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A text message-based intervention to bridge the healthcare communication gap in the rural developing world

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Abstract. Healthcare delivery in the rural developing world is limited by a severe shortage of health workers as well as profound communicative and geographic barriers. Understaffed hospitals are forced to provide care for patients that reside at a great distance from the institutions themselves, sometimes more than 100 miles away. Community health workers (CHWs), volunteers from local villages, have been integral in bridging this patient-physician gap, but still lose enormous of amounts of time in transit between hospital and village. We report the results of a retrospective mobile health (mHealth) pilot at St. Gabriel's Hospital in Malawi designed to eliminate many of these trips in favor of communication via text messages. A group of 75 CHWs were supplied with cell phones and trained to utilize the network for a variety of usage cases, including patient adherence reporting, appointment reminders, and physician queries. At the end of the pilot, the hospital saved approximately 2,048 hours of worker time, $2,750 on net ($3,000 in fuel savings minus $250 in operational costs), and doubled the capacity of the tuberculosis treatment program (up to 200 patients). We conclude that mHealth interventions can provide cost-effective solutions to communication barriers in the setting of rural hospitals in the developing world.

Keywords: Mobile health (mHealth), cell phones, text messaging, SMS, FrontlineSMS, Malawi, St. Gabriel's, community health workers (CHWs), tuberculosis, HIV, patient adherence monitoring, communication barriers, hospital efficiency, brain drain

1. Introduction

The World Health Organization (WHO) estimates a shortfall of 4.3 million health care workers in the developing world. This deficit is faced by 57 countries, 36 of which are in sub-Saharan Africa [5]. Health care workers migrate and work in developed countries due to a lack of professional development and poor working conditions in their native countries. Given this trend, there has been a continuous effort to persuade health care workers from emigrating. According to health worker surveys in Cameroon, Ghana, South Africa, and Uganda, the route to success would involve improvements in working conditions and health care system management [2].

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Malawi, one of the world's poorest countries, exemplifies the health care worker shortage and the challenges to overcoming this problem. With a population of approximately 14 million, there are only 1.1 doctors and 56.4 nurses per 100,000 people [4]. In fact, by the 1980's there were more Malawian physicians in Manchester, UK than in the entire country. Since the creation of the University of Malawi College of Medicine (UMCM), the first medical school in Malawi, this is fortunately no longer the case [1]. However, UMCM graduates no more than 40 physicians per year [7], and currently 36.3% of physician positions and 18.4% of nursing positions remain vacant nationwide [2]. Hence, there remains a significant health care worker shortage despite recent advances.

The problems associated with health worker shortages are exacerbated by geographic barriers to care delivery. In Malawi, rural hospitals are forced to serve a large catchment area with poor or absent transportation means. This creates a significant communication barrier between patient and physician that impacts the quality of care. Community health workers (CHWs), locals recruited from surrounding villages and trained in primary care, alleviate this gap by serving as intermediaries between health care institutions and the community [6]. Although they improve overall patient-physician accessibility, CHWs are still forced to travel great distances, often on foot, to do so. This limits their ability to obtain health care advice, traffic medical supplies, or request emergency care in a timely manner.

How do we improve communication between the patient and physician in these rural settings? One approach is to increase the number of active health care workers. This, however, would require a significant financial, temporal, and social investment that developing countries are unable to make. A second approach involves increasing the efficiency of current health care workers by maximizing productivity and utilizing natural talent. We focused primarily on this approach through the introduction of a cell phone-based communication network between CHWs and physicians- Frontline SMS:Medic. Fortunately, mobile phone technology is not new to Malawi or to Africa as a whole. Indeed, the upsurge in mobile usage in Africa recently reached an all-time high of 246 million users [3]. Cell phone signal coverage has expanded in tandem with this, making our communication platform an opportunistic solution to a complex problem.

1.1. The FrontlineSMS:Medic network in Malawi

FrontlineSMS is a free, open-source software platform that enables large-scale, organized short message service (SMS) communication. When a computer running FrontlineSMS is connected to a GSM (Global System for Mobile communications) modem or a cell phone, it is converted into a two-way text-messaging hub (Fig. 1). Users equipped with a cell phone can send and receive messages to and from the console, which is linked to a specific phone number with a SIM (Subscriber Identity Module) card. The software manages contacts, allows for mass-messaging, auto-forwarding and auto-reply, special actions based on keywords, and other functionalities.

We employed a FrontlineSMS network at St. Gabriel's Hospital in Namitete, Malawi in an effort to break down the physician-patient communication barrier (mediated by CHWs). St. Gabriel's is a rural hospital that provides care to over 250,000 Malawians, the majority of whom are subsistence farmers living on less than one dollar per day and are spread throughout a catchment area over 100 miles in radius. To help combat high HIV prevalence ($\sim$15%), tuberculosis (TB), and a slew of opportunistic infections, more than 600 volunteer CHWs currently work with St. Gabriel's to assist in healthcare delivery and coordination. There are four departments of CHWs with different care specializations – antiretroviral therapy (ART), home-based care (HBC), tuberculosis (TB) treatment, and prevention of mother to child transmission (PMTCT). Additionally, there is an HBC nurse and a TB coordinator with a motorbike who makes trips to villages from the hospital.

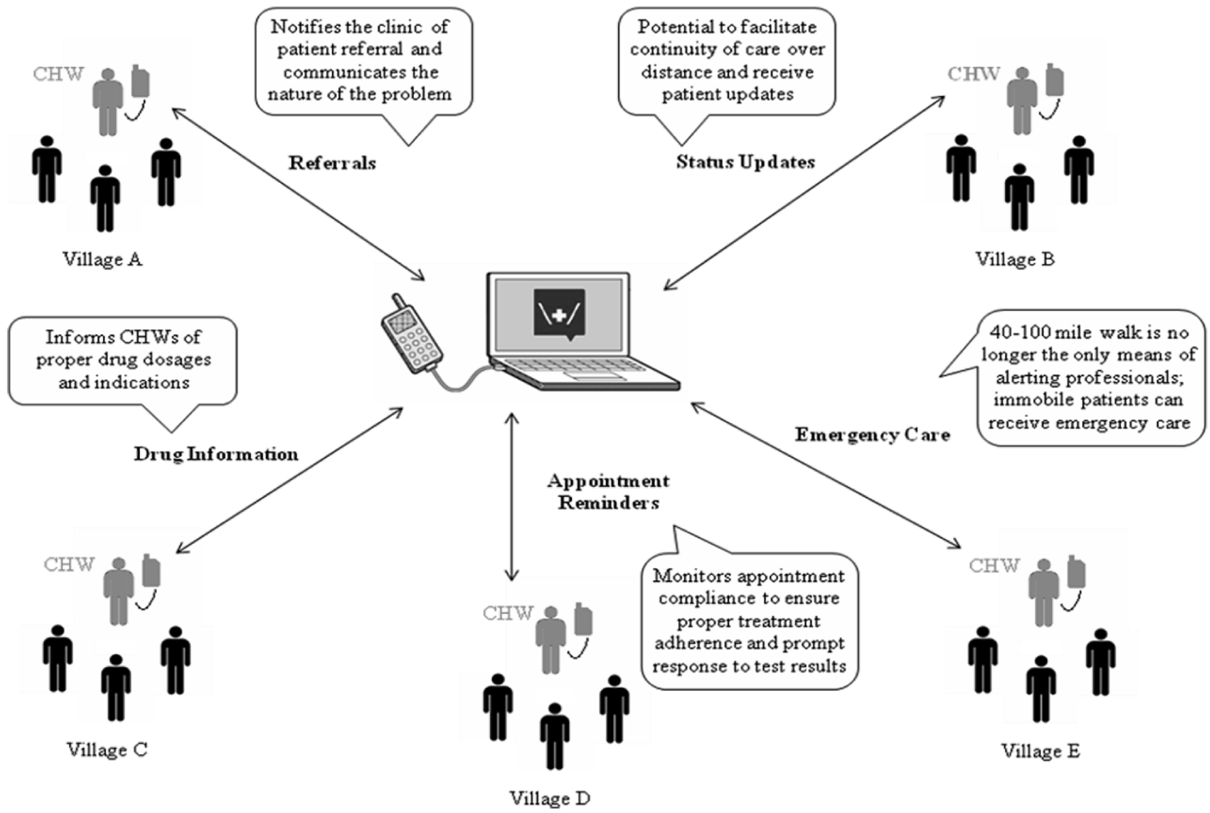

Fig. 1. The FrontlineSMS:Medic System: A laptop running the FrontlineSMS software and located at the hospital manages two-way communication with CHWs, who are dispersed throughout surrounding villages. A variety of usage cases are highlighted to illustrate potential uses for such a network.

Empirically, many of the CHWs – themselves residents of distant villages – were forced to walk dozens of miles simply to deliver patient adherence updates or request medical advice or emergency assistance. Similarly, without a reliable and expedient method of requesting care, the HBC nurse routinely made unnecessary trips to villages where he was not needed. These logistical disconnects severely limited efficiency of care and presented a clear need for a real-time communications solution.

2. Methods

2.1. Pilot preparation and operation

A group of 75 CHWs working at St. Gabriel's Hospital, as well as the HBC nurse, were each given a recycled Motorola Pebl cell phone. Phone chargers were available at the hospital and were also distributed to certain CHWs. In groups of 10–15, CHWs were taught to properly use their cell phones, manage SMS messages, and understand how the FrontlineSMS network operated. The hospital itself was equipped with a GSM-connected laptop running the FrontlineSMS software. Hospital staff was trained to manage all communication activity within about 2 weeks.

Over the course of six months, the FrontlineSMS network was utilized for a number of applications (Table 1, also see Fig. 1). These usage cases came about organically, developed by the CHWs and

Table 1
Usage cases for the FrontlineSMS network

Usage case	Elaboration
Remote requests for medications	If a patient runs out of medications or is unable to travel to the clinic to pick them up, the CHW sends an SMS to request a delivery from the HBC nurse
Notifications of patient death	An SMS of this nature often prevents unnecessary morphine or palliative medication deliveries
Appointment reminders	If a patient misses a scheduled appointment or a diagnostic result requires a clinical visit, clinicians can notify the CHW responsible for that patient
Treatment adherence monitoring	DOTS TB and HIV ART require CHWs to witness patients taking their medications. These updates can be regularly texted to clinics. If a patient's adherence status has not recently been updated, clinicians can text the appropriate CHW to request this follow-up information
Patient or CHW queries	Any medical queries from patients or CHWs can be texted to the clinic for a timely physician response
Requests for acute care	If a patient in a village is seriously injured, a CHW's SMS for emergency care is automatically forwarded to the appropriate response personnel (usually the HBC nurse)
Medication summaries and drug dosage calculations	CHWs are given kits containing various medications. If they forget the purpose a drug, they can text the drug name into the clinic and FrontlineSMS will automatically return an SMS outlining the drug's function and recommended dosages
Replenishing CHW SMS units	If a CHW is running low on units to send SMS messages, texting "units" to the FrontlineSMS server will automatically initiate a message to the wireless service provider requesting that the CHW's phone be "topped off"

hospital staff themselves. All SMS communication occurred through the FrontlineSMS hub so as to catalogue all communication from the field.

2.2. Outcomes evaluation

2.2.1. Usage statistics

In order to determine how the network was being utilized, by volume, incoming messages were grouped into nine categories and tallied based on content: reporting symptoms, requesting supplies, patient reporting (including adherence updates) and referrals, death notifications, requests for help, phone problems, meetings, requests for additional SMS units, and other. This was carried out for the first four months of the pilot.

2.2.2. Efficiency outcomes

To assess if the network affected numeric indicators of hospital operation, three variables were monitored: pilot operational costs, worker time gained/lost, and patient enrollment in the TB treatment program. The calculation of operational cost included fuel costs for the HBC nurse and TB coordinator (this was being routinely recorded before the pilot), the total cost of the SMS messages ($\sim$8.5 US cents per message), and costs for phone repair or replacement. To evaluate approximate worker time gained/lost, the 21 CHWs in the ART monitoring program (as well as the ART coordinator at the hospital) were individually interviewed at the end of the pilot and asked to estimate the amount of travel time saved or lost as a result of the FrontlineSMS network, as well as the number of patient updates that were texted. The TB coordinator also maintained records and was interviewed in a similar fashion. Finally, as a measure of healthcare delivery capacity, the number of patients enrolled in the hospital's TB treatment program was totaled and compared to pre-pilot levels.

Message Content	Number of Messages	Percent of Total
Patient Reporting or Referrals	410	30.83%
Request for SMS Credits	219	16.47%
Reporting Symptoms	199	14.96%
Other	173	13.01%
Request for Help	107	8.05%
Patient Death Notification	75	5.64%
Meetings	60	4.51%
Requesting Supplies	59	4.44%
Phone Problems	28	2.11%
Total	**1330**	**100.00%**

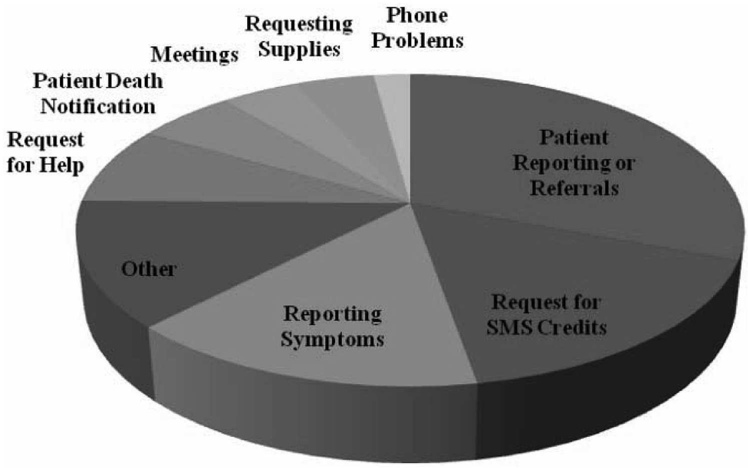

Fig. 2. Text message content distribution.

3. Results

3.1. Network usage statistics

During the first four months of the pilot, a total of 1,330 SMS messages were received at the central hub. The majority of these were patient adherence reports for TB or ART treatment (30.83%). Following this, requests for more SMS units and symptoms reports were also common (16.47% and 14.96%, respectively). Messages referencing technical problems with the phones were rare (2.11%). Of the messages categorized as “other” (13.00%), the majority were confirmatory or forwarded messages. The full content distribution of the messages is shown in Fig. 2.

3.2. Operational net savings

Over six months, the HBC nurse and TB coordinator reported approximately $1,000 and $2,000 in fuel savings, respectively. In total, 2,945 SMS messages were sent during the entire pilot, amounting to approximately $250. No phones were stolen or needed to be replaced, although two of the 75 reportedly stopped working for a period of time. Given that no funds were invested in phone repair/replacement, the net savings for the hospital was approximately $2,750.

Table 2a
Fuel and time savings at six months

Department	Fuel savings	Time savings
HBC	$1,000	500 hours
TB	$2,000	648 hours
ART	–	900 hours
Total	$3,000	2,048 hours

Table 2b
Pre- and post-pilot comparison of clinical volume

Department	Prior to pilot	Post-pilot
TB	100 patients enrolled	200 patients enrolled
ART	25 reports/month	67 reports/month

3.3. Worker time gained

As reported in the 21 ART monitor and coordinator interviews, 25 paper reports were being personally delivered to the hospital per month before the pilot. During the pilot, the ART coordinator received a total of 400 adherence reports via SMS, an average of 16.67 per week. No reports were delivered by hand, and with an average round trip time of six hours, the ART monitors saved approximately 900 hours of transportation time.

Before the pilot, the TB coordinator reported that he was visiting 17 patients per week for adherence monitoring, requiring three trips approximately nine hours each. These monitoring tasks were outsourced to local CHWs throughout the pilot, saving the TB coordinator a total of 648 hours of transportation time.

Finally, the HBC nurse estimated a time savings of 500 hours as a result of the triage system that was implemented using the SMS network. Between the ART, TB, and HBC departments, a total of 2,048 worker hours were saved.

3.4. Increased patient enrollment

The TB coordinator was providing care to 100 patients before the pilot, seeing 17 per week as noted above. With the free time that he gained during the pilot, he was able to manage care for 100 additional patients, effectively doubling the size of the hospital's TB treatment program.

The operational efficiency outcomes are summarized in Table 2.

4. Discussion

Our SMS communication network in Namitete, Malawi – the first of its kind – was successfully implemented to allow CHWs and physicians to share information in real time. The network usage statistics mirror the frequency with which communication was needed for the various categorical events. Patient adherence reports were expected messages that were sent from CHWs monitoring DOTS TB or ART HIV patients on a regular basis, a reflection of the enormous burden of these diseases. In contrast, patient deaths were comparatively rare, and thus accounted for a small portion of the total message volume. There were relatively few SMSs sent to report a problem with the phone and, accordingly, only two phones had documented technical issues during the pilot.

The efficiency outcomes demonstrate impressive changes in the operational capacity of the hospital on all measured fronts. The HBC nurse, in the course of his interview, explained that before the pilot he would stochastically drive from village to village to see if he was needed. During the pilot, he responded specifically to forwarded messages requesting acute care or supplies – a highly-effective triage system. Indeed, the fuel savings alone (combined with those of the TB coordinator) heavily outweighed the operational costs of the FrontlineSMS network (a $2,750 net savings over six months). Similarly, the free time gained by hospital staff (2,048 hours) enabled higher resolution in data reporting (16.67 reports/week versus 25 reports/month pre-pilot) and expanded healthcare delivery capacity (100 additional TB patients put on treatment). For the CHWs, the majority of the time savings was in the form of trips to the hospital that were obviated by the SMS network. With this added free time, coordinators were able to utilize the CHWs to take on more extensive reporting tasks; this is precisely what occurred in the TB treatment department. The prevalence of TB throughout the region was far beyond the capacity of the hospital to provide sufficient DOTS therapy, and so enrollment was empirically limited by the amount of time staff had available to devote to patients. With the FrontlineSMS network, the TB coordinator was able to outsource adherence monitoring to CHWs, allowing his department to double its patient load.

As favorable as these results are, several caveats should be noted. First, as a retrospective observational study, the outcomes evaluation was not designed to be rigorous in its elimination of bias, as would be expected of a controlled trial. For example, CHWs were certainly subject to recall bias during interview sessions, and estimates of free time gained because of the communication network could be either underestimated or falsely inflated. Still, regardless of the magnitude of self-reported increases in CHW free time, it is impossible to ignore the numerical increases in the tuberculosis treatment program, for which there exists long-standing, well-catalogued records. This, indirectly, *is* a good indicator of increased CHW free time. Second, given the large net savings seen in operational costs during the pilot, there is an initial capital investment that should be taken into account (the laptop, cell phones, and GSM modem). This can vary widely depending on the quality of goods procured, but as a bare minimum will total at least $3,000 for a comparable pilot. Finally, although TB treatment enrollment doubled, this says nothing about treatment outcomes. Further controlled studies will need to demonstrate whether or not mHealth initiatives can affect concrete health outcomes such as these. Finally, this SMS-based network was successful because of the availability of reliable cell phone service and signal. Coverage is expanding at a tremendous rate throughout the developing world, especially in parts of Africa, and our approach is likely to be an effective solution for similarly-structured rural healthcare systems. FrontlineSMS may not be the most appropriate solution for areas that have reliable access to internet-based communication, provided that it is cost-effective, or areas without dependable cell phone networks.

Time and efficiency-constraints can impair or cripple healthcare delivery, but this pilot suggests that mobile health (mHealth) solutions can overcome these limitations. The majority of these CHWs had never used a cell phone in their lives, but they were able to adapt to the technological demands of the FrontlineSMS network on the order of days, if not hours. Beyond this, the local staff took complete ownership of project within two weeks- determining usage cases, restructuring their reporting systems, and managing all streams of communication. This is a testament to the untapped potential that simple, appropriate technology solutions have for improving healthcare in the developing world.

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