



**The Mobile Technology for Community Health (MoTeCH) Initiative:  
An m-Health System Pilot in a Rural District of Northern Ghana (Working Draft)**

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**Abstract**

*In 2000, the government of Ghana reformed its health care system by decentralizing the planning and management of health services from the national to the district level. Based on evidence from an operations research project of the Navrongo Health Research Centre, the government combined this decentralization with an initiative designed to improve access to basic health care. In a policy known as the Community-based Health Planning and Services (CHPS) Initiative, the Ghana Health Service aims to scale up community-driven health care services. This paper describes a project known as Mobile Technology for Community Health (MoTeCH) that is based on the premise that health management systems have yet to fully address the information needs of frontline CHPS workers. Beginning in 2009, a study team launched a program to design MoTeCH so that it would facilitate the capture of CHPS primary health care service information and then feedback of essential health information to mothers, workers, and managers. This paper describes MoTeCH and summarizes lessons learned. Unanticipated findings attest to the importance of trial, experimentation, and operations research in m-Health systems development. Policy implications of MoTeCH experience are reviewed and discussed.*

**Introduction**

The global proliferation of mobile phone use has generated international interest in “m-health” initiatives for supporting health care operations in developing countries. However, most such initiatives focus on the provision of specific curative or preventive health services rather than the full range of health information requirements for services to mothers and children at different stages in the continuum of care. This paper discusses an initiative that addresses this problem, *Mobile Technology for*

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*Community Health (MoTeCH)*, by building upon a 1999 policy of the Government of Ghana --“CHPS” for the *Community-based Health Planning and Services Initiative*. CHPS is derived from Navrongo Health Research Centre (NHRC) research showing that childhood mortality could be substantially reduced by relocating nurses from clinics to community health posts, supplying them with motorbikes and basic health care equipment, and providing them with essential pharmaceuticals (Binka, et al. 2007). Supervision, volunteer services, and community support was organized to facilitate nurse household outreach for curative and preventive health care services (Awoonor-Williams, et al. 2010).

While CHPS works well where it is implemented, the program has yet to achieve its full promise as a scaled up service system. Community nurses often base their work in village health posts, failing to provide much needed doorstep care, a dysfunctional variant on CHPS that can be termed “passive supply.” As the supply dimension of Figure 1 illustrates, information systems reinforce this passive approach by failing to assist workers in locating work according to client needs. Service needs associated with pregnancy, delivery, and early infancy is often neglected, because information available to nurses and volunteers is inadequate for supporting home-based services to newborns. The District Health Information Management System (DHIMS) that was developed to support decentralization of Ghana’s health care system is clinic focused and fails to provide workers with information about the timing of delivery. As a result, intensive outreach that is needed to support post-delivery care in the first 48 hours post-delivery is neglected. Instead, community-based health care workers spend vast amounts of time recording service encounters on patient cards and registering insurance forms rather than seeking clients in their homes. Since DHIMS information cannot be used to guide daily work routines, community-based health care workers—the individuals who are critical to successful CHPS programming—do not have the information that they need to implement their programs efficiently and effectively. Moreover, because case episodes are aggregated by hand and merged with sub-district clinical caseload information, the current DHIMS system does not support clinical decision-making processes.

Clients are also deprived of crucial health information. As a result “passive demand” is a major problem confronting the health of children. Parents who are aware of childhood illness delay the seeking of help, or forget to return to clinics when they should be seeking care for their children. Information generated by the health system provides little motivational support for parents to seek care for their children or services at the time of delivery. This problem is illustrated by the demand dimension of Figure 1. If clients could be alerted to needs and encouraged to utilize services, their demand for care might be more fully realized.

***[Figure 1: A Typology for Resolving Information-based Constraints to Health Service Supply and Demand]***

The combined dimensions of the supply-demand challenge portrayed in Figure 1 is complicated by the inappropriateness of paper-based systems to basic information needs. Paper systems extract data from workers rather than support contrasting requirements of patients at different points in the continuum of care. As Figure 2 illustrates, information requirements and needs change for mothers and their children as the continuum of care unfolds. Adapting information requirements to these needs is poorly addressed by rigid registers, printed forms, and paper reports that either standardize information management for all patients at all points in the continuum of care, or require separate registers and procedures for each point in the continuum. Mobile technology can address this problem by providing logic and operations that mechanize the adaptation of information capture and use according to specific needs, thereby simplifying information capture, management and feedback processes.

***[Figure 2: Contrasting Information Requirements across the Continuum of Care]***

Paper system inefficiency further complicates the information management tasks of frontline CHPS workers who must maintain as many as 28 paper registers for recording routine information about the various activities and services that they provide. Time use research has showed that CHPS nurses spend more time on paper data management operations than on clinical care (Frimpong, et al. 2012). Obviously, major efficiencies could arise if paper systems could be streamlined. Moreover, introducing cell phone data capture operations would be impossible if workers were required to maintain a complicated paper system and simultaneously capture data on cell phones. For this reason, reforming the paper system was an important stage setting activity for MoTeCH.

While the problems portrayed by Figures 1 and 2 are significant, they are not insurmountable. MoTeCH has adapted existing mobile phone technology to the information needs of CHPS frontline workers. MoTeCH will determine if mobile technology can help to address these problems by significantly easing information capture and feedback for community-based health care workers thereby improving their efficiency and effectiveness. MoTeCH is now a fully functioning pilot that is producing learning about the potential for m-Health to improve health itself.<sup>1</sup>

Little is known about the feasibility of utilizing mobile phone technology for reforming routine health information operations and improving community health care worker efficiency and health service effectiveness. Filling these critical knowledge gaps, the project builds upon promising health care reform efforts to date in Ghana, sets the stage for the completion of such efforts, and tests whether

promising technology can strengthen the community-based health care services that are increasingly being implemented throughout the developing world.

### **The Setting**

The Upper East Region is located on Ghana's northern border with Burkina Faso and is comprised of nine rural districts (Figure 3). Of the 10 regions of Ghana, the Upper East ranks as the poorest. Yet, the Upper East has the highest CHPS coverage of any region. Over half of the population is covered by doorstep CHPS services, and in the KND-W pilot area, over 80 percent of the population was served by the CHPS nurses (Regional Health Administration, 2011). Although, CHPS was not fully implemented in some communities owing to the lack of construction of a community health compound, functionality of the program was nearly complete. Health officers operate out of health centres or other buildings and provide basic services to the population even where facilities are absent.

*[Figure 3: Kassena-Nankana West District, Upper East Region]*

### **What is MoTeCH?**

MoTeCH tests whether an innovative mobile-phone based health information system targeting community health workers and their patients can improve the quality and effectiveness of community-based health care in rural and impoverished communities in Ghana. The primary study objective is to increase the coverage of essential health interventions targeting pregnant women, neonates and infants such as ANC4+, use of IPTp and bednets during pregnancy, attended birth delivery, first post-natal visit within two days of birth, and childhood immunizations. The secondary study objectives are to reduce the amount time spent by community health workers on non-clinical tasks through the automation of monthly reporting processes, and improve the quality of health information data collected and aggregated by community health workers through the use of mobile phones for data capture.

The MoTeCH system is composed of three components that are posited to improve the efficiency and effectiveness of community health workers operations: i) the development and deployment of a Simplified Register, which centralizes the recording of health data in a significantly reduced number of books; ii) the development of a *mobile-phone based health information system for health workers*, which automates the production of monthly activity reports and provides alerts and reminders about possible defaulters; and iii) the implementation of a *mobile-phone based health promotion* module, which provides pregnant women and mothers of newborn with key information required to enhance the quality and frequency of patient-provider interaction as well as alerts and reminders of upcoming or missed care events.

*Simplified Registers.* Simplified clinical registers (SR) were introduced in all functioning CHPS zones and Sub-district Health Centres of KND –West with the goal of streamlining data recording

processes and facilitating subsequent mobile phone data capture. Whereas community health workers recorded clinical data in 12 registration books, MoTeCH consolidated this into three SRs: i) A register for pregnancies and antenatal care, ii) a register for infant and child care, and iii) a register for the general population (age 5 and above). A prototype was jointly developed and revised by members of the study team and the regional and district health management teams, prior to introduction into pilot CHPS facilities. Two nurses were then oriented to the SRs over a two day period by staff of the national Centre for Health Information Management (CHIM), thereby ensuring that the SR pilot would address all of the information needs of the GHS.

*Mobile-phone based health information system for health workers.* MoTeCH is a system that uses low-cost mobile phone technology to capture, transmit and process health service data collected by community health workers during patient encounters. For CHO who already own more sophisticated phones, a simple form may be used to enter this same information (Xform), but all nurses participating in the trial were issued low-cost java-enabled phones so that operations could be standardized. The MoTeCH system generates individual event data, continuously updating records of pregnancies, births, deaths, and morbidity. The system also manages information on the health insurance status of clientele and will eventually allow automating production of monthly caseload reports to DHIMS through queries and tabulations of the centralized patient database. It is designed to send reminders and alerts to community health workers to ensure continuum of care for pregnant mothers and newborns. The use of MoTeCH is free to both mothers and workers.

Network errors and connection problems are frequent in the Upper East Region of Ghana. MoTeCH service is available on all of the existing mobile networks in Ghana. If the network is unavailable, outbound messages from MoTeCH to CHOs are saved on the MoTeCH computer servers and sent again when the network becomes available. For messages sent to MoTeCH by CHPS workers, outgoing messages can be stored on the mobile phone and will be sent when the network becomes available. Data recorded on the SR provide back-up and will ensure that no data are lost during network outages.

In order to automate data aggregation and reporting, patient data captured by CHO with the Mobile-phone based health information system, as well as operational data collected during the mobile-phone based health education campaign, are stored on a dedicated server that remotely hosted outside of Ghana. This was deemed necessary in order to ensure adequate bandwidth for MoTeCH operations, the highest safety standards for secure transmission and storage of patient information and reliable and consistent up-time of the system for the duration of the project. The Ghana Health Service owns the URL and passwords for this operation and is the controlling authority for data captured and used by

MoTeCH. In recent years, the Ghana Health Service has gained international experience with web sites, data sharing, and other activities that require remote transmission, storage, and retrieval of information. CHIM has played a key role in these initiatives.<sup>2</sup>

*Mobile-phone based health promotion for pregnant women and recent mothers ("Mobile Midwife")*\_MoTeCH also initiates a mobile-phone based education campaign targeting pregnant women and mothers of infants with the goal of providing women with key information necessary to achieve i) a healthy pregnancy, ii) a safe delivery, and iii) the proper growth and development of their newborns and infants. The project team has thus developed a mobile-phone system that allows sending users of the system such information. At enrollment, clients in the treatment group are asked to provide their phone number, their age and an expected date of delivery. Once registered, clients receive text messages (SMS) or automated voice messages informing them about key aspects of health behaviors during pregnancy and infancy. For example, they receive text messages about the importance of sleeping under bednets during pregnancy, or the positive health benefits associated with exclusive breastfeeding. They also receive more specific messages related to their own pregnancy or the health of their newborns/infants. A pregnant woman in her seventh month of pregnancy and who has yet to receive her first IPTp dose is thus reminded that she should seek such treatment through a SMS sent by the system. A mother whose child has not yet received his/her first OPV/DPT dose by age 8 weeks is reminded to seek such immunization from the clinic.

### **The MoTeCH System**

The MoTeCH application combines existing software systems for mobile data collection, electronic medical records, and interactive voice response (IVR) to bridge the health information gaps. In this respect, developing MoTeCH was a systems integration task rather than a de novo systems development operation (MacLeod, et al. 2011). Maintaining individual level electronic health data is central to MoTeCH. A minimal electronic health record to record health status and health service delivery data for each patient is used. With this, MoTeCH calculates the upcoming schedule of care for each client and, when care is due, it notifies the client and the health workers responsible for that client. The individual level data also obviates the need for nurses to manually calculate aggregated health status and health service delivery by age group and gender because the system can automate these computations and all routine reports.

MoTeCH uses the OpenMRS ([www.openmrs.org](http://www.openmrs.org)) software for maintaining the individual level client data, the OpenXData ([www.openxdata.org](http://www.openxdata.org)) software for data collection on low-cost mobile phones and the IntelliIVR ([www.yo.co.ug](http://www.yo.co.ug)) application for Interactive-Voice-

Response (IVR) messages to patients. OpenMRS provides MoTeCH with a well design extensible platform for defining client data fields and for adding software logic.

The extensible features of OpenMRS provided a solid foundation to build MoTeCH functionality. The OpenMRS concept dictionary allowed the project to combine predefined health attributes with project specific data fields (ie, patient telephone number). In addition, OpenMRS has a modularized architecture that facilitates the addition of additional medical record functionality. Applying this capability, MoTeCH has modules for web based data management, nurse and patient messaging logic, an event engine that calculates a schedule of upcoming care for each patient, and an administrative reporting tool. MoTeCH augments the open source codebase of OpenMRS with a routine for automated recalculation of upcoming care requirements for any patient that is registered in the system. For example, when OpenMRS receives information about a child immunization, the timetable for upcoming immunizations for this child is updated accordingly..

. The requirements for mobile data collection evolved over the course of the project. However, key features of the system were utilized throughout the project facilitated this iterative systems development process. An mForms mobile data collection application was built from OpenXData. This open source application includes a mobile client that runs on low-cost phones, a form designer, and server side data upload features. OpenXData adopts the xForms standard for form and data representation. The ability to quickly define and revise mobile data entry forms played a critical role in the delivering new functionality in a timely manner. The OpenXData application software to include the ability to report inconsistent data that could only be determined on upload to the server (for example, an invalid patient ID).

The IntellIVR application provides the voice messaging functionality of MoTeCH. The short development time frames necessitated the use of this proprietary application and the project did benefit from the application engineering support provided by the Yo! Uganda company. An open source IVR for MoTeCH is under development.

## **MoTeCH Research**

*Standardization.* MoTeCH includes a system of research and investigation designed to clarify the impact of the system on client behavior and the impact of operations on worker performance. In order to guarantee that results of the MoTeCH trial are not affected by the level of CHPS implementation in study areas, the MoTeCH project commenced with activities designed to “standardize” the level of CHPS operation across the study district. By 2009, the Ghana

Health Service had developed 11 fully functioning CHPS zones in KND West (KND West) district.

A rapid assessment was conducted to appraise the comparability of facilities indicated that the level of CHPS implementation differed significantly across zones. To ensure a common platform for evaluating changes in outcomes in the intervention and comparison areas, a strategy of CHPS standardization was developed based on findings from the assessment for standardizing community health service operations. Standardization activities included: i) expanding community health worker's knowledge-base through in-service training of midwives, community health officers, health extension workers, and volunteers in particular in the area of maternal and newborn health; ii) providing essential clinical equipments for service delivery (e.g., blood pressure cuffs, delivery beds etc.), and providing essential equipment that facilitates the conduct of outreach and home visits (e.g., motorbikes, bicycles). These activities ensured that all communities covered by CHPS operations had equivalent access to community-based care prior to the onset of MoTeCH research.

*The Time Use Study.* A baseline time-use study (TUS) was conducted to precisely measure the proportion of work time community health workers in KND West district well as in three external “control” districts of the Upper East. The TUS assessed time devoted to clinical and non-clinical tasks; and how time-use changes over time. At the end of the pilot the TUS will be repeated. The study will thus permit the MoTeCH project to test the hypothesis that mHealth technology reduces time spent by different categories of community health workers on non-clinical tasks through the automation of monthly reporting processes. The secondary objective of the study is to determine which factors (e.g., burden of disease in local communities, worker-level characteristics, sub-district level characteristics, district level characteristics, etc.) account for variation in time-use across community health workers operating in districts of the Upper-east.

The TUS was conducted by direct observation of the daily activities conducted by community health workers at regular time-intervals. Procedures estimated the percentage of time spent on various activities (e.g., clinical care, administrative work, non-productive time) by community health workers. To achieve this, fieldworker visited a community health clinic on a randomly selected day to observe the activities of a health worker. At predetermined intervals the field worker located the community health worker and tried to determine which tasks the worker is performing and then recorded on a pre-printed time-sheet whether the worker was conducting child-welfare clinics related activities, compiling standard reporting forms, or simply



waiting for patients. The fieldworker repeated these tasks every few minutes without interacting with the worker under observation. Compilation of this information permitted tabulation of the percentage of observations recorded for a particular activity providing an estimate of the total time that health workers spent on this activity.<sup>3</sup>

Results from the baseline study showed that the provision of direct patient care accounted for less than 25 percent of time on the job (Frimpong, et al. 2012). In bivariate analyses, productivity was higher among midwives, older health workers and in facilities with a high volume of care. The most important determinant of worker performance was supervisory encounters. After controlling for (possibly unobserved) characteristics of the health workers and health facilities in a fixed effect regression analysis, one or more quarterly worksite encounters with a supervisor was associated with a 48 percent increase in productive use of time. Barriers to effective supervision included limited means of transportation, absence of a supervision checklist and lack of an action plan for recommending and implementing changes and improvements to service delivery.

*The Quality of Aggregated Data (QAD) Study.* CHOs and volunteers record information about service encounters in paper-based registers, on patient-held health booklets, and on insurance forms. This information is essential to monitoring the health of communities, guiding national planning, and sustaining funding. Insurance forms determine reimbursement to the GHS for services that its CHOs render. Comparative scrutiny of facility data provides the basic information for managers to gauge the performance of frontline health workers. Workers generate data for their reports by monthly review of records and the manual tabulation of events and outcomes according to age and sex of all patients seen during the previous month. A series of reporting forms are provided for this task, with the expectation that aggregated information will be transferred to district health management teams for further aggregation into quarterly district reports, which are eventually recorded in the District Health Information Management System.

MoTeCH is conducting an operational study to assess the quality of data in the health workers' monthly reports and the completeness and accuracy of key case registration and outcome data compiled by community health workers and test whether the introduction of mobile phones mechanized data aggregation improves the improves the quality of data reported by community health workers. The QAD study consists of comparing summary reports aggregated from patient data by community health workers ("zone report") to summary reports

compiled by data audit experts using the same raw data (“validated report”). A first round of the QAD was conducted in 2010 and the study will be repeated in 2012.

Data reported by community health workers are considered *complete* if community health workers have recorded any value for a specific field; data will be considered *accurate* if none of the examined variables in the zone report are missing or showed a difference of more than 5% compared to the validated report. During the MoTeCH project, community health workers will continue to record information from patient encounters in patient registers. Mobile phones will be used to enable data entry and facilitate the aggregation of clinical data. Thus by using data from the registers, MoTeCH researchers can assess whether the introduction of mobile phones significantly reduces error rates in reports of community health workers. Independent reviewers will collect zone reports from the district health management teams and from the regional health administration and will systematically review registers of patient encounters providing raw data on episodes of care. Each zone report will be reviewed and recompiled independently by two reviewers. They will enter patient data in a database, and the cumulative caseload activity report are then automatically re-aggregated on the basis of this information by the independent reviewers. Cases of discrepant data entry are resolved through re-inspection of the patient registers. By repeating this operation at baseline and at the end of the study, MoTeCH will ascertain whether trends in data accuracy are attributable to better aggregation through use of mobile phones, or to concomitant trends in the completeness of patient registers. Completeness and accuracy of data from zone reports will be compared to that of independently validated reports for six case-registration variables: i) Number of antenatal care visits per month, ii) number of family planning visits, iii) number of postnatal follow-up visits conducted by community health workers. iv) number of immunizations among children under age 2. v) the quality of data on the following general morbidity indicators will also be assessed, and vi) the number of malaria cases

*Qualitative Systems Appraisal.* Focus group discussions and in-depth interviews are in progress that will aim to explore possible barriers to service utilization for clients, barriers to service delivery for community health workers, and patterns of mobile phone use by patients and health workers. In addition, this study will seek to gain a better understanding of health information seeking behaviors for community health workers and clients, preferences for mobile phone-based reminder messages, responses to test SMS messages, and suggestions on the design of a text message platform for increasing health knowledge and service utilization. Sampling of health facilities will be stratified according to uptake of and compliance with the MoTeCH

intervention to allow for the development of a profile of low-achieving and high-achieving facilities in using the MoTeCH mobile phone component.

This assessment is using qualitative research methods to collect interviews and focus group discussions with community members and health service providers. The assessment is under way in CHPS zones and Health Centres within the MoTeCH project area of Upper East Region, as well as with RHA and DHMT personnel. The study includes panels of health services providers/managers, CHOs actively using the SRs and mobile phone component from low-performing zones and high-performing zones, individuals who are in charge of the SRs and mobile phone component from low-performing zones and high-performing zones, sub-District Leaders for facilities using the SRs and mobile phone component, KND West District Health Management Team personnel and Upper East Regional Health Administration personnel. To gauge community reactions to the system, studies of community members are in progress that includes pregnant women and women with children under 1 year of age who have been enrolled in the Mobile Midwife component of MoTeCH and have consistent access to MoTeCH messages as well as panels of women who have had inconsistent/no access to MoTeCH messages. Panels are also convened that include partners of women enrolled in the Mobile Midwife component of MoTeCH, elder relatives of women enrolled in Mobile Midwife (such as mothers, mother-in-laws), and Community Health Volunteers.

Qualitative analyses of these data will explore possible barriers to service utilization for clients, barriers to service delivery for community health workers, and patterns of mobile phone use by patients and health workers. In addition, data collection activities will seek to gain a better understanding of health information seeking behaviors for community health workers and clients, preferences for mobile phone-based reminder messages, responses to test SMS messages, and suggestions on the design of a text message platform for increasing health knowledge and service utilization.

### **Lessons Learned**

The MoTeCH project results attest to the importance of implementation research, monitoring, and qualitative appraisal. All elements of the project research design have prodigiously produced unanticipated findings. In particular, the project goal of developing technology that would impact on parental health seeking could not be achieved because social, behavioral, and technical problems prevented effective feedback of information from the system to mothers. Baseline survey results portrayed a context for mobile technology application that failed to represent the true context of phone use and access. Northern Ghana is a profoundly gender stratified societal setting, where men co-opt

family resources of all kinds. Women’s access to cell phone technology is analogous to their access to health services in general –a social constraint to health seeking that has been termed “gate keeping” in previous research in this setting (Ngom et al. 2003).

The software development aspects of the MoTeCH project represent its major achievement, with technology that may contribute to a wide range of applications in other settings. Development of the system was nonetheless marred by overlaying the agenda of developing local commercial software engineering capabilities in the context of developing a complex software application. Also, the challenge of developing an application for the Ghanaian context was at times at odds with the goal of developing generic systems for applications elsewhere.

Studies of the work force, time use, and service environment refined project understanding of the service context. In general, operational variance was much greater than expected, producing challenges for system introduction and sustainability. Unexpectedly, workers view the introduction of mobile phone technology as imposing extra tasks rather than simplifying their work routines. However, this response is due to the late introduction of automated data aggregation and related procedures that would save worker time and effort.

**Table 1: Unexpected Results from MoTeCH Research**

<b>MoTeCH Research or Monitoring Activity</b>	<b>Unexpected Results</b>
<b>Baseline survey</b>	Baseline survey data suggested that access to cell phones was extensive. Monitoring data show that many MoTeCH clients do not, in fact, have reliable access to mobile phones, contradicting survey responses. Survey data fail to account for social access problems related to gender dynamics, actual connectivity problems related to power outages and network overload, and phone literacy problems that hamper call back operations.
<b>Software development</b>	<ul style="list-style-type: none"> <li>• Software development requires extensive field implementation research, particularly on user interface issues.</li> <li>• Capacity building of local developers conducted in conjunction with software development required extra time and training responsibilities and extensive redevelopment effort.</li> <li>• Use of Open-MRS simplifies software development in settings where organized development expertise is diffuse. Utilizing isolated and individualized engineering expertise benefits from decisions to embrace generic software platforms, such as Open-MRS. MoTeCH 1.0 was optimized for the Ghana context.</li> <li>• Software developed for Africa is sub-optimal for large Asias populations where system efficiency is of paramount importance. MoTeCH 2.0 is optimized for large populations.</li> </ul>
<b>Worker Survey</b>	<ul style="list-style-type: none"> <li>• Owing to the shortage of facilities, there are multiple “Community Health Officers” within community facilities. As a consequence, work responsibilities within community clinics are more differentiated than expected.</li> <li>• Community outreach and household visitation has less attention than anticipated.</li> </ul>
<b>Time use study (baseline)</b>	<ul style="list-style-type: none"> <li>• Over half of all time use is for non-patient care. Data operations consume more time than patient care.</li> <li>• Far less time is spent on doorstep services than expected.</li> </ul>
<b>Quality of Aggregated Data study</b>	Much poorer quality of routine data than anticipated.
<b>CHPS Zone Standardization</b>	Pronounced variation in CHPS facility and equipment readiness.

<b>Simplified Register development</b>	More data redundancy in the old system than anticipated with simplification achieving more reduction in worker data management activity than anticipated.
<b>Simplified Register rollout</b>	<ul style="list-style-type: none"> <li>• Launching the Simplified Register requires manual re-registration of patient history information. This required a full week of start-up effort in each facility for a single worker.</li> <li>• The Simplified Register is very popular with workers, and viewed by most as MoTeCH's most important single contribution.</li> </ul>
<b>Software implementation</b>	<p>Despite completion of a comprehensive software system, the "Mobile Midwives" feature of MoTeCH did not work. Many MoTeCH clients were unfamiliar with the use of phones or with numbers, limiting their ability to access their MoTeCH messages;</p> <ul style="list-style-type: none"> <li>• Network congestions is a significant constraint in sending messages to clients and in health workers sending health information to MoTeCH;</li> <li>• In general, patients are not calling back into MoTeCH to access messages that were not initially delivered. The low frequency of calls from such clients suggests that MoTeCH is not addressing the information needs of women who do not have direct access to phones.</li> <li>• Client phones do not respond to MoTeCH calls because they are turned off to save electricity or because the battery is drained.</li> </ul>
<b>Qualitative Systems Appraisal</b>	Community Health Officers view MoTeCH as "extra work" rather than a time-saving tool.

Despite surprises and challenges associated with MoTeCH results, the system is now fully operational and positioned for an important new phase of replication research that will test procedures for extending the system outside of pilot communities. This extension phase, combined with implementation research, will provide valuable insights into prospects that a comprehensive mHealth application can improve service operations and health itself.

## Looking Forward

*A Randomized Control Trial.* As yet, there is no evidence in the formal literature showing that mobile technology can improve health. Based on the platform for inference that MoTeCH represents, proposals are pending that will permit the study team to address this knowledge gap. A proposed randomized controlled trial (RCT) of the use of mobile phone technology will allocate clients of ANC clinics in KND West health facilities to a treatment group in which participants receive the standard of care provided by the Ghana Health Service augmented by alerts, reminders and health education messages relating to maternal and newborn care versus a control group in which participants receive the standard of care, but do not receive alerts, reminders and health education. Similarly, the nurse would receive alerts and reminders only about the care of patients who have been randomly chosen to participate in MoTeCH. At the end of the project, the study team will compare the outcomes (i.e., time to PNC visit, facility-based delivery, time to first immunization) of those in the treatment and control groups using simple statistical tests. Subjects are women pregnant at the time of enrollment. Clients will be eligible to participate if they are adults (18 years or older), they plan on residing in the study area over the 6 months following enrollment, they are in the second or third trimester of their pregnancy at the time of enrollment, they are not otherwise enrolled in another RCT protocol of the Navrongo

Health Research Centre. It will not be required that clients own a cell phone to be eligible for the study. The study is intended to test whether the cell phone initiative improves the coverage and timeliness of the utilization of health services during delivery and early infancy (*primary outcomes*). We hypothesize that clients in the treatment arm will be i) more likely to deliver at health facility, ii) receive post-natal care from a health worker within two days of the child's birth, iii) obtain immunization for their child by the target date (i.e., at birth for BCG and OPV0; at 6,10, and 14 weeks for doses of DPT and OPV). The study will also test whether the cell phone initiative favors safe delivery practices (e.g. clean cord care, promotes exclusive breastfeeding during the first months of life, and prevents post-natal depression among mothers (*secondary outcomes*)).

*Expanding functionality.* Although MoTeCH is now a fully functioning system, the project team envisions further work, not only to test its impact, but also to expand its functionality. Critical components of the primary health care system are not yet addressed by MoTeCH. Family planning, for example, is readily addressed by MoTeCH architecture, since alerts and reminders for patients due for resupply conform to logical requirements of existing MoTeCH capabilities, such as alerts and reminders for childhood immunization.

*Addressing systems limitations.* Beyond adding functionality, however, the MoTeCH team aims to document and address critical limitations of the system. First, evidence is emerging that women are not sufficiently exposed to messages owing to limited access to phones in their households, systems problems preventing network connectivity, and power problems that affect the functioning of phones. The study team has reviewed traditions of resource sharing, volunteerism, and communication to identify cultural resources for enhancing systems connectivity with its clientele. Testing ways to improve access to functioning phones remains a priority for future work. In particular, we aim to develop systems for loaning mobile technology to pregnant women to address gender and family resource problems that constrain telephone access. Also, community organizational methods that have successfully developed volunteer programs in Ghana could be applied to the need for volunteers who would provide battery charging and telephone support services. Finally, telephone applications that extend MoTeCH to emergency systems support is feasible and much needed.

*Integration.* MoTeCH was developed to support the information needs of frontline workers and mothers, but it does not yet address its full potential to reform Ghana's Health Management Information System (HMIS). The complexity of the current system is illustrated by the flow of information in Figure 5 and the preponderance of paper forms and data storage and

retrieval points. In the pre-MoTeCH system, paper forms were a major impediment to worker performance (Figure 4, *A*). But this problem also hampers operations at the clinic and hospital level (Figure 4, *B*). If MoTeCH-like functionality were introduced on clinic laptops or notebooks, the procedural advantages of the system would be extended to clinic operations. Note, moreover, that the forms of the National Health Insurance System (NHIS) have yet to be incorporated into MoTeCH (Figure 4, *C*). For this reason, gratuitous manual data capture and data-input procedures persist. Finally, critical components of the HMIS operation, known as DHIMS, are not yet developed in MoTeCH. In particular, reproductive health and family planning operations are separate DHIMS reporting systems (Figure 4, *D*) Onerous paper procedures, forms, and data aggregation procedures are yet to be informed.

*[Figure 4 about here:  
The Complex Paperbound National Health Information System]*

If all aspects of MoTeCH operations were integrated into the District Health Information Management System (DHIMS), the capture, flow, and feedback of data would be simplified and enhanced (Figure 5). Paper forms would be replaced with automated transmission of data, to include family planning, NHIS forms, and fixed facility information. All workers, including community workers, would have task-specific automated information feedback. Information for clientele would be generalized so that services provided at any point in care would produce appropriate MoTeCH-like alerts and reminders. Thus, we view MoTeCH as the beginning of HMIS reform, not a completed program of systems development.

*[Figure 5: An Integrated MoTeCH-DHIMS System for Ghana]*

## **Conclusion**

MoTeCH represents an important contribution to m-Health development by serving the needs of both mothers and frontline workers with a wide range of information capabilities. It is designed to be adaptable and extendable, and has considerable promise for anchoring the process of generalized HMIS reform by integrating data capture, management, and feedback for various requirements of the continuum of care. MoTeCH also represents work in progress. There is a need for sustained focus on social and contextual problems involved in the introduction of technology. There is a continuing need to address basic questions about the impact of mobile technology on health itself. Once the full ranges of development steps are taken, and evaluation

research is completed, the MoTeCH model may prove to be a powerful means of marshaling information in ways that save lives.

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**Figure 1: A Typology for Resolving Information-based Constraints to Health Service Supply and Demand**

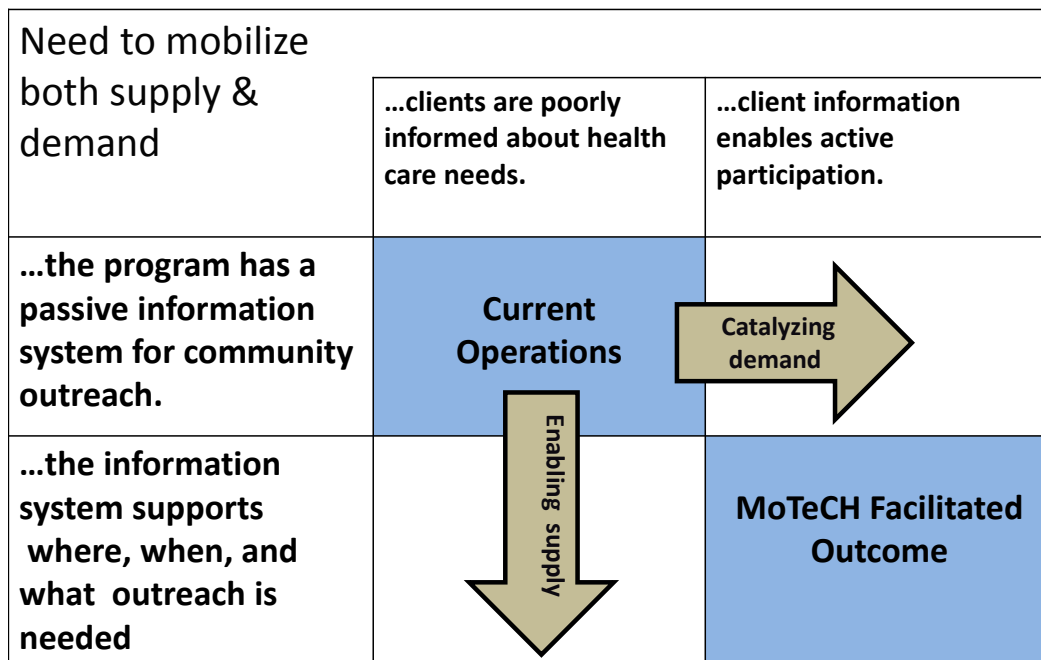


Figure 2: Contrasting information requirements across the “Continuum of Care”

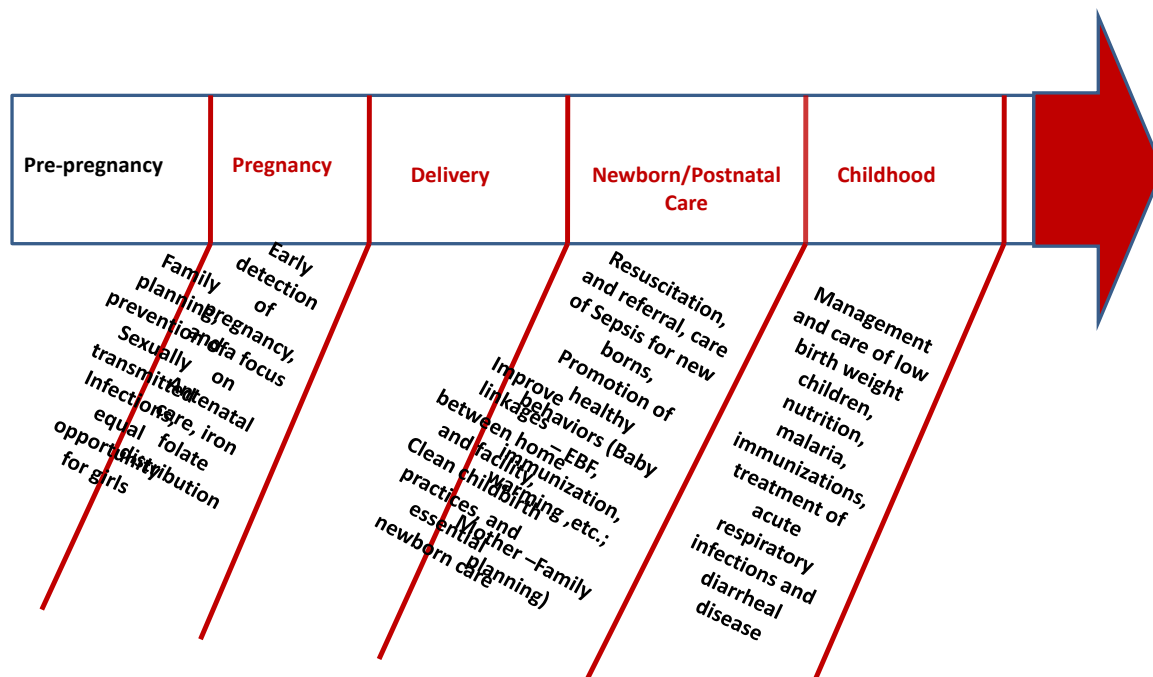
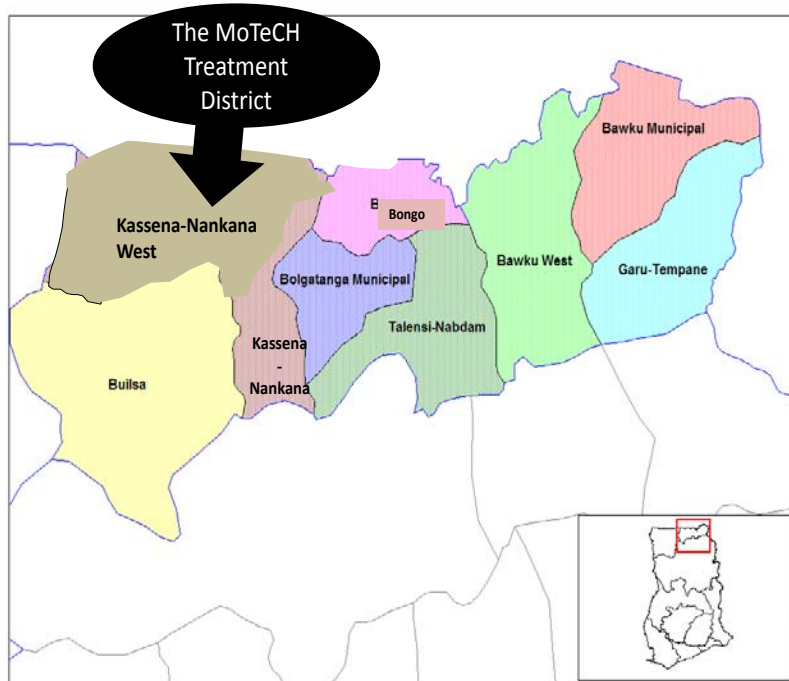


Figure 3: Kassena-Nankana West District, Upper East Region



**Figure 4: The Complex Paperbound National Health Information System**

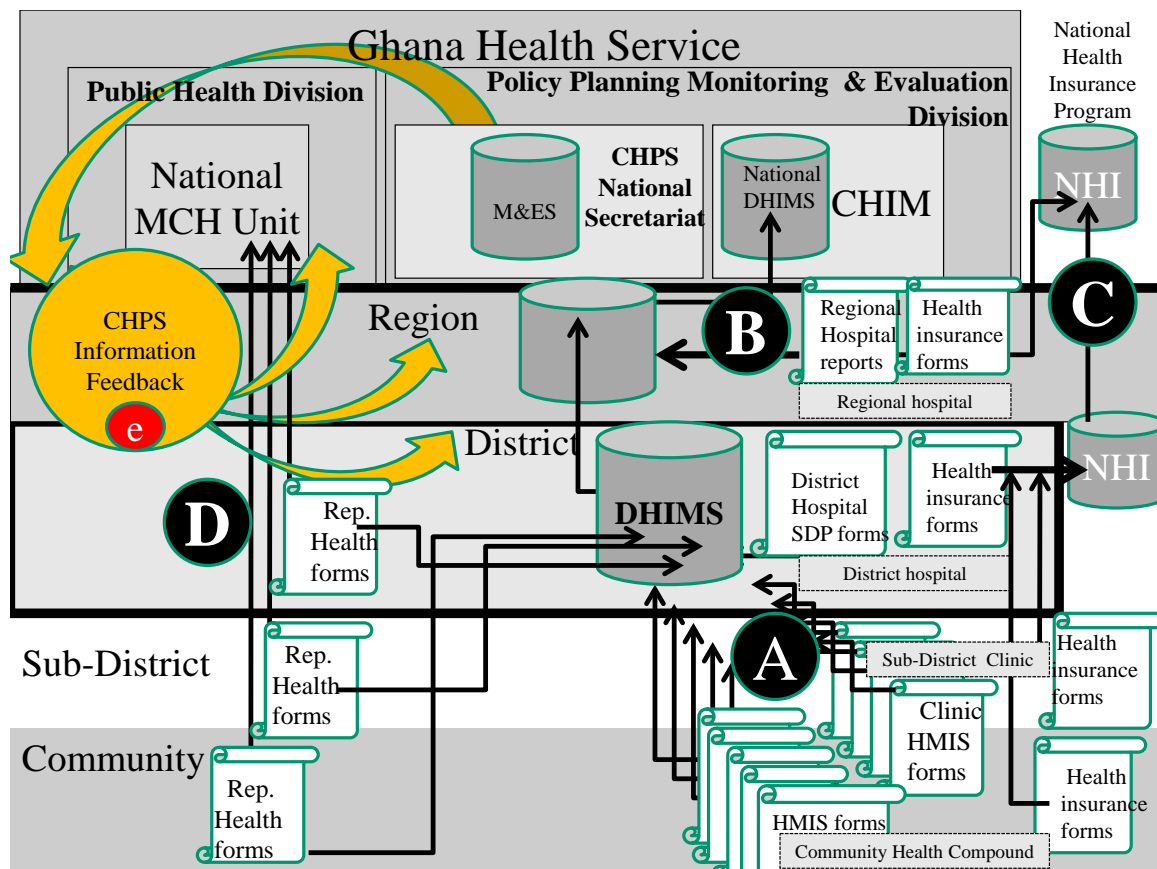
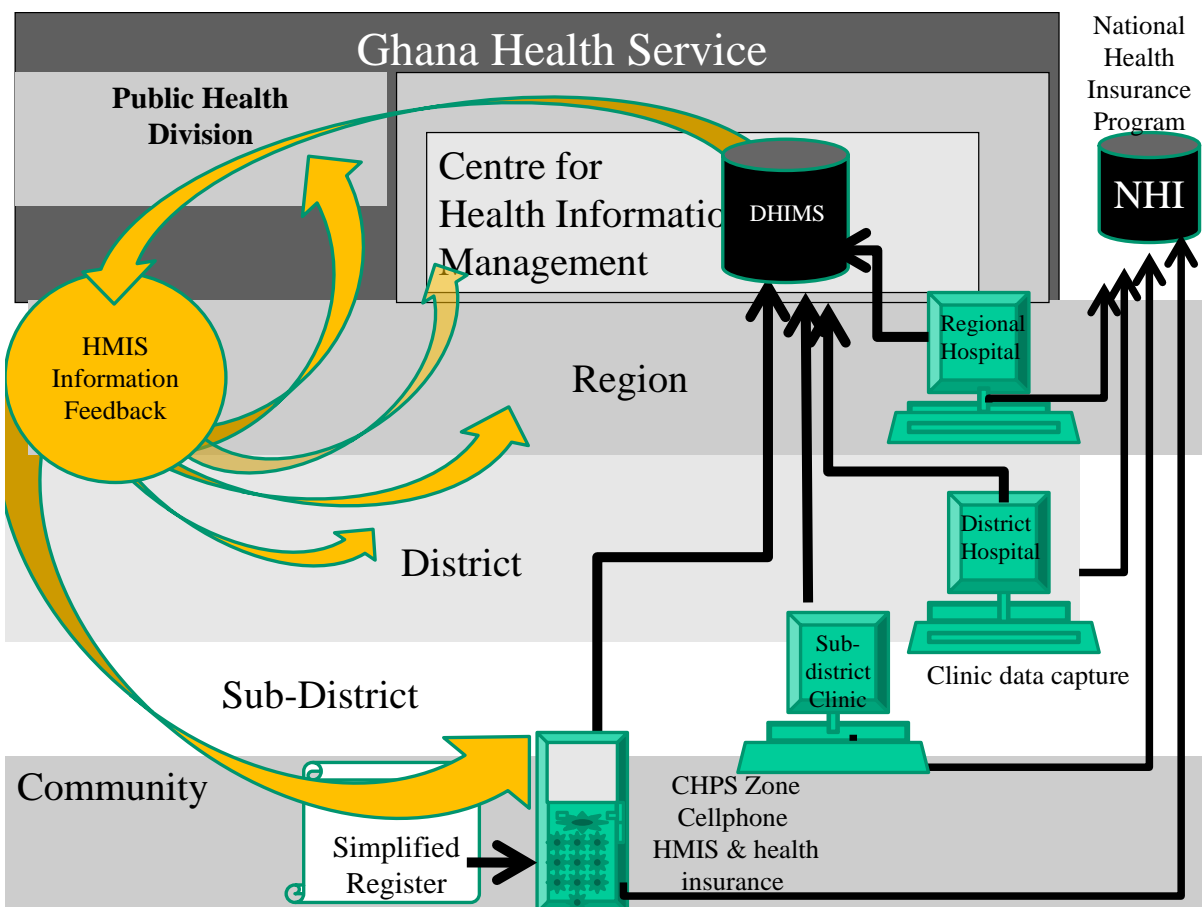


Figure 5: An Integrated MoTeCH-DHIMS System for Ghana



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<sup>1</sup> MoTeCH is a project of the Ghana Health Service that is conducted with support from Columbia University's Mailman School of Public Health and the Grameen Foundation.

<sup>2</sup> For the duration of the project, MoTeCH engineers and project members (from the Ghana Health Service, Columbia University and the Grameen foundation) had access to the server for all project operations so that software can be tested and developed in a framework that facilitates progress, while establishing GHS ownership of operations, technology, and data. The MoTeCH project has been designed to develop CHIM data management and access capabilities. However, data access by non-medical staff has been governed by conventional ethical safeguards that protect the confidentiality of medical records.

<sup>3</sup> In the literature, this approach is also known as “work sampling”<sup>3</sup>. Direct observation (i.e., work activity sampling) has been found superior to data self-reported (during retrospective interviews, or through the use of diaries) by health workers on their own time-use because 1) self-reported data are prone to large recall biases<sup>3</sup>, and 2) self-reported data are also prone to large social desirability biases, with workers often over-reporting or under-reporting the amount of time they spend on clinical tasks (Bratt, et al. ).