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Monitoring using mobile technology:
the case of Dispensers for Safe Water

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Since 2009, Dispensers for Safe Water (DSW) has collected thousands of community surveys, dispenser surveys, promoter surveys, installation forms, and chlorine delivery records to track and monitor the quality of service it provides to local communities in Kenya and Uganda. In late 2011, the program began the transition to electronic surveys on handheld mobile devices and the complex data management systems needed to support this technology. Mobile surveys have proven faster, cheaper, and more accurate than paper forms; they have also enabled increased innovation, iteration, and course correction through rapid feedback and analysis. However, challenges remain, including connecting daily field activities to higher-level analysis and aggregation of results in the cloud. To address this, DSW is working to build a system of dashboards and mobile applications to better enable the field team to access, edit, and operationalize the information collected.

Program overview

Dispensers for Safe Water (DSW) began in 2009 as a scale-up initiative of Innovations for Poverty Action (IPA), a non-profit organization that works to apply rigorous research to development economics by conducting randomized controlled trials of poverty reduction interventions.

Upon discovering that many of the water quality gains from source protection were lost to recontamination during storage in the household, researchers at IPA experimented with strategies to increase household chlorination. One such intervention, the Chlorine Dispenser System (CDS), consists of a dispenser calibrated to release a 3mL dose of 1.2% sodium hypochlorite that is installed at communal water sources; a locally-elected promoter responsible for encouraging chlorine take-up within the community and refilling the dispenser; and a chlorine supply chain. In a randomized controlled trial in Western Kenya, the CDS was found to increase chlorination six-fold, from 6-14% in the control group to 50-61% of households in the treatment group (as confirmed by positive tests for Total Chlorine Residual [TCR] in stored household drinking water (Kremer et al. 2011).

While the CDS has graduated from the trial phase to the scale-up phase, DSW remains committed to IPA's mission of evidence-based policy as it expands the reach of this innovation. The program undertakes extensive monitoring of chlorine adoption, promoter activity, hardware conditions, and service delivery in the communities it serves, working to understand key drivers of adoption and test innovations in behaviour change and supply chain strategy. To date, DSW has collected over 8,000 surveys to monitor over 2,200 dispensers that serve an estimated 430,000 people in Kenya and Uganda.

In light of the complexity and scale of DSW's monitoring needs, the transition to electronic data collection was made in late 2011 – early 2012. The new system was designed to standardize data collection across different programs and pilots, compiling information in an easily-accessible format that would allow for better integration of results for analysis across survey modules and time. The field staff was retrained in data collection using Android phones, and an Associate Information Systems Manager (ML) and a supporting Data and IT Officer (MN) were brought onto the team to build the systems needed to facilitate this transition and better leverage DSW's data to maximize the quality of field operations and increase program cost-

effectiveness. While not without challenges, this transition has already allowed for the creation of program dashboards to enable rapid responses to field issues, and has reduced the turnaround time between data collection and analysis to facilitate course correction and program learning.

System overview

DSW's mobile surveys are implemented using Open Data Kit (http://opendatakit.org/), a free, open-source data collection toolkit. ODK has a number of features that have proven useful for survey coding (Table 1).

Table 1. Useful features of ODK				
Range of field types	**Constraints**	**Structures**	**Rich content**	**Administrator control**
• Text • Integer • Automatically-generated date, time, device ID • Select-one and select-multiple choice lists • Calculate fields based on previous answers	• Restrict integers to a range of values • Add error messages • Expand choice lists through the use of "other" fields	• Define question groups • Create repeating survey modules • Assign "relevance" constraints to individual questions or groups to enforce skip patterns and define form progression according to previous answers • Add notes or instructions for surveyors	• GPS coordinates • Barcode scans • Photographs	• Review and edit completed surveys before submission • Collect and save data offline • Upload with cell network, wifi, or manual transfer via micro-USB

Figure 1. Mobile surveying system diagram

Source: Dispensers for Safe Water
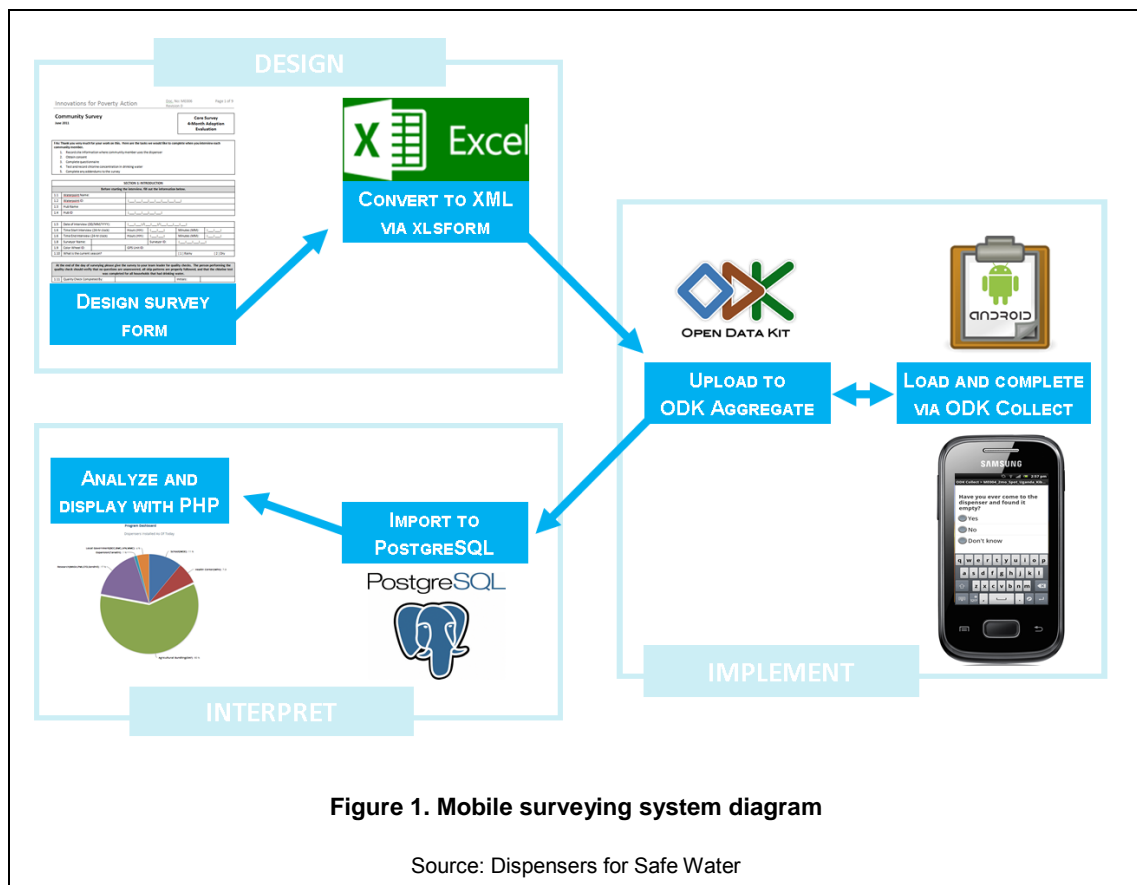
Surveys are designed in Microsoft Excel 2010 and converted to XML files using the XLSForm converter tool provided by ODK. Forms are uploaded using ODK Aggregate, where they can be accessed and

downloaded to mobile phones using the ODK Collect application for Android. Currently, surveys are conducted on Samsung Galaxy Pocket S5300, Samsung Galaxy Mini S5570, Samsung Galaxy Y S5360, and Huawei Ideos phones and uploaded remotely to the ODK Aggregate server by staff in the field, where they are compiled into downloadable spreadsheets in real time (Hartung et al. 2010). Using SQL and PHP scripting, submitted forms on the Aggregate server can be cleaned and restructured into real-time dashboards displayed on a program website to facilitate field staff decision-making (see Figure 1).

Accordingly, the hardware components required to successfully set up a similar mobile survey system are:

- A smartphone or any other device that can be used for capturing data, preferably running on the Android mobile operating system;
- A online server that will house the surveys, so that data entry staff can download and submit surveys from any location as long as they have a mobile internet connection;
- A working internet connection that enables smartphones to connect to the server, in order to submit completed surveys and to download new survey forms when they are available.

Estimated costs for setting up such a system are summarized in Table 2 below.

Table 2. Costs of Setting Up a Mobile Survey System		
Component	**Constraints / recommendations**	**Cost**
Smartphone	• Runs on Android • Fast enough to handle surveys	Per unit KSHS 7,000 (USD 79.91)
Online Server	• One-off cost (physical server), OR • Annual cumulative cost (cloud storage)	Annually KSHS 48,000 - 50,000 (USD 567.63 - 570.77)
Internet connection (optional)	• Reliable post-paid connection with good quality of service (i.e. rarely goes down and takes maximum 1 hour to come back online), OR • Pre-paid data bundles provided for by mobile service providers (e.g. Safaricom)	Annually KSH 60,000 (USD 684.93)
Developer (optional)	• Strong technical skills to seamlessly implement information system	Annually KSH 720,000 (USD 8214.48)
Staff training	• Training on phone technology and data transfer, independent of training on survey forms and protocols themselves • Communicate a clear procedure for flagging and resolving problems with the technology, and for accessing support from the field	Varied (Tea, staff transport, etc.)

Benefits of incorporating mobile technology

Dispensers for Safe Water currently operates out of six field offices distributed across Western Kenya and Eastern Uganda. While operating at the pilot level, DSW was already employing three full-time data entry staff. Larger rounds of surveys required up to two weeks to complete data entry, at a maximum rate of 150 surveys entered per day. As operations scaled to multiple offices, the logistical hassle of maintaining paper-based records increased exponentially.

Electronic surveying removed the need for repetitive and cumbersome efforts to physically transport and record paper surveys for centralized record keeping. Data collected in the field is now uploaded to the server at the end of each day of surveying, allowing for instant data compilation. Question-specific constraints that require the surveyor to respond to questions with the appropriate inputs (i.e. numbers for numeric fields), are built into each form to reduce surveyor error in the field. The electronic transmission of surveys further limits the opportunities for data entry error.

Beyond direct cost savings and increased accuracy, electronic data collection has improved operations by enabling program staff to refine survey questions early and often, quickly tailoring surveys and interventions to realities in the field. These course corrections no longer require the stop-and-go approach of completing a survey wave, conducting analysis, and then beginning a subsequent wave; instead, the team is gradually

moving to a continuous-survey model in which sites are visited year-round and up-to-date information can immediately influence operations.

The expansion of DSW's data infrastructure has also facilitated the creation of tools to optimize service delivery:

a) Mapping – Smartphones with GPS capabilities have improved mapping of chlorine dispensers. This has allowed for better planning and greater operational efficiency.
b) Issue Tracking – A mobile application known as the Issue Tracker allows DSW to report and resolve problems in the field (see Figure 2). The Issue Tracker includes live dashboards to monitor reporting and resolution of field issues, and generates task lists for managers and field staff to prioritize their responses.

This combination of mobile surveying and improved reporting will ultimately allow DSW to understand systemic and recurring issues as well as the potential avenues for addressing them. It will also enable DSW to track trends over time, such as the increasing efficiency of the team's response to problems in the field.

Figure 2. Sample DSW Issue Tracker Screenshot

Source: Dispensers for Safe Water
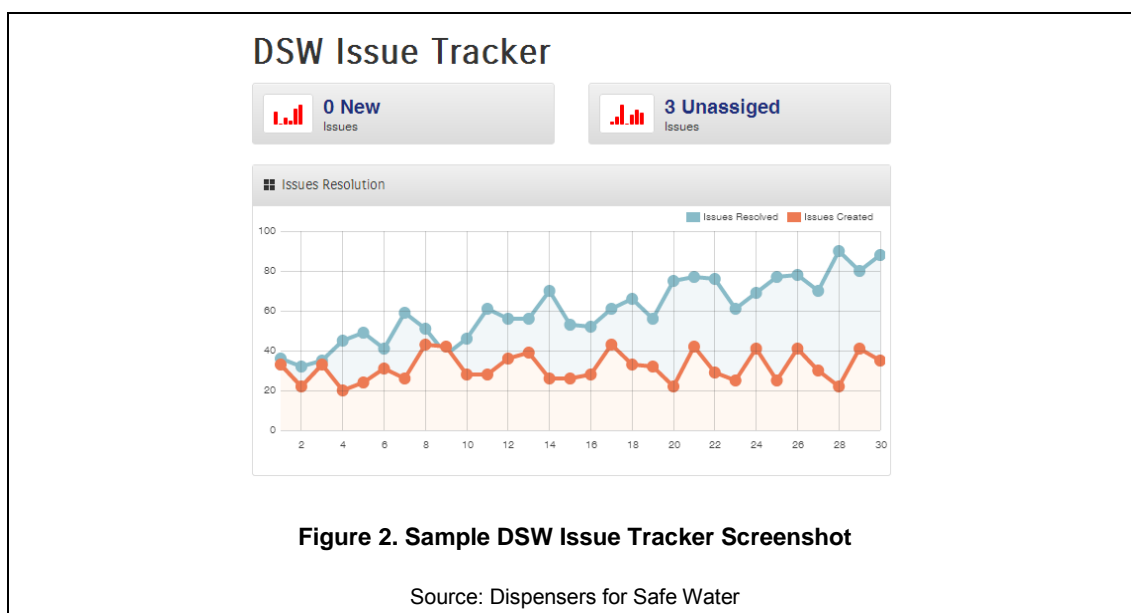
To optimize the use of applications such as the Issue Tracker, the DSW operations team has incorporated mobile handheld devices equipped with electronic survey applications directly into its suite of operations tools (which includes a wide range of other resources such as maps, and community education scripts which inform community members about water-borne diseases and proper dispenser use). This allows the process of data collection and reporting to be tightly integrated into the operations process, rather than being considered as a separate evaluation activity.

Finally, mobile technology has enabled new types of data and community interaction that would otherwise be impossible. Collecting a database of phone numbers from community members interested in receiving updates related to the Chlorine Dispenser System and pairing these phone numbers with mass-SMS platforms provides a low-cost way of communicating with tens of thousands of dispenser users. DSW has piloted the use of FrontlineSMS to send bi-weekly messages of encouragement to community members, reminding them about the health benefits of using chlorine. Another system, mSwali, has enabled the Dispensers for Safe Water team to send brief surveys to promoters and users that can be answered for free by texting to an SMS short code.

Challenges of incorporating mobile technology

The introduction of mobile technology into program operations has not proceeded without challenges. At the most fundamental level, the system itself requires technical and hardware support to ensure that data are transmitted correctly and promptly. While loss of data has not been a significant issue, the field staff is

occasionally unable to upload completed surveys in a timely manner and assorted challenges around short battery life and poor internet connectivity have arisen. To combat such issues, spare batteries and phone airtime are provided to the staff as needed to ensure real-time integration, and backup hard copies of forms are supplied in some instances. Additional problems with failed barcode scans and delays reading GPS coordinates have been addressed through multiple entry (e.g. electronic barcode scans combined with manual entry of serial numbers) and repeat surveying.

While facilitating the data entry process, the use of mobile survey technology has the potential to complicate back-checks and data cleaning. Mistakes in data sets can no longer be compared with paper forms, making it more difficult to track errors and understand how they were made. To prevent such problems, the field staff is rigorously trained on how to error check their work before uploading completed surveys to the server. However, spelling mistakes still occur once in a while, and especially where open text is used (e.g. when entering name of a water point). Efforts are underway to minimize free text entry and convert such fields into drop-down lists where appropriate.

Securing staff buy-in was a third challenge faced in the transition from paper to mobile forms. The conversion to mobile surveying may impact staff satisfaction if employees feel that the shift makes their job harder and the benefits are not well explained or justified. In addition, the storage of data in the cloud can be frustrating for field assistants who cannot physically track the number of surveys completed or peruse survey results without a computer. Furthermore, mobile technology can be intimidating to enumerators who are using smartphones for the first time. To address these concerns, DSW has prioritized the development of operations tools over higher-level analysis tools, working first to build the applications that are most immediately useful for the team on the ground in order to bridge the divide between data collection and interpretation. DSW has also worked to solicit and incorporate feedback from the field team; for example, given challenges with the small size of the keypad on the Ideos phones, the program has switched to buying Samsung phones to take advantage of their wider screens.

Expanding the use of mobile technology

Following the program success in Kenya, DSW launched its Uganda program in January 2012. Unlike the Kenya team, the Uganda team had no exposure to DSW's paper survey forms and started their work directly with the smartphone technology. As part of the induction training for the new team, a specific component on smartphone surveying was included. In addition to improved efficiency, this strategic choice led to cost-savings for the new program overall, as the up-front costs of printing survey forms and hiring data entry staff were eliminated.

Ensuring the success of a smartphone-based survey system is ultimately dependent on how expectations are managed and how the system is communicated to the staff that uses it. The Uganda team benefited greatly from the experience of the DSW Kenya team. By the time of their adoption in Uganda, most of DSW's survey forms had been created, tested, and standardized and many of the initial glitches, which can often lead to suspicion in the system, were not present. The new staff was pleased with the easy format of mobile surveying and welcomed not having to carry paper forms to the field, especially during the rainy season. Furthermore, having a smartphone made them feel more professional and modern.

The Uganda experience indicates that introducing pre-tested electronic surveying systems at the outset of a program may be easier than transitioning mid-program. However, in both cases collecting and incorporating staff feedback from the end users of the system is essential in ensuring that the system can be improved and better tailored to the needs on the ground.

Advice on implementing mobile technology

One of the key advantages of the ODK survey toolkit is the ease with which it can be adapted to programs with different sizes, purposes, and levels of technical expertise. At the most basic level, ODK can be simply and cost-effectively used to run a single survey on a single phone, requiring only that staff members can use the toolkit's Graphical User Interface to create their own survey forms and that they can download and interpret the resulting CSV datasets using standard analysis software (Stata, Excel, etc.). On the other hand, the toolkit can be used to run a full suite of surveys across different offices, with dozens of phones simultaneously submitting data from the field. At this scale, shifting to a large-scale database management system and hiring programmers to automate and supervise this transition may be appropriate and/or necessary.

DSW's program combines both approaches. Surveys are often piloted and tested on a small scale, and single-round surveys may be conducted without automatic incorporation into the database. However, in the long run DSW is working to make survey rounds and forms as universal, automated, and standardized as possible, with an eye to ultimately creating a sustainable system that "runs itself."

Such a complex implementation of mobile survey systems requires time to set up, and substantial costs must be incurred in order to get a good information system that is both easy to use and detailed in the information contained. To achieve this end, organizations should work to hire talented developers to build out their information systems while also articulating a very clear understanding of what they aim to achieve through the use of mobile surveying and electronic data. Depending on the information systems to be developed, it may take between 6 months and 1½ years of developer time to build a fully functioning information system that compliments a given mobile survey system.

Conclusion

Ultimately, DSW has had a productive and rewarding experience in its transition to mobile technology. The ease with which mobile surveys can be created, adapted, and accessed within the ODK system, when combined with the dramatic reduction in the data entry and transcription costs associated with the use of paper forms, have already produced considerable tangible benefits from the transition.

At the same time, shift to mobile technology has been an ongoing process of adaptation. In addition to adjusting team structures to incorporate IT staff and new trainings, DSW has worked hard to ensure staff buy-in throughout the transition and to guarantee that the benefits of mobile surveying extend down to the field level. The creation of operations dashboards and field tools has been an important component in smoothing this transition and conveying the potential held by the new systems.

At the most basic level, mobile phone technology is cheap and easy to implement, with readily apparent benefits. However, organizations planning to institute this technology at a grand scale should expect to undergo a long process of transition and change management in realizing these rewards. The fruit of such careful planning and clear communication of expectations is a complete revolution in standard data collection, entry, and analysis procedures, as characterized by a move from stop-and-go surveying to rapid analysis, iteration, and course correction.

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