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SmartCDS: Malaria Diagnosis, Treatment, and Surveillance using Smartphones

Despite the progress made in reducing under-five (0-49 months of age) mortality in low income countries, three quarters of deaths within this age-group is still due to malaria, pneumonia, diarrhea and newborn conditions. The correct treatment of these conditions is the most powerful intervention. However, in those countries facility-based services alone do not provide adequate access to treatment; and most importantly, not within the crucial window of 24 hours after onset of symptoms [1]. In Uganda for example, a recent Malaria Indicator Survey reported that 42% of children (0-49 months) were infected with malaria parasites, yet only 14% received the recommended Artemisinin-based Combination Therapy (ACT) within 24 hours of onset of symptoms [2]. Malaria causes significant morbidity and mortality in many developing countries—the World Health Organization (WHO) estimated that in 2010 there were 219 million cases of malaria and 660,000 deaths attributed to the disease. The WHO and UNICEF [1] have called for the strengthening of community health workers (CHWs) so that services are brought closer to the community within the integrated Community Case Management (iCCM) strategy targeting the three killer diseases (malaria, pneumonia, and diarrhea). In this strategy, CHWs (lay people without medical knowledge) complete a short training program to enable them provide a life-saving intervention at household and community levels against these diseases that was formerly provided by facility-based nurses or doctors only. The training for CHWs is provided either by Ministry of Health staff or non-governmental organizations in collaboration with the ministry of health, so that they are able to obtain the skills and knowledge necessary to provide appropriate care. The iCCM model has been adopted with countries adapting WHO/UNICEF implementation guidelines [3, 4]. Some 46 countries were reported to have in addition incorporated testing for malaria in iCCM using rapid diagnostic methods [5]. The main challenge though is that current malaria surveillance systems detect only 10% of the estimated global number of cases. Therefore, with the inherent limitations in the reporting system in the public sector [5], a low-cost innovative approach to collecting malaria surveillance data is strongly needed to enhance the iCCM strategy. Furthermore, collecting surveillance data will allow for the analysis of spatial distribution patterns of malaria cases over time which may help direct intervention efforts. This technology also has the potential to be applied across many diseases to create comprehensive disease surveillance and early notification systems and to track the effect of human movement on disease spread.

We have developed and piloted the SmartCDS (Smart Care and Disease Surveillance) java-based Android 2.0 powered Smartphone application which simultaneously aids CHWs to offer the iCCM package in people's homes, records the location of the households with a built-in global positioning system, and can transfer the patient information as a disease surveillance data file in real-time to a server. Following the iCCM and malaria diagnosis protocols the CHW uses SmartCDS to ask a series of screening and follow-up questions about the patient's clinical symptoms. One question appears per screen and branching algorithms automatically provide CHWs with the appropriate questions to ask based on the patient's (or caregiver's) responses to prior questions. CHWs enter the responses using the touch screen on the smartphone. As appropriate (based on the responses) SmartCDS tells the CHW to test the patient for malaria using a rapid diagnostic test (RDT) and if the test is positive tells them the appropriate course of action (provide treatment according to weight/age, refer for further evaluation). As the numbers of patient records are transferred to the server this information can be automatically added to a database from which a map of cases can be generated to visualize their spatial distribution. The supporting back-end database which can provide numerous types of reports can be accessed via a secure website or the requested data reports can be generated and emailed to the desired recipients.

Using the geocoded data, high-risk areas can easily be displayed to guide in prioritization of resources for urgent intervention in those malaria endemic low income countries that currently have fragile or no surveillance infrastructure. Our Smartphone application automates a usually paper-based protocol that CHWs are using in the iCCM model. It is quicker, incorporates the use of rapid diagnostic tests (RDTs) for malaria and generates updated disease surveillance reports.

There are numerous low-cost ($40-100) Android 2.0 smartphones available now, largely developed for low income country markets, and more will likely appear on the market in the coming years. In addition to what we described above, advantages of using low-cost Android Smartphones include the following: long battery life, easy to learn by lay-people; capacity to add features to the application (e.g.,

send photos to aid in diagnosis of other conditions) and interfacing with other systems (e.g. OpenMRS electronic medical records system), and low cost data transmission (about $0.60/month per CHW).

Preliminary Feasibility. We have piloted the SmartCDS in a rural area in Uganda. First, in a one-day training we trained CHWs to use the smartphone app and tested it with 50 outpatients at a public Ugandan rural hospital. Using the feedback from CHWs in the initial pilot test, we revised the app and then tested in in the field. Three CHWs used the app as part of their usual community work for two months. Feedback from the CHWs and patients has been incredibly positive. There have been some technical issues with the smartphone GPS functioning and stockouts of malaria treatment but overall the preliminary piloting suggests the app is acceptable to patients and CHWs but it needs some additional technical troubleshooting to ensure full data capture.

Widespread public health impact. The iCCM model was embraced with countries adapting WHO/UNICEF implementation guidelines [3, 4]. To date, CHWs in some 46 countries were reported to be testing for malaria in the iCCM service delivery model to appropriately target antimalarial drugs [5]. Therefore, creating a strong and accurate surveillance system with inbuilt instant malaria surveillance data collection capability and generation of reports will enable service providers and stakeholders to address those areas of high risk with a timely response before the spread of epidemics. Accurate near real time surveillance data is essential as countries move to eradicate malaria. The need for such data was highlighted in recent articles in Science [6] and Lancet [7]. For CHWs, storage of paper records (such as book registers with several pages) is inconveniencing and delays the utilization of the collected information for planning purposes. The book is only retuned to be checked by the supervising health unit quarterly. Further with the drive to eradicate malaria, a comprehensive surveillance system is more realistic right from the community level through the formal health care system. SmartCDS also makes it possible to estimate the true malaria disease incidence since CHWs will instantly transfer health data even from the population that is not normally attending public health units.

Future research possibilities. Using mobile phone technology to collect disease surveillance data in developing countries has tremendous potential to not only allow tracking of disease trends over time and triggering rapid public health responses to disease outbreaks but it also affords the opportunity to study how human movement and social interactions relate to disease transmission. At present smartphone and mobile internet use in developing countries is limited to the wealthy, however, as these products and services become less expensive their use will likely expand exponentially. This will increase opportunities to study social interactions and movement as they relate to disease. One mobile phone service that is currently used widely in developing countries is mobile payment systems. Tapping into data on mobile payment use to see if it is related to better or worse health outcomes in communities is another area of potential research.

References

1. World Health Orgainization (WHO)/UNICEF Joint statement: integrated community case management (iCCM) – an equity-focused strategy to improve access to essential treatment services for children. http://www.unicef.org/health/files/iCCM_Joint_Statement_2012.pdf
2. Uganda Bureau of Statistics (UBOS) and ICF Macro 2010. Uganda Malaria Indicator Survey 2009. Calverton, Maryland, USA: UBOS and ICF Macro.
3. de Sousa A, Tiedje KE, Recht J, Bjelic I, Hamer DH. Community case management of childhood illnesses: policy and implementation in Countdown to 2015 countries. Bull World Health Organ. 2012; 90(3):183-90.
4. Integrated Community Case Management of childhood malaria, pneumonia and diarrhea: Implementation guidelines. http://www.malariaconsortium.org/inscale/downloads/uganda/ICCM-implementation-guidelines.pdf
5. World Health Organization. World Malaria Report 2012. WHO, Geneva. http://www.who.int/malaria/publications/world_malaria_report_2012/wmr2012_full_report.pdf
6. Wesolowski A, Eagle N, Tatem AJ et al. Quantifying the impact of human mobility on malaria. Science. 2012; 388: 267-70.

7. Cotter C, Sturrock HJW, Hsiang MS, Liu J, Phillips AA, et al. The changing epidemiology of malaria elimination: new strategies for new challenges. Lancet. 2013. Published online April 15, 2013 http://dx.doi.org/10.1016/S0140-6736(13)60310-4.