

Using Mobile Applications for Community-based Social Support for Chronic Patients

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Abstract

In this paper, we present a phone-based application called CommCare which supports community health workers (CHWs) as they provide home-based care and social support to HIV+ and other chronic patients. We report on our experience developing and testing the application with five CHWs in Dar es salaam, Tanzania. We have developed a simple and easily useable system by rapidly prototyping CommCare with the community health workers, in quick iterations based on their feedback. The system guides the user through about 15 questions during each household visit. The CHWs answer the questions using the phone's number pad, and the results are submitted over the cellular network to our server when the session is over.

We report on lessons learned from training and our initial deployment. We discuss the few hardware and software problems that arose during our initial piloting, most of which have been addressed. This use of CommCare has little effect on the time or efficiency of home visits, but results in much easier, much faster, and potentially more accurate reporting. In particular, it saves the CHWs approximately four hours per month spent on compiling reports in the paper system.

Finally, we conducted an initial qualitative assessment of the perception of the phone-based system by the clients of the CHWs who used it. We report on the findings below, which generally show a favorable impression of the system, including an appreciation that a phone can be more discreet than paper notebooks and that it can report data more quickly.

Introduction

In this paper we present findings from our initial field investigations with a mobile application to support Pathfinder International's home-based care for HIV+ and other chronic patients in Tanzania. This is part of the CommCare project to use mobile applications to strengthen and monitor community health programs in low-income countries. Strengthening community health programs can play a vital role in addressing the dire health situation of the hundreds of millions of people living in extreme poverty. People living in extreme poverty often do not seek care at a facility even when dying, or do so too late. Community-based approaches allow us to reach people in their homes. Community health workers (CHWs) are, thus, often in the best position to promote preventive care, encourage safe pregnancy, and refer ill people for diagnosis and treatment at appropriate facilities. Several studies have demonstrated the benefits of CHWs, including reductions of 30-50% of infant mortality in low-income countries [Darmstadt, 2005; Baqui *et. al.*, 2008; Kumar *et. al.*, 2008].

However, there are many challenges to deploying community-based interventions. Community health workers are themselves difficult to organize and manage for the same reason they are so effective: they live in the community and so know the people they serve well but are hard to manage and rarely see their home office or supervisors. Furthermore, successful implementation requires that the outreach efforts are properly supervised, coordinated with other service delivery efforts and that the CHWs are supplied with the materials they need. Additionally, it is crucial to

analyze and monitor the activities and data of the outreach workers to assess and improve the overall performance of the program.

We are developing CommCare, a software application that runs on mobile phones for CHWs. The CHWs will use CommCare to help plan their day, manage household visits, and report their data. CommCare provides medical decision support to CHWs, enables feedback loops for supervision and process improvement, and taps into the tremendous potential for community-based health surveillance. The CommCare software is open source J2ME code that can run on a wide range of Java-enabled phones. It is an extension to the JavaROSA codebase (code.javarosa.org), which is being used to support many different mobile health and data collection applications in low-income countries.

In this paper, we present our initial findings from deploying CommCare with a small number of home-based care providers in Tanzania. We report on lessons learned from training and our initial deployment. We discuss the few hardware and software problems that arose during our initial piloting, most of which have been addressed. This use of CommCare has little effect on the time or efficiency of home visits, but results in much easier, much faster, and potentially more accurate reporting. In particular, it saves the CHWs approximately four hours per month spent on compiling reports in the paper system.

Finally, we conducted an initial qualitative assessment of the perception of the phone-based system by the clients of the CHWs who used it. We report on the findings below, which generally show a favorable impression of the system, including an appreciation that a phone can be more discreet than paper notebooks and that it can report data more quickly.

Background

In this section, we provide background on community health programs in general. We then discuss background on the use of electronic decision support for health workers, the use of mobile phone applications in development of low-income countries, and finally provide details of the open source project, JavaROSA, that CommCare is built upon.

Community Health Programs

There are a great variety of community health programs. Here we focus on CHWs who have responsibility for a group of individuals or households that they visit on a routine basis to promote health and address illness. Even within this focus, there is substantial variation among countries and organizations about how much actual treatment CHWs can perform (versus referral to a health facility), how much training they have, how extensive their visits are, whether they are paid or volunteer, literacy requirements, etc.

CHWs are typically in the best position to promote preventive care and convey important health information, and strengthening community health programs can be the most feasible place to start within overall weak health systems [Knippenberg *et. al.*, 2005]. CHWs can encourage prompt care-seeking behavior and detect and refer those at risk for tuberculosis, malaria, HIV, and other important communicable diseases that devastate families and communities. There is a renewed interest in using community health workers (CHWs) to help meet the Millennium Develop Goals. Ethiopia, for example, is training 30,000 CHWs with a focus on maternal,

newborn, and child health, malaria, and HIV. India, Kenya, Uganda, Ghana, and South Africa are also considering expanded CHW programs [Haines *et. al.*, 2007].

Home visits from CHWs have been shown to be particularly effective at addressing maternal and newborn mortality. Indeed, an analysis of outreach, family-community care, and facility-based clinical care predicted that an 18–37% reduction in neonatal mortality could be obtained with substantial improvement in outreach and family-community care alone, without improvements in facility-based services [Darmstadt, 2005]. A recent study in Bangladesh showed a 34% reduction in neonatal mortality through an essential newborn-care intervention delivered by CHWs during home visits compared to almost no reduction when the same information was delivered through group community information sessions [Baqui *et. al.*, 2008]. A similar study in India showed a 54% reduction in neonatal mortality when CHWs delivered essential newborn-care [Kumar *et. al.*, 2008].

CHWs, however, often receive relatively little medical training [Lewin *et. al.*, 2005], have high turnover [Karab *et. al.*, 2001], and have limited opportunities to reinforce their knowledge once they begin working in the field [Kelly *et. al.*, 2001]. They typically lack effective tools required to maintain the longitudinal records required to provide effective care. Furthermore, CHWs are difficult to organize and manage for the very reason they are so effective: they live in the community and only rarely have contact with their supervisors.

Computerized Decision Support in Health Delivery

The use of structured tools such as checklists has recently been shown to have dramatic improvements even with highly trained clinicians in the United States [Lingard *et. al.* 2008]. Similarly, many studies have shown that better adherence to protocols and other clinical standards can improve health outcomes for low-income populations [Bryce *et. al.* 2005]. A recent study showed that a simple surgical checklist could reduce deaths during major operations by more than 40% in eight cities around the world including ones in Jordan, India, Tanzania, and the United States [Haynes *et. al.*, 2009].

A recent on the adoption of information technology in health indicated that there is sufficient evidence to conclude that technology can improve compliance with medical treatment guidelines and reduce medication errors [Fonkych *et. al.*, 2005]. The most widely used type of information technology in health is the Electronic Medical Record (EMR) system, which has been shown to significantly reduce medical errors and save money [Bates, 2000]. There has also been work in low- and middle-income countries. Systems developed and used by Partners in Health, for example, have been successfully used to track patients and predict expensive drug utilization for drug resistant Tuberculosis in Peru [Choi *et. al.*, 2004]. Further, automated systems have also been shown to improve health-worker adherence to protocols. A recent study in Tanzania showed that clinicians using a PDA-version of a standard protocol for treating childhood illness performed 84.7% of steps required by that protocol compared to 61% of steps observed during conventional practice [DeRenzi *et. al.*, 2008]. Studies have shown that similar systems could be used effectively by lay counselors in South Africa [Mitchell, *et. al.*, 2008] and non-physicians in rural India [Peters *et. al.*, 2005].

Mobile devices in global health

3G Americas (www.3gamericas.org) announced On Dec 22, 2008 that the milestone of four billion mobile phone subscriptions had been passed. Mobile phones and usage plans have steadily been growing cheaper, faster, and more powerful and the trend is sure to continue. While many of the poorest people in the world do not own phones, a large percentage has access to them and mobile phones can be found in operation in almost all corners of the globe.

This has led to a great interest in the use of phones for applications within global health in low-income countries. One particularly compelling example is a recent PDA-based survey of 270,000 households in Mtwara, Tanzania by the Ifakara Health Institute, following a smaller baseline study [Shimira *et. al.*, 2007]. PDAs with GPS units were also shown to be effective at large-scale nationally representative household surveys to assess insecticide-treated bed net coverage [Vanden Eng *et. al.*, 2007]. Rwanda's Treatment and Research AIDS Centre used cell phones to collect aggregate data from every AIDS treatment center in Rwanda on a monthly basis using the Voxiva mobile phone system [Donner, 2005].

Data can be inexpensively transmitted over the cellular network to a central repository to provide information to medical directors, project managers, and policy makers. The above studies of mobile devices for data collection, as well as many others (e.g., [Blaya *et. al.*, 2006]), have shown that they dramatically improve the speed of data reporting and can reduce transcription errors.

The open source JavaROSA platform

CommCare is being built on top of the JavaROSA (<http://code.javarosa.org>) software platform. This is part of a growing trend towards using open source software to develop computer applications for use within global health. Open source solutions can be locally owned, adapted, and maintained—a key ingredient for long-term adoption and success of any technology in an environment as complex as rural health. JavaROSA has been produced by members of the OpenROSA (www.openrosa.org) consortium, a group of organizations working together to foster open-source, standards-based tools for mobile data collection, aggregation, analysis, and reporting. No other open source mobile data collection software has attracted such an active, broad community of software developers. JavaROSA has active developers in Bangladesh, Kenya, India, Norway, Pakistan, South Africa, Tanzania, Uganda, and the United States.

JavaROSA has a strong emphasis on standardized data representations, based on the XForms specification. The emergence of JavaROSA has greatly reduced the duplication of effort among groups developing solutions for phone-based data collection. JavaROSA has an active developers mailing list, an active developer's chat channel, and has invested effort into several collaborative methodologies such as support for unit tests, automated build servers, and project management tools. JavaROSA was launched with funding from the Canadian International Development Research Center and has also received direct core funding from the Rockefeller Foundation, the World Health Organization, and EpiHandy as well as many of the participating organizations that have invested resources into developing and consolidating the code base.

JavaROSA has been fortunate to have senior developers and junior developers from both the developed and developing world working in collaboration to ensure that best practices around design, development, testing, and releases are used and skills transferred. In addition to CommCare, organizations are using JavaROSA for household surveys as well as more complex

solutions. Because JavaROSA is open source, many different applications can quickly be built upon the core functionality. In particular, JavaROSA is designed to support interaction with electronic medical record systems (EMRs) and can maintain longitudinal records over time.

Project description

Details of Partner CHW Program

Pathfinder International is an international a non-profit family planning and reproductive health organization working with developing countries in Latin America, Africa and Asia. Pathfinder has a strong emphasis on community-based approaches and works extensively in underserved urban neighborhoods to isolated rural areas. In Tanzania, Pathfinder relies on volunteer CHWs to provide health promotion, counseling and support for clients with chronic diseases such as HIV, TB and diabetes. The country office oversees about 2,000 CHWs; who operate in both rural and urban environments. The CHWs are volunteers who receive a small travel allowance for a monthly meeting. There is no set schedule or number of clients that each CHW must have. Each CHW typically has 5 to 15 patients they are responsible for, though some have up to 40. The CHWs do not have an established work plan, but are expected to visit every client at least once a month. It is often more frequent than this, with CHWs deciding which households to visit based on urgency of the client's needs and existing conditions.

The CHWs are initially asked to fill out a one-time registration form for each of their clients when the client enrolls in service. Thereafter, for each subsequent visit they are expected to take notes during visits. Based on their notes, they must compose a report with aggregate statistics of their activities that month to share with supervisors during their monthly meeting.

To develop our application, we have worked closely with 5 CHWs who are part of a group of about 40 operating in the Kibida area in Temeke district of Tanzania. In this group of 40 CHWs there are more men than woman (about 30% are woman), and most are between the ages of 25 and 40, though with some older CHWs. Almost all of them are married, and most have some other form of employment. Of the five we worked closely with, primary school was their highest level of education. Four of the five have been working as CHWs since 2003, and one since 2006. They each received 3 weeks of training initially from Pathfinder International for their work, and 1-2 weeks since then as a refresher. They all primarily speak Swahili, though 3 speak some English as well. They all have other jobs (farmer, driver, mason, and two tailors). During our investigations, the CHWs we worked with seemed to see 2 to 4 clients each week, though often visiting a single client twice or more during that week.

The CHWs serve their clients through several activities, including identifying people who are seriously sick and referring them for care at a health facility, training the people who are living with HIV/Aids clients on how to care for the clients (strengthening peer support), and counseling the clients—many of whom are depressed. Sometimes the CHW will help their clients with chores, such as cleaning the house and cooking meals.

The CHWs refer clients for various clinical services, such as testing for TB, HIV, or enrollment in Prevention of Mother To Child Transmission (PMTCT) services for pregnant woman. For certain referrals, the CHW requests the client to go to the clinic or hospital immediately, and are given a paper referral form for the clinician to look at and sign. The client or their care taker is

supposed show the signed receipt from the clinician to the CHW to confirm that the client did complete the referral. If they do not report back, the CHW should follow up with the client and encourage them to seek care if they have not already. The CHWs can also refer for social services at non-clinical facilities.

CommCare Prototype

Our CommCare application starts with a login screen. The providers can login with their personal password, or can select a demo mode for practicing. After logging in, the provider is able to select from five different activities: fill in the Pathfinder household visit questionnaire, register a new client, view uncompleted referrals, review their previous 7 days worth of work and send all unsend data to the server.

As shown in Figure 1, if the CHW chooses to fill in the Pathfinder Followup form, they are asked questions one at a time and can answer them using the phone's keypad. When a question is answered, the questions and the answers are scrolled up so that they can still be seen. The question itself is replaced by a short version of the question. The CHW can easily go back to change an incorrect answer.



Figure 1 Choosing a client and then answering the questions in the Follow Up Form (shown in English and Swahili)

The questions in the Pathfinder Followup cover the data elements required by Pathfinder, including whether or not the CHW referred the client for clinical services. If the client is referred then, as discussed above, the CHW should track the referral until the client gets the car they need. CHWs can use CommCare to view any uncompleted referrals. As shown in Figure 2, the CHW can choose "Show uncompleted referrals" from the main menu and then would be shown the list of referrals that need to be completed. The CHW can select one and then is asked a few questions, including if it was resolved, and if they have seen the signed doctor receipt or only received verbal confirmation. If they indicate the referral was completed, then it would now show up on the list the next time the CHW viewed the uncompleted referrals.

Rapid Iterative Development Methodology

We did not design the above solution all at once. While the above design is simple, our experience is that it difficult to know which simple design to select even after focus groups and user input, and it is easy to think up features which seem useful or intuitive but turn out to be neither. Instead, our approach has been to work closely with the health workers in the field. We started with a very simple system that allowed a CHW to fill in a form, or questionnaire, on the mobile phone that contained all of the information that was normally recorded on paper for a home visit. We quickly made changes to the electronic form based on feedback from the health workers. We have found that it is important to make even simple changes that the health workers request very quickly so that they are able to see that we take their suggestions seriously. Two good examples from early on in our process were that they CHWs asked us to change the order of some of the questions and to make Swahili the default language rather than English. These may seem minor, but the effect of making them quickly is to make a better application and to create a strong partnership with the CHWs on our team. Throughout our design and prototyping process, we are rapidly adjusting things in order to encourage the providers to be vocal about any usability issues they have or changes they would like to see made.



Figure 2 Logging into CommCare, and checking for uncompleted referrals.

More features were added to CommCare as the users became comfortable with the software. The first feature to be added was the ability to submit completed forms back to a centralized server where we are able to view and aggregate data being submitted in real time. While this is useful to us, the health workers have requested the majority of the features that were added, including: the ability to record follow ups for a client, a list of clients to choose from when visiting a household, the new registration form for enrolling clients, the ability to review the forms that have been completed in the last week and a login screen to ensure that the data on the phone—and their clients' privacy—is protected.

Before adding complicated features for tracking referrals, we used a modified version of a technique called “paper prototyping”. We storyboarded (see Figure 3) how we expected the features to work using paper drawings of the phone screen. The CHWs provided valuable feedback while we were explaining the workflow, including requesting that we omit client names on the client list to increase privacy.

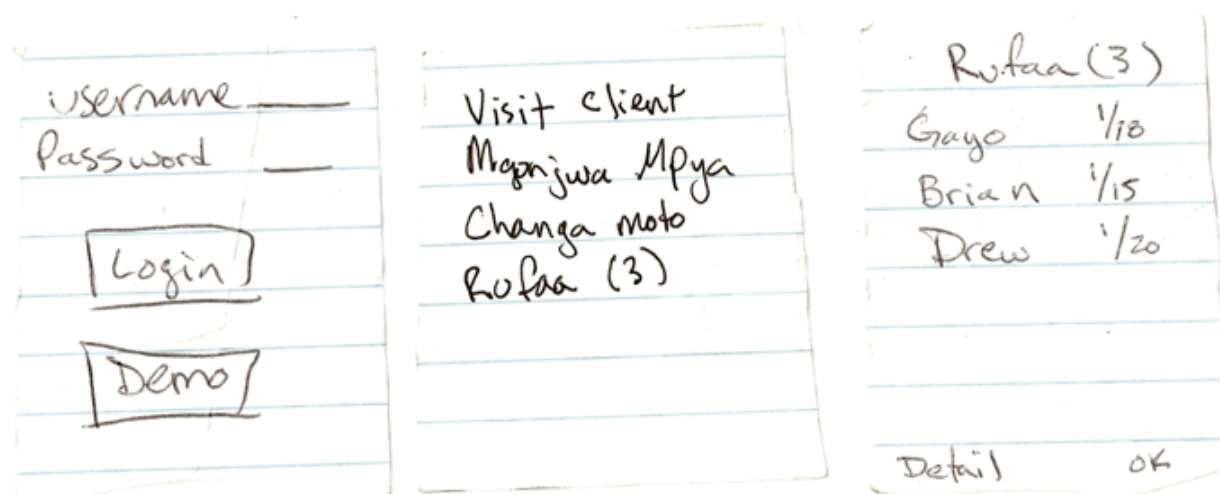


Figure 3 Paper Prototype Used to Design Referral Functions with CHWs

Results

Training

We began working with 5 CHWs in the Kibada area, outside the City of Dar es Salaam in November 2008. As described above, the system evolved a great deal during the first few months, so there was no discrete period of training. During the study time, the CHWs conducted a total of 52 visits using CommCare.

In general, the amount of training required to use CommCare varied from CHW to CHW. Four of the CHWs owned their own phone. As might be expected, the one who did not required the most training. The models of phones we used (Nokia 3110c, Nokia 3500c and Nokia 6085) were more expensive and had more features than phones typical to the area, so the training included careful instructions on how to use the phone, starting with how to turn it on and off. The initial training for the simplest version of CommCare included:

- About 2 hours of group instruction, which included the introduction of the phone model we were using and its various functionalities and going through a 2-page training manual (called a ‘ReadMe’) for how to use the phone and CommCare.
- 30 minutes in which the CHWs worked in pairs to practice the use of the system. This helped the trainer identify who was learning quickly and who was learning slowly, so he was able to focus his attention appropriately.

- 2 hours spent on follow up visits with each CHW. A trainer went with each CHW during a routine home visit to see how the CHW interacts with clients and make sure s/he uses CommCare correctly.

While developing the system, using the rapid iterative style described above, we spent about 2 hours each week with the entire group of CHWs. Some of this time was spent on training for new features, while some was devoted to re-training on old features that the CHWs may have struggled with the week before. From this experience, it seems that bringing the CHWs together at least once a week to discuss any challenges and answer their questions as they come up during the first weeks of use of CommCare may be a crucial part of training.

There were some small things we did that seemed to make a big difference. For examples, the CHWs the phones we used preset the user with a grid layout for the menu choices. The CHWs were not used to this so we set it to a list view, which helped keep focus on the new system we were introducing. We also spent a lot of time creating the Swahili README guide, a two page set of instructions with a picture of the phone and simple instructions for how to use each part and how to use CommCare.

Hardware and Software Problems

During the 52 visits, there were two hardware problems and five software or system problems.

Two of the three hardware problems involved charging the phone. We have given money to the CHWs to charge their phones at a local charging station. In one case, the battery was switched during charging with a cheaper “fake” battery that loses its charge very quickly when the phone is used for voice or data transmission even though appears to be reach a full charge normally. In a second case, a CHW went to a visit with a small charge left on the phone that she hoped would be enough. However, during the visit, the charge ran out and the system shut down.

In another case a problem was averted. A CHW went for a visit but as she was using the system during her visit, she forgot how to continue to the next page, she tried to ring another CHW who seemed be experienced but his phone was off, she remember a ReadMe document that was provided during the training, she took and read it and was able to figure out how to go about and was able to continue with the visit.

We have also been experimenting with solar chargers, with mixed success. We have deployed two Solio chargers and one iTech solar charger. Two CHWs were not able to use the Solio charger.

There were two cases when the CHW did not use CommCare because he could not figure out how to log in (he missed the training when the login was introduced) and another CHW forgot she was supposed to log in, though she had attended the training session so ended up using the demo log in to send real data even though the Demo is supposed to be used for practice only. In a fourth case, a CHW forgot the login password, but after persisting, he remembered it and was able to login.

There was one other problem that arose because we tried out different models of phones. We switched around the different models so that each CHW could try different ones. However, one client refused to allow the CHW to use the phone when she saw the CHW had a different phone than the previous visit. She refused because she thought the original phone had been given to

someone else with her information and was concerned about the privacy of her data. The CHW explained that this was not the case and that her data was safe, but still respected the client's wishes and did not use CommCare during that visit.

All of the software problems were issues that the CHWs raised within the first weeks of use and have been or are in the process of being resolved by improving the software or training.

Comparison to the Paper-based System

From our initial observations, it seems clear that CommCare will save time and results in faster and more accurate reporting than the paper-based system.

Most of the time and accuracy improvements relate to reporting data rather than collecting data during visits. Based on focus groups and following a number of different CHWs during their home visits, we have learned that the length of any one visit is highly variable. If the client is doing well, the visit may take only 10 or 15 minutes to complete, but if the client is ill or has a number of challenges to discuss, the visit can easily take more than one hour. The recording of the data seems to be a small part of the overall visits.

Different providers also perform record keeping in different ways. Some take no notes, but record outcomes from the visit after returning from seeing the client. Others take notes in a notebook while with the client. We don't have timing data for the paper version, but the forms that the CHWs sent back to the server using CommCare contain timing data. From a 24 samples that we analyzed, we were able to extract the length of time it took to fill the forms in on the phone. The quickest was 30 seconds and the longest was 12 minutes. In the case of the 30 seconds, the client was not home, so the provider had very few questions to answer. The longest case was an outlier, as the next longest was just under 4 minutes. These cases could be explained by the CHW pausing in the middle of the form filling to discuss an issue or provide support, or to discuss one of the answers. On average it took 2 minutes and 10 seconds to fill a form. Removing the 12 minute outlier it took 1 minute and 47 seconds.

While the paper-based system may be accurate and quick for visits, the process to report data is time-consuming and error prone. The CHWs must complete aggregate monthly forms. The process involves manual calculation and transcription, and there are a number of points where errors can be introduced, whether it is forgetting to ask all questions, forgetting answers before recording them, or errors in aggregating the visits. The CHWs report spending at least four hours each month compiling reports.

We expect to eliminate the time required for compiling reports once CommCare is fully operational. We will automatically produce the reports from the data sent to the server.

Qualitative Assessment of Client Perception

We conducted a qualitative interview with 7 clients whom have been visited by CHWs using CommCare. All seven had been visited by CHW using CommCare. Six of the respondents recalled having been visited more than three times and one client has been visited once by CHW using CommCare.

The table below presents the qualitative questions that were asked and summarize the answers. Note that the questions are written in English as they were printed on the form, though the interviewer (the first author of this paper, and a Tanzanian nurse) asked the question in Swahili.

Note that we used ‘HBCP’ as an abbreviation for home-based care providers, which is what these CHWs are known as.

While it seems that the clients were inclined to speak positively of the phone-based system the interviewer was associated with, these results do suggest that there are no serious concerns with using CommCare. It is interesting that the phones were generally seen as better for privacy since they are more discreet and that information cannot be as easily read of them as paper.

Did the HBCP explain about the new methods before he/she used the phone on the first day? Yes/No	All 7 said yes.
Did you like the service you received by the provider by using the phone? Yes/No	All 7 said yes.
If Yes or No write down the reasons	The answers given included that paper can be misplaced more easily than the phone, that it is better for privacy, that it can transmit data quickly, and it had shorter visits.
What are your concerns regarding paper-based systems?	5 had no concerns, but one mentioned that a notebook can be misplaced and anyone can read it, and another respondent said that carrying a book causes an alarm to the neighbors who can ask what is going on.
What are your concerns about phone-based services?	All 7 of the respondents said they are not concerned
How do you compare the service using the phone with the one of using paper?	3 of the respondents said it is ok but if there are two systems paper and phones they would still prefer the phone, 4 said they preferred either of the two methods.
List down the reasons why do you prefer that method?	Most of the clients did not understand what to say but when pressed the answers giving were: faster (4 respondents), better privacy (3 respondents), shorter visits (1 respondent),
Are you worried in terms of privacy when the provider uses the phone method? Why?	All 7 said no.
Are you worried in terms of privacy when the provider uses the paper method? Why?	5 respondents said no, and 2 said “not really”.
How would you like this method of using the phone be improved?	5 respondents had no suggestions, and the other 2 suggested they be given a phone to submit their own data.
How many times a month would you like the phone system to be used?	1 respondent said once per month, 1 respondent said twice per month, 1 said four times per month, 1 respondent said five times per month, and 3 respondents said as much as possible based on the availability of CHW.
Do you have any other suggestions or questions that you would like to give?	No new information was given by the respondents.

Conclusions and Lessons Learned

This experience has reinforced several lessons for us. First, simplicity is paramount. We resisted the temptation to add in more complex features and believe that this led to a system that the CHWs are able to use quickly and easily. Additionally, it is impossible and unproductive to try to anticipate all the issues or design the perfect system before fielding it. We found many unexpected problems (e.g., battery swapping) and some things we would expect to be problems were not.

For our particular application, we found that privacy is important for both clients and CHWs. We learned that since many of the clients are HIV positive and many people are not willing to publically talk about it, it is important to maintain privacy. For example, there was one point when we were talking to client on the survey, another relative came up, we had to stop discussing about the survey for half an hour until when that person left then we continued with our discussion.

Perhaps the most important lesson is to form true partnership in the design process from the users. We are very grateful for the enthusiasm and effort shown by the CHW volunteers who worked with us. In particular, we noticed that we got some of the best feedback from most basic users. The person who struggled the most to learn how to CommCare often helped us find ways to improve the interface and gave a great deal of interesting feedback during our sessions.

Our next steps include extending the system to work with other Community Health Programs, developing modules to support community-based safe motherhood programs, and scaling up to larger number of users.

References

Baqi AH, El-Arifeen S, Darmstadt GL, Ahmed S, Williams EK, Seraji HR, Mannan I, Rahman SM, Shah R, Saha SK, Syed U, Winch PJ, Lefevre A; Santosham M, Black RE; Projahnmo Study Group. "Effect of community-based newborn-care intervention package implemented through two service-delivery strategies in Sylhet district, Bangladesh: a cluster-randomised controlled trial", *Lancet*. 2008 Jun 7;371(9628):1936-44.

Bates DW, Teich J, Lee J, Seger D, Kuperman GJ, Boyle D. The impact of computerized physician order entry on medication error prevention. *BMJ*, 2000;320:788-791.

Blaya J, Fraser HS. Development, Implementation and Preliminary Study of a PDA-based tuberculosis result collection system. *AMIA AnnuSymp Proc* 2006:41-5.

Bryce J, Gouws E, Adam T, Black RE, Schellenberg JA, Manzi F, Victora CG, Habicht JP. "Improving quality and efficiency of facility-based child health care through Integrated Management of Childhood Illness in Tanzania." *Health Policy and Planning*. 2005 Dec; 20 Supplement 1: i69-i76.

Choi S, Jazayeri D, Mitnick C, Chalco K, Pachao F, Bayona J, Fraser HSF. A Web-based Nurse Order Entry System for Multidrug-Resistant Tuberculosis Patients in Peru. *Proc. Medinfo2004*, 11: 202-206.

Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de-Bernis L. Evidence-based, cost effective interventions: how many newborn babies can we save? *Lancet* 2005; 365: 977-88.

DeRenzi B, Lesh N, Parikh T, Sims C, Maokla W, Chemba M, Hamisi Y, Shellenberg D, Mitchell M, and Borriello G. 2008. E-IMCI: improving pediatric health care in low-income countries. In *Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy, April 05 - 10, 2008). CHI '08. ACM, New York, NY, 753-762.

Donner J. User-led innovations in mobile use in sub-Saharan Africa. *Vodafone Receiver* 2005, 14.

Fonkych K, Taylor R. The State and Pattern of Health Information Technology Adoption. Rand Corporation, 2005.

Haines A, Sanders D, Lehmann U, Rowe A, Lawn J, Jan S, Walker D, Bhutta Z. Achieving child survival goals: potential contribution of community health workers. *The Lancet* 2007, 369:2121 - 2131

Haynes AB, Weiser TG, Berry WR, Lipsitz SR, Breizat AH, Dellinger EP, Herbosa T, Joseph S, Kibatala PL, Lapitan MC, Merry AF, Moorthy K, Reznick RK, Taylor B, Gawande AA; the Safe Surgery Saves Lives Study Group. A Surgical Safety Checklist to Reduce Morbidity and Mortality in a Global Population. *N Engl J Med*. 2009 Jan 14.

Kelly JM, Osamba B, Garg RM, Hamel MJ, Lewis JJ, Rowe SY, Rowe AK, Deming MS (2001). Community health worker performance in the management of multiple childhood illnesses: Siaya District, Kenya, 1997-2001. *Am J Public Health*, 91(10):1617-1624

Knippenberg R, Lawn JE, Darmstadt GL, et al. Systematic scaling up of neonatal care in countries. *Lancet* 2005; 365: 1087-98.

Kumar V, Mohanty S, Kumar A, Misra RP, Santosham M, Awasthi S, Baqui AH, Singh P, Singh V, Ahuja R, Singh JV, Malik GK, Ahmed S, Black RE, Bhandari M, Darmstadt GL. Effect of community-based behaviour change management on neonatal mortality in Shivgarh, Uttar Pradesh, India: a cluster-randomised controlled trial. *The Lancet* vol. 372 pp. 1151-161 (2008).

Lewin SA, Dick J, Pond P, Zwarenstein M, Aja G, van Wyk B, Bosch-Capblanch X, Patrick M., Lay health workers in primary and community health care. *Cochrane Database Syst Rev*, 2005(1): p. CD004015.

Lingard L., Regehr G, Orser B, Reznick R, Baker GR, Doran D, Espin S, Bohnen J, Whyte S. Evaluation of a Preoperative Checklist and Team Briefing Among Surgeons, Nurses, and Anesthesiologists to Reduce Failures in Communication. *Arch Surg*. 2008;143(1):12-17.

Mitchell M, Lesh N, Wilson I, Fraser H, Grobusch M, Menezes C, John MA, Jackson J, Robinson L, Taljaard J. Using electronic decision support to expand access to AIDS treatment in South Africa, XVII International AIDS Conference, August, 2008, Mexico City.

Peters D, Kohli M, Mascarenhas M. Can computers improve patient care by primary health care workers in India? *International Journal for Quality Health Care*. 2005 18 (6): 435-445.

Shimira K, Mukasa O, Armstrong-Schellenberg J, Manzi F, John D, Mushi A, Mrisho M, Tanner M, Mshinda H, Schellenberg D. The use of personal digital assistants for data entry at the point of collection in a large household survey in southern Tanzania. *Emerging Themes in Epidemiology* (2007) , 4:5.

Vanden Eng JL, Wolkon A, Frolov A, Terlouw DJ, Eliades MJ, Morgah K, Takpa V, Dare A, Sodahlon YK, Doumanou Y, Hawley WA, Hightower AW. Use of Handheld Computers with Global Positioning Systems for Probability Sampling and Data Entry in Household Surveys. *Am. J. Trop. Med. Hyg.*, 77(2), 2007, pp. 393–399.