

Systematic Review

Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: systematic review*

Smisha Agarwal^{1,2}, Henry B. Perry¹, Lesley-Anne Long³ and Alain B. Labrique^{1,2}

1 *Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA*

2 *Johns Hopkins Global mHealth Initiative, Baltimore, MD, USA*

3 *mPowering Frontline Health Workers, mPowering Frontline Health Workers, Washington, D.C*

Abstract

OBJECTIVES Given the large-scale adoption and deployment of mobile phones by health services and frontline health workers (FHW), we aimed to review and synthesise the evidence on the feasibility and effectiveness of mobile-based services for healthcare delivery.

METHODS Five databases – MEDLINE, EMBASE, Global Health, Google Scholar and Scopus – were systematically searched for relevant peer-reviewed articles published between 2000 and 2013. Data were extracted and synthesised across three themes as follows: feasibility of use of mobile tools by FHWs, training required for adoption of mobile tools and effectiveness of such interventions.

RESULTS Forty-two studies were included in this review. With adequate training, FHWs were able to use mobile phones to enhance various aspects of their work activities. Training of FHWs to use mobile phones for healthcare delivery ranged from a few hours to about 1 week. Five key thematic areas for the use of mobile phones by FHWs were identified as follows: data collection and reporting, training and decision support, emergency referrals, work planning through alerts and reminders, and improved supervision of and communication between healthcare workers. Findings suggest that mobile based data collection improves promptness of data collection, reduces error rates and improves data completeness. Two methodologically robust studies suggest that regular access to health information via SMS or mobile-based decision-support systems may improve the adherence of the FHWs to treatment algorithms. The evidence on the effectiveness of the other approaches was largely descriptive and inconclusive.

CONCLUSIONS Use of mHealth strategies by FHWs might offer some promising approaches to improving healthcare delivery; however, the evidence on the effectiveness of such strategies on healthcare outcomes is insufficient.

keywords mHealth, community health workers, health personnel, mobile health

Introduction

Frontline health workers (FHWs) are often the first and only point of contact for people who seek healthcare services in the developing world [1]. They usually serve the local communities to which they belong and work in different capacities such as midwives, nurses, pharmacists, doctors and community health workers (CHWs) to address the basic health needs of those living in remote and rural areas [1, 2]. FHWs deliver a range of low-cost,

life-saving interventions across a spectrum of community healthcare needs and enable the strengthening of the interface between the healthcare facility and the community [3]. The many challenges faced by FHWs, from the maintenance of skills and knowledge to the complexity of tasks performed in the field, have the potential to be supported by information and communication technologies (ICT). The advent of solutions that leverage the ubiquity of mobile phones to improve health system functions, widely described as ‘mHealth’, hold tremendous potential to facilitate and improve delivery of health care by FHWs. We aimed to systematically describe the existing

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literature on the use of mHealth strategies by FHWs, critically review the evidence base on the effectiveness of such strategies and identify the gaps in the current knowledge base.

WHO estimates that, based on population need, there is a shortage of about 7.2 million healthcare workers. This is expected to rise to about 12.9 million globally by 2035 [4]. This shortage will further exacerbate the inequity in distribution of healthcare providers in low-resource settings as evidenced by the fact that of the 57 countries facing a shortage, 36 countries are in sub-Saharan Africa [5]. Furthermore, even though one half of the global population lives in rural areas, they are served by <38% of the total nursing workforce and by <25% of the desired number of physicians [6]. Task shifting has allowed for the transfer of many responsibilities from higher-level care providers to lower-level care providers after special training [7]. This has resulted in FHWs such as CHWs, auxiliaries and midwives being responsible for the provision of crucial services such as treatment of communicable diseases such as tuberculosis, malaria and HIV/AIDS in areas of high burden, skilled birth attendance, immunisations, promotion of breast feeding, reduction of child undernutrition, and prevention and treatment of serious childhood illnesses [8].

FHWs face several challenges in the field as follows: lack of appropriate means to collect data, inadequate access to training and reference materials, poor communication with peers or supervisors to handle situations that are beyond their skills, and difficulty in scheduling household visits and follow-up appointments with patients [9]. The isolation and rudimentary training of this cadre has often limited their capacity to provide little more than the most basic care. To address some of these barriers, various mHealth strategies have been developed to support these workers at the frontlines of healthcare delivery. Such strategies include the use of mobile phones for data collection, access to training, communication between health workers, as mobile job aids and decision-support tools, and for promotion of health behaviours in the community. There is rapidly emerging evidence to support the feasibility and efficacy of some of these strategies.

Methods

An electronic review of the existing literature was carried out in December 2013 of the following medical, public health and global health databases: PubMed/MEDLINE, Global Health/OVID, EMBASE, Scopus and Google Scholar. The search was limited to peer-reviewed articles and institutional reports published in English between

2000 and 2013 in developing countries. Key search terms comprised variations and combinations of terms for mHealth [mobile, phone, cell phones, information and communication technology, cellular phone, mobile device, SMS, text message, interactive voice response (IVR)] and FHW (frontline worker, health worker, community health worker, traditional birth attendants, lay worker, village health worker, midwife, health auxiliary, peer health worker, medical auxiliary, health provider, lay advisor, lay counsellor, lady health worker and lay educator). This yielded a total of 1262 documents for review. Duplicate citations from across databases were excluded, and the titles and abstracts of the remaining articles were screened for relevance by a single reviewer.

Inclusion/exclusion criteria

To be included in the review, articles had to mention a relevant term for both FHWs and mHealth in the title or abstract. After screening for these terms in the title and abstract, 379 articles remained from all databases. Two independent reviewers then checked these papers in depth, based on the following definitions: mHealth was defined as the use of mobile devices such as mobile phones, tablets and personal digital assistants (PDAs) and other handheld wireless devices for health [11] FHWs include all health workers directly providing services to communities and include CHWs, and midwives, but may also include pharmacists, nurses and doctors who work in local clinics and provide primary healthcare services [2].

Only those articles which contained original research about frontline health workers using mobile health technology or information and communications technology (ICT) were included. A number of documents reported on use of mobile phones for data collection by trained data collectors. These were excluded. Other desk reviews, commentaries and summary briefs were also excluded. References lists of the publications were reviewed to identify additional relevant articles. After removing articles for which the full text versions could not be found, 42 articles remained for review (Figure 1).

Synthesis of results

For the purpose of synthesis of the results, the following information was abstracted from the included articles: study design, mHealth application, study location, type of FHW, number of FHWs, study objectives, type of intervention delivered, primary study outcomes and challenges in deploying mHealth intervention. Synthesis of the method in which mobile phones were used for deliv-

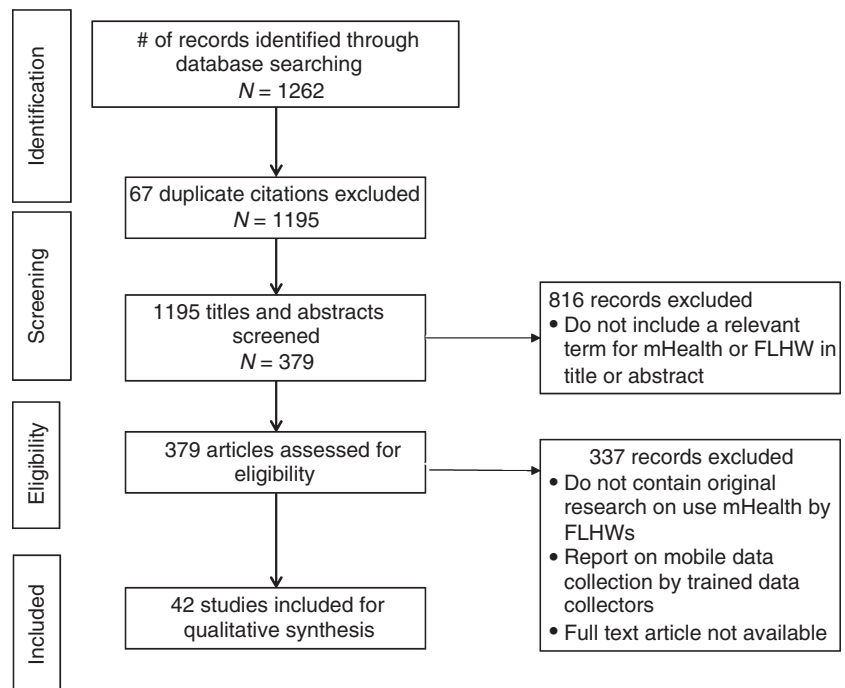


Figure 1 Literature Search Strategy.

ery of care by FHWs informed the proposed framework and structure of this review. Common themes identified across studies were synthesised for reporting key highlights and challenges.

Results

The studies included in this review captured evidence along three main domains: feasibility of use of mobile tools by FHWs, training of FHWs in the use of mobile tools and effectiveness of the varied applications of mobile tools by FHWs across diverse disease groups. Most studies were located in the Africa and South Asia, with a few studies in South America.

Feasibility of use of mobile phones by FHWs

Fourteen studies included in this review assessed the feasibility of the use of mobile phones by FHWs. These studies largely used qualitative methods to understand the complexities in designing of mHealth interventions that may make it easier for FHWs to adopt the mobile tool. The studies covered a range of health domains and mobile phone applications: use of mobile phone-based videos by for dissemination of knowledge about anaemia [12], mobile phone-based direct observation of treatment (mDOT) for tuberculosis by CHWs [13], perceptions of

CHWs towards use of technology for monitoring drug dosing [14], feasibility of mobile-based data collection [15–17] and feasibility of using mobile phones for reporting on post-partum haemorrhage [18]. All studies suggested that, with adequate training, FHWs were able to learn to use mobile phones. FHWs consider mobile phone-based tools as a useful means to reinforce and improve the services provided by them and felt empowered by having access to such tools. Some studies characterised psychosocial changes resulting from an FHW's use of mobile phones to deliver health services. Several studies reported that the use of mobile phones improved FHW motivation and empowerment [19] and improved their credibility in the community [15, 20–22]. Chib *et al.* [23] categorised some additional benefits as follows: opportunity production, capabilities enhancement, and social enabling and knowledge generation. Based on qualitative interviews with FHWs in Aceh Besar [15, 16] and India, the authors suggest that use of mobile phones facilitates more efficient use of time, thereby increasing opportunities for FHWs to engage in other income-generating activities. Lee *et al.* [17] reported similar findings suggesting that cell phone use among midwives was positively associated with higher self-efficacy and health knowledge. The study by Jimoh *et al.* [21] in Nigeria suggested that older workers scored worse than younger workers on knowledge and attitude about the use of

mobile technology, but better on perceived ease of use and usefulness.

Training of FHWs in the use of mobile phones for healthcare delivery

Several studies highlighted the importance of training FHWs to adopt mobile tools. Depending on the previous skill level of the FHWs and the scope of the mHealth program, training on the use of mobile phones ranged from a few hours to about a week. Training often comprises of introduction to the functions on a mobile phone, pictographic instructions on how to use a mobile phone, orientation to any additional software being used, configuring general packet radio service (GPRS) internet connection [24] and addressing technical difficulties [18, 25]. The study by Ngabo *et al.* [26] reported that regular training of FHWs reduced the error rate for data entry from 54% at the start of the program to 8% over the course of 1 year.

One study used a training of trainers (ToT) model to train community midwives in typing an SMS to transmit pregnancy data using mobile phones. Eleven two-person teams of nurses were trained in the use of the phones, and they trained 99 low- and non-literate traditional midwives (TM) using a standardised training protocol [19]. The study reported a significant increase in the overall cell phone knowledge scores, suggesting that ToT might be an effective model in scaling up training in the use of mobile phones by FHWs [19]. The study reported only on whether the TMs were able to use cell phones and send text messages, but not on accuracy of the text messages. If the mHealth system is integrated with the existing ICT infrastructure, training should be available to providers at each level of the health system (i.e. national, district and facility-level health teams) [27].

Applications and effectiveness of the use of mobile tools by FHWs

Based on the review of the literature, five key mHealth functions that support FHWs in providing effective care to their communities were identified as follows: data collection and reporting, decision-support tools and training, emergency referrals, alerts and reminders, and supervision (Figure 2). These categories are a subset of the core mHealth innovations described by Labrique *et al.* [28] Table 1 summarises these mHealth functions and health domains to which they were applied. A few studies described the role of the FHW in the collection of relevant data about client's health status to send them targeted health information messages [12, 29–31]. SMS-

based health education and behaviour change communication has not been included as a separate mHealth function below, as it does not directly engage the FHW beyond the initial data collection process. However, it has been added as an additional category in Table 1 to differentiate the studies that used mobile tools only for data collection from those where data collection served as an interim step to facilitate client education.

Data collection and reporting. Twenty-five studies included in this review had data collection as one of the primary mHealth functions being performed by FHWs. Several studies suggested that mobile phones are an effective way to collect and report data from the community [9, 32, 33] transfer patient-relevant information to a centralised database and reduce the need for face-to-face communication between FHWs and other members of the health delivery team such as ambulance drivers, health facility staff and staff at district- and central-level hospitals [26, 34]. Once the client data have been entered into the system, it can be used to send health need specific messages and reminders to the client's mobile phone to facilitate health education and behaviour change communication [30, 31]. Studies suggest that use of mobile phones for data collection circumvents the need for FHWs to travel to a health facility to transfer client information, thereby allowing them to spend more time focusing directly on service provision [34]. Additionally, mobile phone data collection with GPRS-enabled phones permits real-time identification of data falsification. It takes less time to compile reports using electronic systems than paper [9], and mobile data collection is more cost-effective than paper-based systems [35]. Mobile-based data entry permits checking for logic flow and has capabilities to identify incorrect entries, thereby reducing error rates [31].

A study in rural India assessed the latency of data collection, defined as the time taken between the collection of data by FHWs and the receipt of data by a regional coordinator. The study reported that data collection using mobile phones reduced average latency from 45 days to 8 h [22]. Additionally, data completeness improved from 67% of the required fields being filled in the paper-based system compared to 84% of the required field being filled in the mobile-based system [22].

Decision-support tools and provider training. A mobile-based patient assessment tool that incorporates treatment guidelines for specific health problems can provide patient-side decision support to FHWs. Five studies included in this review assessed the feasibility and effectiveness of decision-support tools used by FHWs in

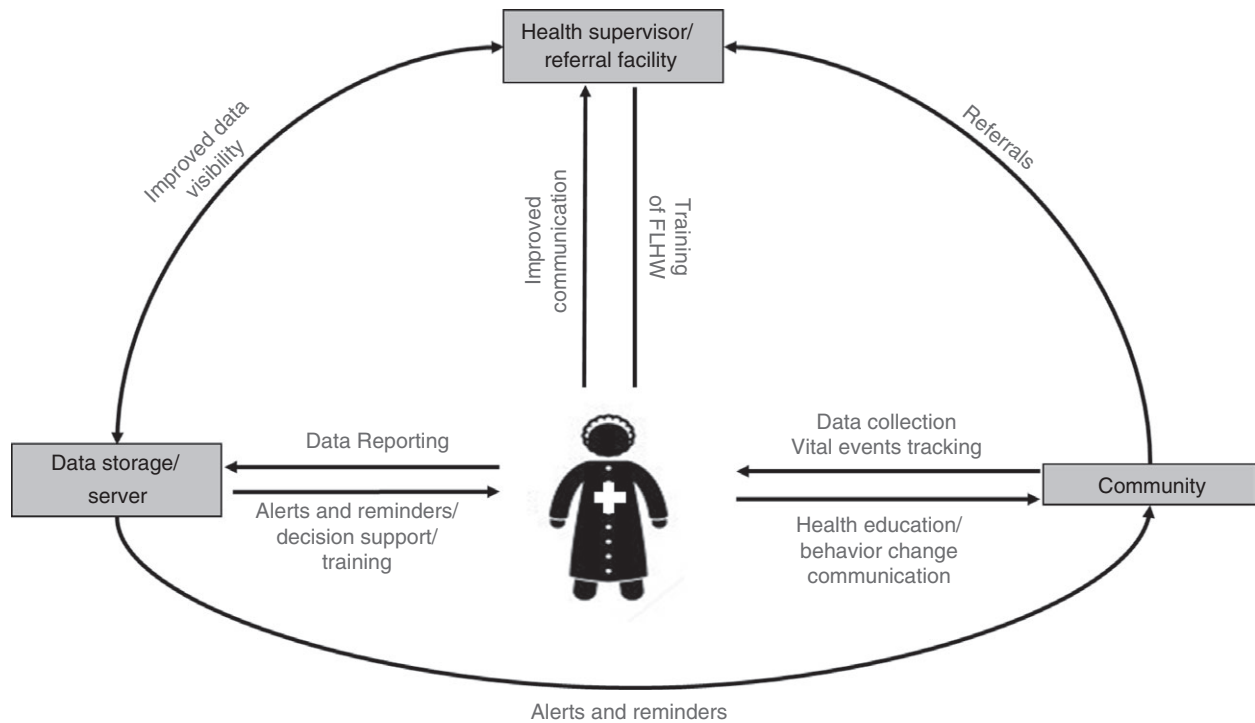


Figure 2 Overview of role of Frontline Health Workers in delivering care using mobile health strategies.

improving patient health outcomes [36–40]. Zurovac *et al.* [41] reported that health workers who received motivational messages about management of children with malaria had a demonstrated improvement in correct management by 24% compared to those workers who did not receive similar messages. This effect was maintained even 6 months after the start of the study. Another study, in Tanzania, provided FHWs with electronic decision-support tools for Integrated Management of Childhood Illnesses (IMCI) and reported a significant improvement in the provider's ability to adhere to the IMCI treatment protocol [38].

The studies recognise that, while provision of decision-support tools is potentially an effective means to promote shifting of essential health services to lower cadres of health workers, a balance between the technical requirements and costs of such a system is a vital factor in scalability of such solutions [36].

Emergency referrals. Four studies included in this review suggested that timely collection of patient data and reporting to the health facility facilitated the process of developing an alert system for emergency referrals of patients [26, 34, 42]. A study in Gambia connected CHWs and TBAs to a hospital by providing them with mobile phones. In case of an emergency involving a

pregnant woman or a young child, the FHW can contact the ambulance driver and the maternity ward at the hospital [43]. The use of mobile phones to create this 'emergency chain of care' ranges from simply providing the FHW with a mobile phone so that she is able to arrange emergency services, to a far more sophisticated system where the FHW-generated community-data are linked with the facility-level data, and any patient alerts are automated. The evidence of impact in this area is, for the most part, limited to health worker and client experiences, as well as anecdotal examples.

Alerts and reminders. This theme includes mobile-based work planning through customised patient-specific alerts and reminders about follow-up visits sent to a FHW's mobile phones. Nine reported on the utility of sending appointment and care reminders to FHWs. Once relevant patient data are entered onto a system, regular alerts and reminders can be sent to both the FHW and the patient for follow-up care based on pre-programmed treatment algorithms [10, 26, 31]. DeRenzi *et al.* [10] reported that sending mobile reminders to CHWs resulted in an 85% reduction in average number of days clients were overdue for a visit. A cluster-randomised trial by Lund *et al.* in Zanzibar concluded that pregnant women who were connected to their healthcare provider through

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Author [References]	Type of health worker	Health Domain													mHealth Function									
		ANC	Family Planning	EmOC	SBA	Post - natal care	Under 1 children	Children	PMTCT	HIV	Malaria	TB referral	Drug supply	Chronic diseases	Not specified	Medicine dosing	Data collection	Client education	Alerts and reminders	Supervision / coordination	Emergency referrals	Decision support / training		
Alam <i>et al.</i> [32]	<i>Shashthya Karmis</i>	X																						
Andirretta <i>et al.</i> [52]	Birth Attendants					X																		
Barrington <i>et al.</i> [27]	Facility health worker											X								X				
Blank <i>et al.</i> [36]	Not specified					X																		
Bogan <i>et al.</i> [9]	CHWs																							
Chaiyachati <i>et al.</i> [42]	Healthcare workers																							
Chang <i>et al.</i> [53]	Peer health workers																							
Chib <i>et al.</i> [15]	Midwives	X																						
Chib <i>et al.</i> [16]	Midwives	X																						
Chib <i>et al.</i> [23]	ASHA	X																						
(India)																								
Cole Ceesay <i>et al.</i> [43]	TBA, CHW																							
De Renzi <i>et al.</i> [10]	CHW																							
Florez-Arango <i>et al.</i> [37]	CHWs																							
Ganesan <i>et al.</i> [29]	Health Workers																							
Githinji <i>et al.</i> [44]	Facility health worker																							
Hoffman <i>et al.</i> [13]	Treatment supporters																							
Kaewkungwal <i>et al.</i> [46]	Not specified																							
Jennings <i>et al.</i> [20]	CHWs, nurses																							
Jimoh <i>et al.</i> [21]	Health workers, midwives	X																						
Jones <i>et al.</i> [54]	Facility health workers																							
Lee <i>et al.</i> [17]	Midwives	X																						
Lemay <i>et al.</i> [47]	CHWs	X																						
Little <i>et al.</i> [24]	HEWs, midwives	X																						
Lori <i>et al.</i> [19]	Midwives	X																						
Lund <i>et al.</i> [30]	Not specified																							

Table 1 (Continued)

Author [References]	Type of health worker	Health Domain											mHealth Function											
		Not Specified	ANC	Family Planning	EmOC	SBA	Post - natal care	Under 1 children	Children	PMTCT	HIV	Malaria	TB referral	Drug supply	Chronic diseases	Not specified	Medicine dosing	Data collection	Client education	Alerts and reminders	Supervision / coordination	Emergency referrals	Decision support / training	
MacLeod <i>et al.</i> [31]	Nurses, midwives, CHWs		X															X						
Mahmud <i>et al.</i> [55]	CHWs																	X						
Manda <i>et al.</i> [34]	Medical personnel, CHWs	X																						
Meankaew <i>et al.</i> [56]	Village malaria volunteer																							
Medhi <i>et al.</i> [22]	Rural health workers						X	X																
Mitchell <i>et al.</i> [38]	Facility health workers						X	X																
Mitchell <i>et al.</i> [40]	Facility health worker						X	X																
Ngabo <i>et al.</i> [26]	CHWs								X															
Palazuelos <i>et al.</i> [14]	CHWs								X															
Rajput <i>et al.</i> [35]	CHWs																							
Ramachandran <i>et al.</i> [12]	Accredited social health activist																							
Rotheram-Borus <i>et al.</i> [33]	Peer mentor																							
Svoronos <i>et al.</i> [39]	CHWs																							
Tomlinson <i>et al.</i> [25]	CHWs																							
Woods <i>et al.</i> [57]	Midwives																							
Zurovac <i>et al.</i> [41]	Outpatient health workers																							
Zurovac <i>et al.</i> [21]	Facility health workers																							

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bidirectional mobile phone messaging were more likely to have skilled birth attendance (SBA): A total of 60% of births in the intervention group were delivered by a SBA *vs.* 47% in control group. None of the studies included in this review have evaluated the changes in continuity and regularity in care as a result of FHWs receiving such reminders.

Supervision and interaction of health systems actors. A few studies suggest that mHealth tools can improve quality of supervision available to FHWs by facilitating regular and prompt communication across different levels of providers [31, 34] as well as enabling assessment of the FHW's performance through the web-interface dashboard [25, 26]. DeRenzi *et al.* [10] emphasise the importance of connecting FHW activities to regular supervision by higher level of providers or managers to reinforce the continuity of care. They reported that when the supervisory aspect of their study was removed, FHW performance decreased – the average number of days a FHW client remained overdue for a visit increased from 9.1 to 26.9 days ($P = 0.023$). However, the study notes that only 6.5% of the FHWs in their study remained non-responsive to mobile prompts and required supervisory intervention. Involvement of supervision is more expensive, and alternate strategies for FHW motivation should be explored [10]. A few studies which evaluated SMS reporting of drug stocks by FHWs engaged health providers and managers at district and higher-level facilities. Improved data visibility at each level of the health system resulted in a significant decline in frequency of stock-outs [27, 44, 45]. One study reported that district managers accessed the mHealth system an average of eight times a week to monitor drug stock levels and responded to 44–73% of the stock-out signals by redistributing the commodities between different facilities [44].

Summary of key challenges in the adoption and use of mobile tools by FHWs

The studies included in this review identified common challenges in the use of mobile phones by FHWs to deliver care. These challenges include poor network reception [18, 19, 30, 43], poor health system capacity to integrate the patient records into existing electronic health records [31, 36] and challenges in training FHWs in implementing the mHealth intervention [15, 30, 36, 42, 43].

Three main barriers to adoption of mobile tools by FHWs which can be programmatically addressed were identified in this review. First, cultural barriers to adoption of the mHealth program should be accounted for. The program should assess how sharing of mobile phones

between health workers and members of their family may affect their ability to deliver care [20, 42]. Second, as much as possible, FHWs should be engaged in the process of the development and implementation of the mHealth tools to make the user interface intuitive and easy to understand. Programs employing FHWs for delivery of care using mobile technology should take into consideration the age, level of education and years of experience of health workers for planning the program [12, 20, 21, 42]. Third, the findings suggest several implications for designing an optimal mHealth platform to facilitate both adoption and sustained effective use. Some studies suggested that the tasks that can be performed on a small mobile phone screen are limited [34]. FHWs with low literacy or poor writing skills often find using free-form text challenging [34]. Therefore, for data collection, the user interface should be easily readable and allow for intuitive navigation by FHWs. There should also be sufficient initial and ongoing training to support the transition of workflow from a paper-based system to a digitised system [35]. In developing digital workflows, the extra burden of digital data entry should be calculated and weighed against the benefits and time-savings of automated data aggregation and report generation [10].

Discussion

Use of mHealth strategies can potentially circumvent several of the structural and systemic barriers faced by FHWs in delivering health care. Evidence suggests that use of mobile phones for healthcare delivery is feasible for FHWs irrespective of their education or prior training [19, 24, 26, 27]. However, a majority of the studies in this area are pilot activities and provide minimal information about the effectiveness of the use of mHealth tools by FHWs on the quality and efficiency of health systems functions and/or client health outcomes. A number of studies suggest that FHWs can effectively use mobile phones for data collection and surveillance [13, 18, 27, 29, 31, 32, 36, 42, 44, 46]. Mobile-based data collection improves promptness of data collection, reduces error rates and improves data completeness [42]. Two robust experimental studies suggest that access to health information through SMS or through mobile-based decision-support systems can improve FHW adherence to treatment regimens [38, 41]. A number of descriptive studies suggest that mHealth tools also aid in improving communication between different levels of the healthcare system [10, 16, 27, 42, 44, 47] and improve emergency health referrals [26, 30, 31, 34, 43]. The existing literature establishes that such interventions are feasible and largely well received by the FHW, clients, other members of the

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healthcare system. However, rife with a descriptive analysis of the potential of such interventions on healthcare outcomes, few have empirically assessed the incremental effectiveness of such interventions on healthcare coverage, utilisation, efficiency, quality or outcomes. Although enthusiastic about the potential of the use of mHealth tools by FHWs, the literature on the effect of mobile phone-based alerts and reminders sent to FHW's mobile phones, supervision and emergency referrals is still in its infancy and largely inconclusive.

This review identifies the potential role of mobile tools in providing a channel for training of FHWs and in supporting FHWs in the provision of care. Several studies included in this review also suggest that use of mobile tools is perceived as an opportunity for self-improvement and can consequently improve FHW motivation, self-efficacy and enthusiasm to continue their work [15, 17, 19–22]. Improved FHW motivation, access to knowledge and organisational support are critical non-financial incentives that contribute to FHW retention [48–50]. To further build on this knowledge, we propose a framework that depicts how mHealth functions may support FHW's

across their professional lifespan under the domains of training, provision of care and retention (Figure 3).

In 2013, Braun *et al.* published a systematic review of mHealth tools being employed by community health workers [51]. The review included 25 studies, several of which employed 'data collectors' as opposed to 'health workers' for mobile data collection. Our review reveals that the number of reported mHealth projects focused on FHWs has nearly doubled over the last year. Some researchers have broached the use of mHealth tools by FHWs with caution, suggesting that the introduction of a new and innovative intervention to FHWs leads to a 'novelty effect'. This implies greater adoption at the onset of the program due to the excitement around introduction of a new technology, which slowly wears off – this may be happening, but could perhaps be mitigated by leveraging good user-centred design, engagement strategies and providing feedback to the users on their performance, so the mobile phone eventually becomes more of an integral part of day-to-day practice for FHWs.

Understanding the impact of mHealth programs requires a multidimensional evaluation approach utilising

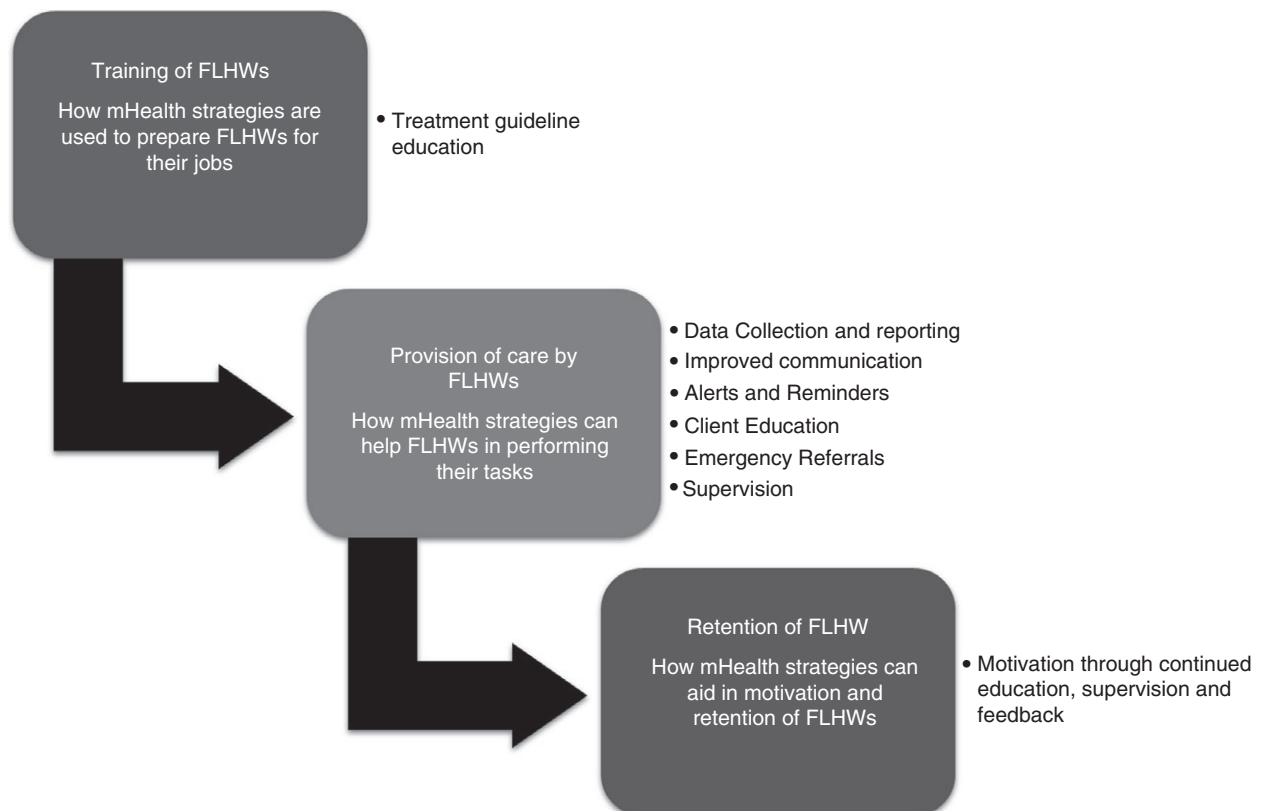


Figure 3 mHealth Functions which support FHWs across their professional lifespan.

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mixed methods to examine the effects of the program on health workers, clients and the health system. The biggest gap in our knowledge about the use of mHealth strategies by FHWs at present is in the lack of evidence on how such strategies may improve health outcomes, health system efficiencies and cost-effectiveness of service delivery.

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Corresponding Author Alain Labrique, Department of International Health, Johns Hopkins Bloomberg School of Public Health, W5501, 615 N. Wolfe St., 21205 Baltimore, MD, USA. E-mail: alabriq1@jhu.edu