2012; 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 (Chib, Cheong, et al., 2012). Spatiotemporal arguments (Castells, 1989) were used in rural Nepal to structure the potential of mobile phones for rural communities (Chib,

**Table 1.** Studies with main focus on input papers ( $n = 32$ )

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Barrington et al., 2010	Data collection health worker	Malaria	Rural Tanzania	Cell phone system for antimalarial stock counts	Pilot study, quantitative	129 health facilities	<ul style="list-style-type: none"> <li>Stock count data provided in 95%</li> <li>Response rate &gt;93%</li> <li>Error rate for composition of SMS responses averaged 7.5%</li> <li>Data accuracy was 94%</li> <li>Use of personal mobiles</li> <li>Cell phone coverage within an acceptable distance</li> <li>Free response number</li> </ul>	<ul style="list-style-type: none"> <li>Effective training sessions</li> <li>Government commitment</li> </ul>	<ul style="list-style-type: none"> <li>Proportion of health facilities with no stock of one or more antimalarial medicine fell from 78% at week 1 to 26% at week 21</li> <li>Artemether/lumefantrine stocks increased by 64%, and quinine stock increased 36% across the 3 districts</li> </ul>
Asimwe et al., 2011	Data collection health worker	Malaria	Rural Uganda	SMS-based malaria reporting system; RapidSMS	Implementation, evaluation, quantitative	140 clinics	<ul style="list-style-type: none"> <li>Setup cost US\$100/health facility, local technician support US\$400/month, and US\$0.53/week/clinic</li> <li>88.6% of health facilities reporting weekly</li> <li>12.1% of the 104 clinics reported total medicine artemisinin-combination therapies stock out for at least 1 week</li> <li>District 1: 23.4% of suspected malaria cases reported, 44.8% of these confirmed with rapid testing</li> <li>District 2: 47% of suspected malaria cases reported, 4.5% received rapid testing diagnosis, total stockout of artemisinin- combination therapies 54.3%</li> <li>All but a few clinics were within reliable coverage areas</li> <li>Traditional birth attendants were able to use the specified reporting and SMS protocols</li> <li>425 births and 13 (3.1%) cases of postpartum hemorrhage were reported during the 90-day period after training</li> <li>App was said to be more efficient than existing system; reducing interview time, no time delays for input of data, and no incomplete data input</li> <li>Module showed reduced cost than the automation card system (without data)</li> </ul>	<ul style="list-style-type: none"> <li>Familiarity of users</li> <li>Local expertise in programming and in cell phone services</li> <li>Concerns about control of data</li> <li>Developing Ministry of Health guidelines and policies to involve district health officers</li> </ul>	
Andreatta et al., 2011	Data collection health worker	Maternal newborn and child health; postpartum hemorrhage	Rural Ghana	SMS-based	Unclear	10 traditional birth attendants			
Alam et al., 2010	Data collection health worker	Maternal newborn and child health	Urban Bangladesh	Cell phone app for collecting health info about pregnant women	Unclear	3 centers, 9 health workers		<ul style="list-style-type: none"> <li>Easy training of health workers</li> <li>Acceptability by health workers and patients</li> </ul>	

Svoronos et al., 2011	Maternal newborn and child health	Rural Tanzania	Cell phone app "Comm Care" for managing health workers day and report data on pregnant women in real time	Unclear	5 community health workers	<ul style="list-style-type: none"> <li>Pilot submission data</li> <li>Problem of resubmitting forms that were not initially sent because of network problems</li> </ul>	<ul style="list-style-type: none"> <li>Broader supervisory structure necessary for successful community health worker program, regardless of information and communication technology</li> </ul>	<ul style="list-style-type: none"> <li>Anecdotal evidence of longer and more comprehensive household visits, more consistent follow-up of existing pregnancies, and more active identification of pregnancies</li> </ul>
Zhang et al., 2012	Maternal newborn and child health	Rural China	Cell phone app for collecting data	Study comparing cell phone and paper-and-pen methods	120 mothers of infants aged 0 to 23 months in 4 village clinics	<ul style="list-style-type: none"> <li>No significant difference in interrater reliability between the methods for the questionnaire pairs (<math>p = .32</math>) or variables (<math>p = .45</math>)</li> <li>No data entry errors in cell phone questionnaires, while 65% of paper questionnaires had data entry errors</li> <li>Mean duration of an interview was not significantly different between the methods (<math>p = .19</math>)</li> <li>Mean costs per questionnaire were higher for the cell phone questionnaires (US\$23) than for the paper questionnaires (US\$13)</li> </ul>	<ul style="list-style-type: none"> <li>The cell phone data collection method was acceptable to interviewers</li> <li>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</li> </ul>	
Rajatonirina et al., 2012	Influenza-like illnesses	Madagascar	Innovative case reporting system based on the use of cell phones	Lessons learnt evaluation	Data collected daily from 34 sentinel centers corresponding to 862,585 patient visits	<ul style="list-style-type: none"> <li>86.7% of the data were transmitted within 24 hr</li> <li>95,401 cases (11.1%) presented with fever; a special form was completed for 80,691 of these patients (84.6%)</li> <li>Costs less than US\$2/month per sentinel center, and each center's cell phone equipment costs US\$10</li> </ul>	<ul style="list-style-type: none"> <li>Motivation has been maintained through the provision of medical equipment and training opportunities</li> <li>High staff turnover problem; addressed by training health district officers to train and supervise new staff members</li> </ul>	<ul style="list-style-type: none"> <li>Daily surveillance using SMS can effectively improve the public health surveillance systems already in place</li> <li>Combined biological surveillance and surveillance using SMS makes it possible to rapidly detect the circulation of the influenza virus</li> <li>By detecting unusual patterns of disease activity, SMS surveillance can quicken the response to disease outbreaks</li> </ul>
Ganesan et al., 2011	Disease outbreak	Rural India	The app "mHealth-Survey" on cell phone used to collect and transmit patient health records	Pilot study	Unclear, health workers in primary health centers and health subcenters	<ul style="list-style-type: none"> <li>An average 217 health records were submitted each day via cell phone, with 74% from the primary health centers</li> <li>Health workers were required to submit data during patient interaction but majority submitted records after completing their routine work</li> </ul>		

(Continued)



**Table 1.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Kaewkungwal et al., 2010	Data collection health worker and patient appointment reminder	Maternal newborn and child health	Rural Thailand	Cell phone app for collecting health information about pregnant women	Before/after design without control group	Health personnel in healthcare clinic at pilot testing site	<ul style="list-style-type: none"> <li>Costs were US\$0.09 per 100 completed records</li> <li>10% of women received reminder for antenatal visit</li> <li>17% of the child's parents received immunization reminders</li> <li>10% of health workers updated antenatal status on phones</li> <li>45% updated child's immunization information</li> </ul>	<ul style="list-style-type: none"> <li>No change in work routine facilitated the intervention</li> <li>Health workers seeing usefulness of data collection was important</li> </ul>	<ul style="list-style-type: none"> <li>Improved antenatal and immunization coverage</li> <li>Numbers of antenatal on time as per schedule significantly increased</li> <li>Less delay of antenatal visits and immunizations</li> </ul>
MOTECH, 2011	Data collection health worker and health promotion	Maternal newborn and child health	Rural Ghana	Cell phone app informing health workers and pregnant women and interactive voice calls for health information	Initial implementation evaluation	Pregnant women and nurses	<ul style="list-style-type: none"> <li>Nurse handset; SMS vs. Java</li> <li>Content creation process</li> <li>54% patients owned a cell phone</li> <li>Great demand for maternal and child health information and participants seemed very comfortable receiving this via cell phone</li> </ul>	<ul style="list-style-type: none"> <li>Nurse policy</li> <li>Nurse incentives, need for constant encouragement for nurses</li> <li>Women preferred calls over SMS</li> <li>Women wanted to receive information in their local languages</li> </ul>	<ul style="list-style-type: none"> <li>Less delay of antenatal visits and immunizations</li> </ul>
Haberer et al., patient 2010	Data collection	HIV	Uganda	Interactive voice response calls and SMS for automated collection of weekly individual-level antiretroviral therapy adherence data	Randomized trial, no control but two interventions were compared, qualitative interviews	31 of the 121 caregivers in the CHARTA Study who had their own mobiles	<ul style="list-style-type: none"> <li>Weekly completion rates for adherence queries were low (0-33%)</li> <li>Technologies were acceptable</li> </ul>	<ul style="list-style-type: none"> <li>Challenges in training</li> </ul>	<ul style="list-style-type: none"> <li>Improved adherence</li> </ul>
Skinner et al., 2007 (Cell Life program)	Consultation between health workers—data collection	HIV	South Africa	Cell phone redesigned menu "Cell life" for communication between therapeutic counselors and the health services	Qualitative interviews	8 counselors	<ul style="list-style-type: none"> <li>It was easy to learn how to use cell phones</li> <li>Improvements in technology gave additional security</li> </ul>	<ul style="list-style-type: none"> <li>Cell phone did not interfere or distract with relationship between counselor and patient</li> <li>Feeling good because their work integrated them better into the community</li> <li>Having cell phones, a status item, raised status</li> <li>No feeling of pressure at being on call 24 hr per day and keeping the cell phone on all the time</li> <li>Fear of crime because the cell phone meant counselors were more at risk for theft</li> <li>Positive effect on record keeping</li> </ul>	<ul style="list-style-type: none"> <li>Improved adherence</li> </ul>

Lemay et al., 2012	Consultation between health workers—data collection	Family planning/reproductive health and HIV/AIDS	Malawi	SMS system to improve the exchange and use of knowledge among health workers	Baseline evaluation with quantitative and qualitative methods	Cell phones provided to 253 health workers, 35 focus group discussions	<ul style="list-style-type: none"> <li>1,761 regular messages were sent and received</li> <li>All participating community health workers sent at least 1 SMS, with an average of 5 messages per community health worker per month</li> <li>Main reasons for sending messages include reporting stockouts, asking general information, reporting emergencies, confirming meetings, and requesting technical support</li> <li>Health workers with cell phones; most common modes of communication included SMSs (100%), phone calls (94.4%), and face to face (8%)</li> <li>Preliminary time and costs estimates</li> </ul>	<ul style="list-style-type: none"> <li>Feel more effective and secure in role because of rapid help</li> <li>Cell phone use facilitated providing a good service</li> <li>Health workers reported that their participation in the SMS network resulted in local recognition and improved status among their clients and communities</li> <li>Findings indicated that timely information exchange between the district and community levels can directly affect the quality of care patients receive</li> </ul>
Cole-Ceasay et al., 2010	Consultation between health workers	Maternal newborn and child health	The Gambia	Emergency ambulance service linking the community with the hospital through a cell phone system	Unclear	Traditional birth attendants and village health workers	<ul style="list-style-type: none"> <li>Traditional birth attendants reported that villagers provided credit for cell phone, which facilitated them to use it until free phone numbers could be negotiated with network providers</li> <li>Battery life overcame charging difficulties</li> </ul>	<ul style="list-style-type: none"> <li>Traditional birth attendants reported that villagers provided credit for cell phone, which facilitated them to use it until free phone numbers could be negotiated with network providers</li> </ul>
Chandhanayingyong et al., 2006	Consultation between health workers	Orthopedics	Thailand	Teleconsultation MMS in emergency orthopaedic patients	Case-control, age-matched	59 emergency orthopedic cases, 34 normal patients visiting the emergency department	<ul style="list-style-type: none"> <li>Teleconsultation via MMS demonstrated good reliability but poor diagnostic accuracy; sensitivity, specificity, and accuracy were 78%, 54%, and 65%, respectively</li> <li>Overall misdiagnosis rate of 40%, with over-diagnosis of 12% and underdiagnosis of 27%</li> </ul>	<ul style="list-style-type: none"> <li>Teleconsultation via MMS demonstrated good reliability but poor diagnostic accuracy; sensitivity, specificity, and accuracy were 78%, 54%, and 65%, respectively</li> <li>Overall misdiagnosis rate of 40%, with over-diagnosis of 12% and underdiagnosis of 27%</li> </ul>
Macrohon & Cristobal, 2010	Consultation between health workers	General	Rural Philippines	Telecommunication, including cell phones, for referral	Survey	3 health officers and 39 patients	<ul style="list-style-type: none"> <li>Some concerns about time taken for response after SMS referrals, and expenses of the entire system</li> </ul>	<ul style="list-style-type: none"> <li>Generally satisfactory, preference (42% of consultations) for cell phone 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</li> </ul>

(Continued)

**Table 1.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Zolfo et al., 2010	Consultation between health workers—education health workers	HIV	Peru	Cell phone educational platform supporting learning events and tracking participant learning progress	Survey	20 physicians	<ul style="list-style-type: none"> <li>Access to Skype and Facebook, screen/keyboard size, and image quality were cited as more troublesome for the Nokia N95 compared with the iPhone</li> </ul>	<ul style="list-style-type: none"> <li>Overall satisfaction of using cell phone tools was greater for the iPhone</li> </ul>	
Azfar et al., 2012	Consultation between health workers and patients	HIV	Botswana	Cell phone teledermatology consultation	Survey	75 people living with HIV	<ul style="list-style-type: none"> <li>82% reported no concerns, 8% having a face-to-face interaction with the physician and 8% reported concerns over an incomplete representation of their skin or poor photograph quality</li> </ul>	<ul style="list-style-type: none"> <li>Quality of care; 91% believed that they would receive the same treatment and quality of care via cell phone teledermatology consultation as with a face-to-face interaction</li> <li>If privacy was guaranteed, 99% were completely comfortable with a cell phone teledermatology consultation</li> <li>Acceptability; 58% accepted photography of the face, 97% chest, 92% genitals, 96% legs and 95% body as a whole</li> <li>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 cell phone teledermatology consultations, 13% would not prefer cell phone teledermatology over face-to-face consultation</li> </ul>	
L'Engle & Vadhat, 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	<ul style="list-style-type: none"> <li>Common use of SMS</li> <li>Sharing of cell phones, possibility of others reading SMS</li> </ul>	<ul style="list-style-type: none"> <li>Privacy of service</li> <li>Share SMS with family and friends</li> <li>SMS seen as trustworthy</li> <li>SMS reminder of information</li> </ul>	
Mitchell et al., 2011	Health promotion	HIV	Rural Uganda	No intervention aim; perspectives on SMS for HIV prevention	Survey	1,523 students	<ul style="list-style-type: none"> <li>27% owned a cell phone</li> <li>Of adolescents owning a cell phone, 93% had sent a SMS in the past 12 months</li> <li>19% of adolescents who had sent or received SMS in the</li> </ul>	<ul style="list-style-type: none"> <li>Less costs than visiting clinic</li> <li>51% said they were somewhat or extremely likely to access a health education program about HIV/AIDS prevention via SMS</li> </ul>	

Danis et al., 2010	Health promotion	HIV	Uganda	HIV-prevention quiz by SMS	Analysis of quiz responses	10,000 cell phone numbers in general population, 2,494 participants enrolled at the start of the FactoryQuiz	<p>past year said that they sent a SMS on their cell phone to get information about health and disease in the past 12 months</p> <ul style="list-style-type: none"> <li>Participation rates varied from a low of between 5% and 10% in general population to around 50% in the factory quiz</li> </ul>
Chib, Wilkin, et al., 2012	Health promotion	HIV	Uganda	HIV-prevention quiz (13 questions) by SMS	Analysis of quiz responses	10,000 cell phone numbers in general population	<p>Discussed factors:</p> <ul style="list-style-type: none"> <li>Making SMS part of an integrated mass-media communication campaign</li> <li>Stigmatization could be strong obstacle to participation in the program</li> <li>Lower likelihood of cell phone ownership for certain groups, particularly for rural women</li> <li>Self-selection bias into incentive based quizzes</li> <li>Some reported behavior changes after reading health tips</li> <li>Increased confidence among users in sharing health information with their families peers, and neighbors</li> <li>Some reported greater levels of assurance when their doctors provided the same information as in the SMSs</li> <li>Indication of increased information-seeking behaviors</li> </ul>
Maharani et al., 2012	Health information	General	Indonesia	Two paid services: 1. Advice on affordable pharmaceutical drug options via SMS 2. Personal health information via SMS	1. Survey 2. Survey and in-depth interviews	Study 1: 30 users Study 2: pregnant women and mothers who received a free 1-month prescription; 88 (survey), 8 (interview)	<p>Program provided accurate data, which participants said helped them with making decisions when selecting</p> <ul style="list-style-type: none"> <li>Price of subscribing to SMS as it saved them money</li> <li>Info program was affordable</li> <li>Health information is easy and fast to access</li> <li>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</li> <li>Health information received was relevant</li> <li>Detailed information rather than short summarized information was much preferred</li> </ul>
Curioso & Kurth, 2007	Medication adherence reminder	HIV	Peru	No intervention aim; access, use and perceptions regarding Internet, cell phones, and	In-depth interviews	31 people living with HIV at 2 clinics	<ul style="list-style-type: none"> <li>81% were interested in receiving health information by cell phones</li> <li>74% reported willingness to use cell phones to receive reminder messages for their</li> </ul>

(Continued)

**Table 1.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
				PDAs					
Curioso et al., 2009	Medication adherence reminder	HIV	Peru	No intervention aim; perspectives on reminder strategies to improve antiretroviral treatment adherence and SMSs	4 focus groups	26 people living with HIV	Anthropomorphic features: anthropomorphized the system with human characteristics	<p>HIV medication, by a prerecorded voice (74% of those willing) or by SMS (74% of those willing)</p> <ul style="list-style-type: none"> <li>Alarm reminders most useful for antiretroviral treatment-naïve patients</li> <li>81% expressed their interest in receiving SMSes about their sexual health over the cell phone, including information about sexually transmitted infections</li> <li>Of those, 88% would prefer sexual health messages via SMS 68% via calls with a prerecorded voice</li> <li>Many said they would like to receive general HIV information via cell phones</li> </ul> <p>Perceptions towards reminder messages: overall acceptable</p> <ul style="list-style-type: none"> <li>Characteristics of reminder messages: motivational, conciseness, simple and shareable, spiritual tone, confidential</li> <li>Frequency of change: some frequency in to prevent monotony and boredom with them; change weekly/daily</li> <li>Confidentiality and privacy issues: keeping the medication reminders confidential was the most important concern, no "sensitive" words</li> </ul>	<ul style="list-style-type: none"> <li>74% (95% CI [69.2, 78.8]) thought SMS reminder feature would be helpful in maintaining adherence</li> <li>89% did not perceive SMS reminders as an intrusion on privacy</li> <li>79.5% (<math>p &lt; .005</math>) wanted to use their cell phones to call health worker</li> </ul>
Shet et al., 2010	Medication adherence reminder	HIV	India	No intervention aim; perspectives cell phone intervention for improving antiretroviral treatment adherence	Survey	322 persons participated at the 3 clinics, 81% were HIV-infected patients in care	<ul style="list-style-type: none"> <li>73.1% owned a cell phone, and 55% used a cell phone for more than 2 years</li> <li>Use of cell phones; calls approximately 4 times per day, SMS used by 25%</li> </ul>		



Mbuagbaw et al., 2012	Medication adherence reminder	HIV	Cameroon	No intervention aim; perspectives on SMSs for improving antiretroviral treatment adherence	5 focus groups	30 people living with HIV	<ul style="list-style-type: none"> <li>62% wanted receive info on the availability of new drugs and HIV medicine and 68% on research via cell phone</li> <li>26% did not perceive benefits from reminders as they were unnecessary</li> <li>Preferred reminders varied but most preferred were beeps, alarms, SMSs, or personal verbal reminders</li> <li>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</li> <li>No consensus on the content or number of the message</li> <li>90% reported the intervention as being helpful as medication reminders, and did not feel their privacy was intruded</li> <li>87% reported that they preferred the call as reminders, 11% preferred SMS alone</li> <li>59% viewed all the SMSs that were delivered, 15% never viewed any at all</li> <li>No discomfort or stigma was experienced despite that other persons sometimes received the participant's call (20%) or SMS (13%)</li> <li>Comfortable with daily SMSs</li> <li>Personal relationships were an important factor of success, community health workers' understood what was happening and were comfortable enough to tell the supervisor"</li> <li>Most common reasons for overdue visit were that health worker was travelling, busy or forgot Escalation; health workers were not always available</li> </ul>
Sidney et al., 2012	Medication adherence reminder	HIV	India	Weekly interactive call and a noninteractive neutral pictorial SMS on cell phones	Survey	139 people living with HIV	<ul style="list-style-type: none"> <li>10 of 30 declared that they had some difficulty with medication adherence</li> <li>Issues: poor network, possibility of dependence on the SMS, and poor adherence in its absence</li> <li>86% owned a phone</li> <li>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]).</li> <li>93% knew how to make and receive a call</li> <li>86% knew how to receive and 47% how to send a SMS 744 calls were made, 545 (76%) of which were received</li> <li>All participants received the weekly pictorial SMS reminder</li> </ul>
Derenzi et al., 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	<p>Study 1: 13 community health workers</p> <p>Study 2: 87 health workers</p> <p>Study 3: The same 87 health workers, but 26 were excluded</p>	<ul style="list-style-type: none"> <li>Intervention: increase in closed referrals by 33.8%; control: decrease by 34.6%</li> <li>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 (8.2-9.3 days)</li> <li>Removing the escalation step, a supervisor calling the health workers, decreased performance (<math>p = .023</math>)</li> </ul>

(Continued)

**Table 1.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Crankshaw et al., 2010	Appointment and medication adherence reminder	HIV	Urban South Africa	No intervention aim; perspectives on cell phones for clinic appointment reminders and adherence messages.	Survey	300 individuals who presented for treatment at the ART clinic	<ul style="list-style-type: none"> <li>• Preliminary costs; SMS intervention adds an estimated US\$0.84/patient/year</li> <li>• 28% shared cell phone with 1 or more other people</li> <li>• 87% indicated that they usually answered calls that displayed "private number"</li> <li>• 79% used cell phone alarm function as reminder to take medication</li> </ul>	<ul style="list-style-type: none"> <li>• when called by supervisor, local champion health workers were used to reach them</li> <li>• Fewer health workers required escalation calls over time</li> <li>• 25% believed that their SMSs had been read without their permission</li> </ul>	
Wolpaw et al., 2011	Test result reminder	HIV	Urban South Africa	Reminding patients who do not return for HIV test results with text messages and phone calls	Face-to-face interview	902 high-risk participants enrolled over 1 year	<ul style="list-style-type: none"> <li>• 40.6% came back for results</li> <li>• Results and counseling were delivered to 62.3% of participants and all 6 patients with acute HIV infection; 6 (0.67%) were diagnosed with acute HIV infection</li> </ul>	<ul style="list-style-type: none"> <li>• Delay in test results reasons</li> <li>• Travel and difficulty making contact with patients</li> </ul>	
Faisal, 2012	General	General	Bangladesh	No intervention; impact assessment on existing cell phone healthcare support	Surveys, telephone interviews	10 families and 5 doctors	<ul style="list-style-type: none"> <li>• 90% of families had a cell phone</li> <li>• 30% of families were aware of local cell phone health services</li> <li>• 40% of families rely on cell phone health services</li> <li>• Doctors receive about 10-20 calls per day</li> <li>• Doctors experience difficulties in diagnosing patients over the telephone but are able to provide basic advice</li> </ul>		

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

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Theory, framework, model	Selected input factors	Constructs and findings	Selected outcomes
Hwabamungu & Williams, 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 Technology Acceptance Model (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)	<ul style="list-style-type: none"> <li>Appropriateness of chosen technology; cell phones possession for example is high cell phone ownership (51/55) use their cell phone as tool to improve service provision or access (46/55)</li> </ul>	<p><b>Constructs of models not given</b></p> <ul style="list-style-type: none"> <li>Users' perception; importance of technology can affect technology acceptance, most are aware of cell phone applications and would consider using them for health, but issues of privacy, cell phone data storage capacities and cell phone loss</li> <li>Patients' and caregivers' willingness to use the technology does not mean preparedness for paying costs</li> <li>Government and donor support critical to ensure free service that people expect</li> <li>Importance of financial sustainability model</li> </ul>	
Hamilton, 2010	Health promotion	General	Rural Kenya	No intervention	Survey and participant observation such as in-depth interviews	12 Kenyan-based experts and practitioners, 55 residents	Theory: Social marketing (Hastings, 2007)	<ul style="list-style-type: none"> <li>Survey findings (villagers) on the following:</li> <li>Profile of the village</li> <li>In-depth interview findings (experts)</li> <li>Profile of expert respondents</li> </ul>	<ol style="list-style-type: none"> <li><b>1. Price: cost prohibitive</b></li> <li><b>2. Promotion: text messages</b></li> <li><b>3. Product: goal of changing health behavior</b></li> <li><b>4. Place: practicability of a cell phone</b></li> </ol> <p>Survey findings (villagers) on the following:</p> <ul style="list-style-type: none"> <li>Educational attainment's role in cell phone ownership and use</li> <li>Literacy in relation to cell phone ownership and use</li> <li>Relation between media consumption and cell phone ownership and use</li> <li>Access to cell phones, by gender</li> </ul> <p>In-depth interview findings (experts) on the following:</p> <ul style="list-style-type: none"> <li>Gender and access to cell phones</li> <li>Effect of price on cell phone ownership and use</li> <li>Cost of airtime</li> <li>Cost to health provider</li> <li>Cost to user</li> <li>Cost of electricity</li> <li>Psychological cost</li> <li>Cell phones, health and behavior change</li> <li>Surveillance</li> <li>Role of the indigenous leadership</li> <li>Cell phone and media partnership</li> </ul>	

(Continued)

**Table 2. Continued**

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Theory, framework, model	Selected input factors	Constructs and findings	Selected outcomes
Chib, Law, et al., 2012	Consultation between health workers	Maternal newborn and child health	Rural Nepal	No intervention	Focus groups and qualitative interviews	22 community healthcare workers, 10 professional management represent tatives and 19 patients and villagers	Spatiotemporal perspectives on mHealth (Castells, 1989, 2007)	<p><b>1. Communicative practices</b></p> <ul style="list-style-type: none"> <li>Sharing fixed-line and cell phone access</li> <li>Use of combination fixed-line mobile community phone in larger villages</li> </ul> <p><b>2. Perspectives on time</b></p> <ul style="list-style-type: none"> <li>Health workers need information made available immediately by phone but economic, network and infrastructural barriers</li> <li>Need for communication for administration but barrier of late information</li> <li>Importance of training but barrier of time and distance</li> </ul> <p><b>3. Perspectives on space</b></p> <ul style="list-style-type: none"> <li>Remote areas led to gaps in information retrieval, and delivery of services</li> <li>Inconvenience of time lost and perceived emotional distance</li> </ul>	<ul style="list-style-type: none"> <li>Literacy rates in relation to cell phone ownership and use</li> </ul>	<ul style="list-style-type: none"> <li>Health workers need information made available immediately by phone but economic, network and infrastructural barriers</li> <li>Need for communication for administration but barrier of late information</li> <li>Importance of training but barrier of time and distance</li> <li>Remote areas led to gaps in information retrieval, and delivery of services</li> <li>Inconvenience of time lost and perceived emotional distance</li> </ul>
Chib, Cheong, et al., 2012	Consultation between health workers	Maternal newborn and child health	Rural India	–	Qualitative in-depth interviews	Rural healthcare workers (community health workers 27; of which 13 were accredited social health activists), 18 doctors, and 11 patients	Framework: information and communication technologies for healthcare development (Banuri, 2003)	<p><b>Barriers:</b></p> <ol style="list-style-type: none"> <li><b>Infrastructural</b> <ul style="list-style-type: none"> <li>Widespread coverage cell phone connectivity</li> </ul> </li> <li><b>Economic</b> <ul style="list-style-type: none"> <li>Most owned cell phones, despite government providing only a handful of them</li> </ul> </li> <li><b>Technological</b> <ul style="list-style-type: none"> <li>Initial difficulties when learning to use the cell phone</li> </ul> </li> <li><b>Sociocultural</b> <ul style="list-style-type: none"> <li>Role of gender was complex, acting as a supporting factor as well as a hindrance</li> </ul> </li> </ol> <p><b>Benefits:</b></p> <ol style="list-style-type: none"> <li><b>Opportunity producer</b> <ul style="list-style-type: none"> <li>Greater time efficiency and savings, as opposed to generating income, for community health workers</li> </ul> </li> <li><b>Capabilities enhancer</b> <ul style="list-style-type: none"> <li>Cell phones greatly improved flow of communication in the healthcare infrastructure, especially during emergencies</li> </ul> </li> <li><b>Social enabler</b> <ul style="list-style-type: none"> <li>Broadening their social and professional circles</li> </ul> </li> <li><b>Knowledge generator</b> <ul style="list-style-type: none"> <li>Rural healthcare workers rapidly and easily accessed healthcare information via cell phones</li> </ul> </li> </ol>	<p><b>Barriers</b></p> <ol style="list-style-type: none"> <li><b>Infrastructural</b> <ul style="list-style-type: none"> <li>Uneven telecommunications</li> </ul> </li> <li><b>Economic</b> <ul style="list-style-type: none"> <li>Cost of mobile phone and phone credit</li> </ul> </li> <li><b>Technological</b> <ul style="list-style-type: none"> <li>Midwives lacking technical knowledge</li> </ul> </li> </ol> <p><b>Benefits</b></p> <ol style="list-style-type: none"> <li><b>Opportunity producer:</b> <ul style="list-style-type: none"> <li>Increase patient numbers, not in higher income</li> <li>Patient easier getting hold of midwife</li> <li>Midwife greater time and cost efficiency</li> </ul> </li> </ol>	
Chib et al., 2008	Consultation between health workers	Maternal newborn and child health	Rural Indonesia	Cell phones and free monthly call credits were distributed to midwives	Focus groups and in-depth interviews	123 midwives in an experimental group; 101 in control group	Framework: information and communication technologies for healthcare development (Banuri, 2003)	<p><b>Barriers</b></p> <ol style="list-style-type: none"> <li><b>Infrastructural</b> <ul style="list-style-type: none"> <li>Uneven telecommunications</li> </ul> </li> <li><b>Economic</b> <ul style="list-style-type: none"> <li>Cost of mobile phone and phone credit</li> </ul> </li> <li><b>Technological</b> <ul style="list-style-type: none"> <li>Midwives lacking technical knowledge</li> </ul> </li> </ol> <p><b>Benefits</b></p> <ol style="list-style-type: none"> <li><b>Opportunity producer:</b> <ul style="list-style-type: none"> <li>Increase patient numbers, not in higher income</li> <li>Patient easier getting hold of midwife</li> <li>Midwife greater time and cost efficiency</li> </ul> </li> </ol>	<p><b>Barriers</b></p> <ol style="list-style-type: none"> <li><b>Infrastructural</b> <ul style="list-style-type: none"> <li>Uneven telecommunications</li> </ul> </li> <li><b>Economic</b> <ul style="list-style-type: none"> <li>Cost of mobile phone and phone credit</li> </ul> </li> <li><b>Technological</b> <ul style="list-style-type: none"> <li>Midwives lacking technical knowledge</li> </ul> </li> </ol> <p><b>Benefits</b></p> <ol style="list-style-type: none"> <li><b>Opportunity producer:</b> <ul style="list-style-type: none"> <li>Increase patient numbers, not in higher income</li> <li>Patient easier getting hold of midwife</li> <li>Midwife greater time and cost efficiency</li> </ul> </li> </ol>	

preloaded on cell phones for uploading patient info

- Lack of relevant local content (English)
- 4. **Sociocultural**
- Midwives were given equal opportunities to communicate with information and communication technology
- No religious resistance
- Barrier of organizations hierarchy

- 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 healthcare

- 4. **Knowledge generator**
- Improved medical knowledge
- Midwives sharing medical knowledge with patients

Theory:  
dialectical perspective on gender arising from technology introduction

Chih & Chen, 2011

- Autonomy vs. subordination**
- Constraints: denial of women's needs, masked inequalities
- Resolution: used strategies to legitimize benefits and acknowledge constraints

- Personal growth vs. limited technological competency**
- Constraints: domestic role limits time for training, low access to technology, fear to speak up
- Resolution: attempted to work around the limitations of time, used informal learning groups

- Economic independence vs. constraints earning capabilities**
- Constraints: generalized poverty, lack of appreciation for profession by outsiders, increased expenditure
- Resolution: Potential long-term gains, economic gain put aside for gain in dignity and self-respect

- Appropriation of power vs. hierarchical control**
- Constraints: difficulty to appropriate power, reluctance to even out hierarchical power
- Resolution: self-empowerment

Baseline and follow-up survey  
122 midwives in an experimental group; 101 in control group  
Model: Technology Acceptance Model (Davis, 1986)

Chih et al., 2009

- 5. **Health information seeking via cell phone;**
- significant decrease in using health information services via cell phones over time in experimental group

1. **Value perception of cell phone;** marginally significant predictor for perceived usefulness ( $p = .10$ )
2. **Cell phone efficacy;** significant predictor for perceived ease of use ( $p < .01$ ), significant improvement in self-efficacy in experimental group

(Continued)



**Table 2.** Continued

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Theory, framework, model	Selected input factors	Constructs and findings	Selected outcomes
Chib, 2010							<p>Framework: information and communication technologies for healthcare development (Banuri, 2003)</p> <p>Baseline <b>Benefits:</b></p> <p><b>1. Opportunity producer:</b></p> <ul style="list-style-type: none"> <li>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%)</li> </ul> <p><b>2. Capabilities enhancer</b></p> <ul style="list-style-type: none"> <li>Accomplish goals and resolve situations (90.2%); handling of unexpected situations (64.6%) and remaining calm when facing difficulties (75.3%)</li> <li>Reliance on support from colleagues, 69.2% accessing health information from people at work, 43.5% from their health organizations</li> </ul> <p><b>3. Social enabler</b></p> <ul style="list-style-type: none"> <li>Ability to use social resources for work problems, such as midwives (87.9%) and midwife colleagues (83.9%)</li> <li>Collective ties between the midwife for trust (94.2%) and support (83.4%)</li> <li>90.2% were heavily relied on to help in medical situations, compared to obstetriciangynecologists (63.7%), corresponding to the degree of satisfaction with the</li> </ul>	<p><b>3. Perceived ease of use:</b> significant predictor for perceived ease of use (<math>p &lt; .01</math>)</p> <p><b>4. Perceived usefulness:</b> perceived usefulness was significant predictors for health information-seeking behavior (<math>p &lt; .01</math>)</p>	<p>Follow up compared to baseline for intervention group:</p> <p><b>Benefits:</b></p> <p><b>1. Opportunity producer:</b></p> <ul style="list-style-type: none"> <li>Cell phones decreased usage of line phones (<math>p = .04</math>)</li> <li>Inexpensive to use the cell phone (<math>p = .03</math>), and intend to increase usage (<math>p = .04</math>)</li> </ul> <p><b>2. Capabilities enhancer</b></p> <ul style="list-style-type: none"> <li>Increased confidence to solve difficult problems (<math>p = .07</math>)</li> <li>Increased confidence that facilities and equipment provided were adequate to deal with birth complications (<math>p = .09</math>)</li> </ul> <p><b>3. Social enabler</b></p> <ul style="list-style-type: none"> <li>Confidence to store health data for patients effectively (<math>p = .09</math>)</li> <li>Cell phone was a well-known resource (<math>p = .09</math>)</li> <li>Easy to use the cell phone in general (<math>p = .06</math>)</li> <li>Complaints about tele-communication connectivity</li> <li>More likely to turn to health center personnel for medical information needed</li> </ul>	

<p>information gained from them (midwives, 76.7%; obstetriciangynecologists (66.6%)</p> <ul style="list-style-type: none"> <li>Midwife (91.9%) and obstetriciangynecologists (88.8%) are seen as fairly equal in terms of the relevancy of information that midwife seek during work.</li> <li>Social contacts and written material functioned as most common modes of obtaining information, with electronic means lagging behind</li> <li>Traditional methods, where accessibility, approachability and trust play a major role in shaping the efficacy of assimilating information</li> </ul> <p><b>4. Knowledge generator</b></p> <ul style="list-style-type: none"> <li>Knowledge family planning moderate, knowledge of pregnancy related issues lower, 23.9% already used the cell phone often for obtaining relevant information</li> <li>90% confident to use cell phone for information, 85% relevant to their needs, and 70.5% felt that it would influence the way seeking medical advice</li> </ul>	<p>(<math>p = .09</math>) and access health information from the health center using their cell phones (<math>p = .09</math>)</p> <ul style="list-style-type: none"> <li>Improved relationship across the levels of the healthcare system hierarchy</li> <li>Quicker access to midwife for patients</li> </ul> <p><b>4. Knowledge generator</b></p> <ul style="list-style-type: none"> <li>Easier to search for numbers in cell phone lists (<math>p = .02</math>), and get the cell phone to do what they wanted it to do (<math>p = .00</math>)</li> <li>Increased in their trust of obtaining health information from the cinema brochures (<math>p = .04</math>)</li> <li>Medical question scores increased for standard procedures in childbirth process, decrease in medical question score (<math>p = .03</math>) postpartum mother to be referred to a hospital</li> </ul>	<p>223 midwives</p>	<p>Baseline survey</p>	<p>Hypothesized model of midwives' cell phone use, access to resources,</p>	<p><b>2. Access to institutional resources;</b> access to institutional resources had a direct positive effect on midwives' health knowledge, access to institutional resources did not increase self-efficacy</p>
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Lee et al., 2011

(Continued)

**Table 2.** Continued

Paper (first author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Theory, framework, model	Selected input factors	Constructs and findings	Selected outcomes
Ashraf et al., 2010	Health information for patients	General	Rural Bangladesh	Health help line service (Grameen Phone) via their cell phone	Qualitative interviews with storytelling	4 patients and 1 doctor from 3 villages	self-efficacy, and health knowledge  Framework: ICT4D value chain model "Communications-for-Development" (adapted from Bertrand, 2006)		<p><b>3. Access to peer resources;</b> access to peer resources had no direct positive effect on midwives' health knowledge. access to peer resources increased self-efficacy</p> <p><b>4. Self-efficacy;</b> self-efficacy was positively associated with health knowledge</p> <p><b>5. Health knowledge</b></p> <p><b>1. Context</b></p> <ul style="list-style-type: none"> <li>Distance barrier</li> <li>Financial barrier</li> <li>Language barrier</li> <li>Lack of knowledgeable doctors</li> <li>Lack of 24-hr service</li> <li>Lack of healthcare</li> </ul> <p><b>2. Changes in behavioral precursors:</b></p> <ul style="list-style-type: none"> <li>Changes in knowledge and behavior of doctors and patients</li> <li>More positive attitude of doctors and patients</li> <li>Reduction of distance and other barriers</li> </ul> <p><b>3. Changes in behavior:</b></p> <ul style="list-style-type: none"> <li>Increase in awareness level</li> <li>An efficient alternative for emergency treatment</li> <li>More relief patients</li> </ul> <p><b>4. Broader development impact:</b></p> <ul style="list-style-type: none"> <li>An effective data base for research</li> <li>An important tool for implementing Millennium Development Goals</li> <li>Efficient management and administration</li> </ul>	

*Note.* Constructs appear in bold and findings in normal type.

**Table 3.** Studies with main focus on outcomes [ $n = 15$ ], papers [ $n = 21$ ]

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Chang et al., 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 randomized controlled trial and survey of 38 clinic staff	<p><u>Mobile arm:</u> 4 clusters 13 health workers 446 patients</p> <p><u>Control arm:</u> 6 clusters 16 health workers 524 patients</p>	<p><u>Qualitative themes:</u></p> <ul style="list-style-type: none"> <li>Improved but incomplete phone access; patient access to phones varied; did not own phones themselves, many had access by phones in the communities (16% owned phones, 79% previously used a phone)</li> <li>Call costs was a key factor limiting patient communication</li> </ul>	<p><u>Healthcare communication diagram pathways through which cell phones expedited communication:</u></p> <ul style="list-style-type: none"> <li>Formal (peer worker-clinic staff)</li> <li>Informal (patient-family)</li> <li>Other (patient-clinic and peer worker, family and friends-peer worker and clinic)</li> </ul> <p><u>Qualitative themes:</u></p> <ul style="list-style-type: none"> <li>Confidentially concerns; privacy concerns when using others phones</li> <li>Challenges with phones; challenges with phone maintenance, primarily with keeping them charged, theft</li> </ul>	<p><u>Quantitative findings:</u></p> <ul style="list-style-type: none"> <li>No significant differences in virologic adherence, mortality, or retention outcomes</li> <li>Clinic staff (89%) agreed strongly/agreed that "mobile phones used by peer workers improved overall care of patients"</li> <li>Clinic staff (89%) agreed strongly/agreed that "all peer worker should be given mobile phones to use for patient care"</li> </ul> <p><u>Qualitative themes:</u></p> <ul style="list-style-type: none"> <li>Voice calls; patients, peer workers, and staff said that calls on cell phones expedited patient care, improved logistics, save travel time</li> <li>SMS, may have encouraged patients to improve adherence, task shifting, in contrast with voice calls clinic staff had to first review SMSs on computer before responding</li> <li>Improved peer health worker morale, improve capabilities and job satisfaction, improve peer health worker-staff relationships</li> </ul>
Chang et al., 2010					Quantitative analysis of cluster randomized controlled trial				
Chang et al., 2008					Survey of 39 clinical staff		<ul style="list-style-type: none"> <li>Direct startup costs were US\$115 with monthly maintenance</li> </ul>		<ul style="list-style-type: none"> <li>44% (17/39) strongly agreed and 56% (22/39) agreed that the peer worker and mobile intervention improved</li> </ul>

(Continued)

**Table 3.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Zurovac et al., 2011	Consultation between health workers	Malaria	Rural Kenya	One-way SMS about pediatric malaria case-management for adhering to guidelines health workers	Cluster randomized trial	107 rural health facilities 119 health workers	<p>costs approximately US\$15/peer worker program</p> <ul style="list-style-type: none"> <li>Mobile intervention per health worker start-up costs were an additional US\$100 with monthly maintenance costs of US\$10</li> </ul>	<p>Selected mechanism factors</p> <ul style="list-style-type: none"> <li>Qualitative findings on way (end 2011), suggested factors: <ul style="list-style-type: none"> <li>SMS addressing forgetfulness</li> <li>SMS emphasize the clinical importance of doing tasks</li> <li>Increase the priority of doing the tasks</li> <li>Enhancement of health workers' feeling that someone is paying attention to their work</li> <li>Increased motivation from the famous quotes and sayings</li> </ul> </li> <li>The construct of stages of change (based on Prochaska &amp; Di Celemenite's 1983 Stages of Change Model) <ul style="list-style-type: none"> <li>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</li> <li>SMSs were operating mainly at the action and maintenance stages of behavior 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"</li> </ul> </li> </ul>	<p>Selected outcomes</p> <ul style="list-style-type: none"> <li>overall health of patients <ul style="list-style-type: none"> <li>20% (8/39) strongly agreed and 49% (19/39) agreed that it had improved patient adherence</li> </ul> </li> <li>Medication management improved by 23.7% (95% CI [7.6, 40.0]; <math>p = .004</math>) immediately after intervention and by 24.5% (95% CI 8.1, 41.0); <math>p = .003</math>) at 6 months follow-up</li> </ul>
Jones et al., 2012					Qualitative study	24 health workers		<ul style="list-style-type: none"> <li>Feeling of taken cared by</li> <li>Satisfaction levels were significantly higher in</li> </ul>	<ul style="list-style-type: none"> <li>No significant differences in pregnancy outcomes between groups;</li> </ul>
Jareethum et al., 2008	Health promotion	Health promotion Maternal	Thailand	Two SMSs per week (one-way communication)	Randomized controlled trial	68 pregnant women enrolled and 61			



newborn and child health	Health promotion	HIV	South Africa	Informational or motivational SMSs to prompt people to go for HIV counseling and testing	Randomized controlled trial	2,533; 438 participants in each of the 4 interventions groups (3 and 10 motivation SMSs, 3 and 10 information SMSs) 801 in control group	completed the study: 32 intervention group, 29 control group	contained information and warnings	intervention vs. control group in antenatal period (9.25 vs. 8.00, $p < .001$ ) and during labor (9.09 vs. 7.90, $p = .007$ )	gestational age at birth ( $p = .34$ ), infant birth weight ( $p = .35$ ), preterm delivery ( $p = .22$ ) and route of delivery ( $p = 1.00$ )
de Tolly et al., 2012	Health promotion	HIV	South Africa	Informational or motivational SMSs to prompt people to go for HIV counseling and testing	Randomized controlled trial	2,533; 438 participants in each of the 4 interventions groups (3 and 10 motivation SMSs, 3 and 10 information SMSs) 801 in control group	completed the study: 32 intervention group, 29 control group	contained information and warnings	intervention vs. control group in antenatal period (9.25 vs. 8.00, $p < .001$ ) and during labor (9.09 vs. 7.90, $p = .007$ )	gestational age at birth ( $p = .34$ ), infant birth weight ( $p = .35$ ), preterm delivery ( $p = .22$ ) and route of delivery ( $p = 1.00$ )
Odiegbe et al., 2011	Health information and appointment arrangements	Cancer	Nigeria	Patients receiving telephone number of Oncologist	Structured interviews after 24 months of intervention	1,160 patients 219 controls		More than 80% found the number very useful, perceived it most valuable to obtain information, to arrange an appointment, as a morale booster	intervention vs. control group in antenatal period (9.25 vs. 8.00, $p < .001$ ) and during labor (9.09 vs. 7.90, $p = .007$ )	gestational age at birth ( $p = .34$ ), infant birth weight ( $p = .35$ ), preterm delivery ( $p = .22$ ) and route of delivery ( $p = 1.00$ )
Piette et al., 2011	Health information for patients	Diabetes	Rural Honduras	Patients received recorded information in Spanish during interactive voice calls about diabetes management	A single-group, pre-post study Interviews at baseline and 6 week follow-up	85 patients	53% of participants completed at least half of their interactive voice response calls and 23% of participants completed 80% or more	Elimination of the cost of transportation and time spent to travel and waiting time	intervention vs. control group in antenatal period (9.25 vs. 8.00, $p < .001$ ) and during labor (9.09 vs. 7.90, $p = .007$ )	gestational age at birth ( $p = .34$ ), infant birth weight ( $p = .35$ ), preterm delivery ( $p = .22$ ) and route of delivery ( $p = 1.00$ )

(Continued)

**Table 3.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Lester et al., 2010	Medication adherence reminder	HIV	Nairobi, Kenya	SMS for antiretroviral treatment adherence	Randomized controlled trial	Patients initiating antiretroviral treatment 273 received intervention 265 received standard care	<ul style="list-style-type: none"> <li>Acceptance; 191 of 194 patients in the intervention group reported they would like the SMS program to continue, of whom 188 (98%) said they would recommend it to a friend</li> <li>Many patients in the intervention group also reported that they thought the SMS support service was valuable</li> </ul>	<ul style="list-style-type: none"> <li>Forwarding weekly SMSs to nonintervention participants to share support</li> </ul>	medication adherence, and 89% foot care adherence to antiretroviral treatment reported in 168 of 273 patients receiving the SMS intervention compared with 132 of 265 in the control group (relative risk for nonadherence = 0.81, 95% CI [0.69, 0.94]; $p = .006$ )
Lester et al., 2009					Randomized controlled trial protocol of crisis situation			<ul style="list-style-type: none"> <li>Nurses were able to connect patients to new dispensaries</li> <li>Support for emotional distressed patient whose home had been burned during previous</li> <li>3 patients losing cell phones</li> <li>Access denied to airtime</li> <li>“top up” by poor security or economic fallout or were</li> <li>Forced to remain in remote</li> <li>Areas without network coverage</li> <li>Confidentiality barriers; preference to talk with clinic staff in person and issues regarding stigma or confidentiality</li> <li>54% said they would be comfortable receiving HIV-related information by telephone</li> <li>Logistical issues</li> <li>Longer SMS reminders were not more effective than either a short reminder or no reminder</li> </ul>	Suppressed viral loads reported in 156 of 273 patients in the SMS group and 128 of 265 in the control group (relative risk for virologic failure = 0.84, 95% CI [0.71, 0.99]; $p = .04$ )
Lester & Karanja, 2008									
Lester et al., 2006					Survey	111 patients	<ul style="list-style-type: none"> <li>89% had access to a phone</li> <li>12% had ever called or been called by healthcare worker</li> </ul>		
Pop-Eleches et al., 2011	Medication adherence reminder	HIV	Kenya	SMS for antiretroviral treatment adherence	Randomized controlled trial	Patients initiating antiretroviral treatment 4 intervention			53% of participants receiving weekly SMS reminders achieved adherence of at least

Kunutsor et al., 2010	Appointment and medication adherence reminder	HIV	Uganda	Voice calls or SMS for improving clinic attendance and ultimately adherence	Combination cross-sectional and prospective cohort	Control group Survey ( $n = 276$ patients) Cohort ( $n = 176$ patients)	<ul style="list-style-type: none"> <li>Weekly reminders improved adherence, whereas daily reminders did not</li> <li>Patients losing their mobile and changing numbers</li> <li>Forgetfulness major reason for missed visit</li> <li>No confidentiality problems</li> <li>Preference for voice calls as for SMS as a result of illiteracy and language barriers</li> <li>Patients preferring direct patient communication</li> </ul>	90% during the 48 weeks of the study, compared with 40% of participants in the control group ( $p < .03$ )
Chen et al., 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 ( $n = 619$ )	<ul style="list-style-type: none"> <li>Attendance rates were significantly higher in SMS and telephone groups than that in the control group (SMS group: OR = 1.698, 95% CI [1.224, 2.316], <math>p = .001</math>; telephone group: OR = 1.829, 95% CI [1.333, 2.509], <math>p &lt; .001</math>)</li> <li>No difference between the SMS group and telephone group (<math>p = .670</math>)</li> <li>Cost per attendance for the SMS group (0.31 Yuan) was significantly lower than that for the telephone group (0.48 Yuan)</li> </ul>	Attendance rates were significantly higher in SMS and telephone groups than that in the control group (SMS group: OR = 1.698, 95% CI [1.224, 2.316], $p = .001$ ; telephone group: OR = 1.829, 95% CI [1.333, 2.509], $p < .001$ )
da Costa et al., 2009	Appointment reminder	General	Brazil	SMS attendance reminder		29,000 appointments in 4 clinics In 7,890 cases, a SMS reminder was sent to the patient's cell phone	<ul style="list-style-type: none"> <li>Nonattendance reduction rates for appointments at the 4 outpatient clinics studied were 0.82% (<math>p = .590</math>), 3.55% (<math>p = .009</math>), 5.75% (<math>p = .022</math>), and 14.49% (<math>p &lt; .001</math>)</li> </ul>	Nonattendance reduction rates for appointments at the 4 outpatient clinics studied were 0.82% ( $p = .590$ ), 3.55% ( $p = .009$ ), 5.75% ( $p = .022$ ), and 14.49% ( $p < .001$ )
Leong et al., 2006	Appointment reminder	Primary care clinics	Malaysia	SMS and phone reminder for attendance	Randomized controlled trial	SMS group ( $n = 329$ ) Call group ( $n = 329$ ) Control group ( $n = 335$ )	<ul style="list-style-type: none"> <li>Attendance rates of control, SMS and mobile call groups were 48.1%, 59.0%, and 59.6%, respectively.</li> <li>Attendance rate of the SMS group was significantly higher compared with that of</li> </ul>	Attendance rates of control, SMS and mobile call groups were 48.1%, 59.0%, and 59.6%, respectively.

(Continued)

**Table 3.** Continued

Article (author, year)	mHealth category	Health purpose	Location	Intervention	Evaluation	Target	Selected input factors	Selected mechanism factors	Selected outcomes
Liew et al., 2009	Appointment reminder	Primary care clinics	Malaysia	SMS and phone reminder for attendance	Randomized controlled trial	SMS group ( <i>n</i> = 308) Call group ( <i>n</i> = 314) Control group ( <i>n</i> = 309)			<p>the control group (OR = 1.59, 95% CI [1.17, 2.17], <i>p</i> = .005)</p> <ul style="list-style-type: none"> <li>No significant difference in attendance rates between SMS and cell phone reminder groups.</li> <li>Cost of SMS (RM 0.45 per attendance) was lower than mobile call (RM 0.82 per attendance)</li> <li>Nonattendance rates in the SMS group (OR = 0.62, 95% CI [0.41, 0.93], <i>p</i> = .020) and the call group (OR = 0.53, 95% CI [0.35, 0.81], <i>p</i> = .003) were significantly lower than those of the control group</li> <li>Absolute nonattendance rate for call reminders (<i>p</i> = .505) was nonsignificant between the groups</li> <li>Rate of on-time attendance was significantly higher in the test group (79.2%) than in the control group (35.5%)</li> </ul>
Prasad & Anand, 2012	Appointment reminder	Outpatient clinics at a dental center	India	SMS reminder	Intervention and control group comparison study	SMS group ( <i>n</i> = 96) Control group ( <i>n</i> = 110)			<ul style="list-style-type: none"> <li>Only 0.5% of the texted reports investigated differed from the corresponding paper reports</li> </ul>
Seidenberg et al., 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			<ul style="list-style-type: none"> <li>Mean turnaround time for result notification to a health facility fell from 44.2 days before implementation to 26.7 days after implementation</li> <li>Reduction in turnaround time was statistically significant in 9 (90%) facilities</li> <li>Mean time to notification of a caregiver also fell significantly, from 66.8 days before implementation to 35.0 days after implementation</li> </ul>

Law, et al., 2012). The Technology Acceptance Model (Davis, 1986) was adapted to study views of people living with HIV and healthcare workers on usability of mobile phone applications for health care 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 articles: Chib, 2010; Chib & Chen, 2011; Chib, Lwin, Ang, Lin, & Santoso, 2008; Chib, Lwin, & Jung, 2009; Lee, Chib, & Kim, 2011) 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 articles (Chib, 2010; Chib et al., 2008), dialectical perspectives on gender (Baxter & Montgomery, 1996) in one article (Chib & Chen, 2011), the technology acceptance model (Davis, 1985) in one article (Chib et al., 2009), and a hypothesized model of midwives' mobile phone use, access to resources, self-efficacy, and health knowledge in the last article (Lee et al., 2011). The communication for development framework (Bertrand, O'Reilly, Denison, Anhang, & Sweat, 2006) was used to study a health helpline 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 workers' use of mobile phones to help people living with HIV to adhere to antiretroviral therapy in rural Uganda (as this study focused more on outputs it was categorized accordingly; Chang et al., 2011). The construct of stages of change (Prochaska & DiClemente, 1983) was used in a study obtaining health workers' perspectives on receiving SMSs, which aimed to improve their malaria case management. Because this study focused more on outputs it was categorized accordingly (Jones et al., 2012; Zurovac et al., 2011).

We found that studies that were based on theory overlapped more with inputs 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 (Chib, 2010; Chib et al., 2009; Lee et al., 2011). However, the selection and contextualization of some theories was questionable, since these rationales were not explicitly stated in all articles (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; Chib & Chen, 2011; Chib, Cheong, et al., 2012). All of 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), they did not address quantitative effects 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; 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; 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; 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; 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 articles) (Chang et al., 2011; Chang et al., 2008; Chang et al., 2010) using the health care communication (described earlier in mechanism section) found no significant effect 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 (Lester et al., 2010; Pop-Eleches et al., 2011), with one study (represented by four articles) (Lester & Karanja, 2008; Lester, Gelmon, & Plummer, 2006; Lester et al., 2009; Lester et al., 2010) also showing improvements in HIV viral load suppression (Lester et al., 2010). Health promotion SMSs for prenatal support found no significant differences in pregnancy outcomes in Thailand (Jareethum et al., 2008).

Organizational 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 articles (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 inputs studies, 6 mechanism studies, and 1, 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 in this body of research, compared with 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 health care, as conceptualized by the inputs-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; Chib & Chen, 2011; Chib, Cheong, et al., 2012; Chib, Law, et al., 2012; 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 behavior-change theories used 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 (Svoronos & Mate, 2011). Studies mainly used 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; 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 behavior 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 (World Health Organization, 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 inputs-mechanisms-outputs pathway to produce a comprehensive picture of how mobile phones can improve healthcare in low- and middle-income countries.

Researchers at the inputs level, primarily information technologists, need to determine the precise problems to be addressed not just from the viewpoint of technological inputs, but rather from both the 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.

## Funding

The Department of Primary Care & Public Health at Imperial College is grateful for support from the National Institute for Health Research Collaboration for Leadership in Applied Health Research & Care Scheme, the National Institute for Health Research Biomedical Research Centre Scheme, and the Imperial Centre for Patient Safety and Service Quality.

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