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Abstract

The development of community-based health information systems is a constant challenge for any national health system wishing to implement information technology in health care. The challenge is further heightened by the high failure rates of 70-80% in information systems projects. The development of a Community Based Child Injury Surveillance System in a local government unit in Metro Manila offers lessons that spurred the project proponents to alter the course of the systems development to a more favorable but challenging outcome, that of creating a system that responds to actual end-user needs and organizational requirements and creates value at the level of data collection. Two key communications technologies are used: Internet technologies (specifically the web) and GSM short messaging system.

With the emergence of low cost computers and the increasing awareness of health professionals on the value of electronic health information, it is now possible to collect community-based health data using information and communications technology. This project aimed to create a data collection system using short messaging service over cellphones but along the way, shifted strategies to accommodate constraints in economics (cost of sending messages) and long-observed organizational policies (only government-run health centers can submit official health data). Using a combination of methods (immersion, systems analysis, rapid application development, grassroots-oriented training, and onsite technical assistance), the research team attempted to create a computer-based information system that served the needs of the health center facility primarily, and of public health officials secondarily. As the project nears its end, it has produced an extensible and customizable software engine for government health centers, a training program for data collectors (health center staff and community health workers), and has attracted the attention of the national health department and local government units as attested to by numerous requests for demonstration, for the project design, and for installation of the system in their own local health centers.

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1 Research Problem: A Flawed Health Information System

The basic rationale of the project when it started was to create a community-based health information system (in this case, for child injury) that works, and that is able to serve the local needs of the community primarily and of public health secondarily. The research team's premise was that as of the present, there is no effective health information system at the community level in the Philippines that also served the needs of public health officials.

Pasay City is a major local government unit in Metro Manila situated near Manila Bay. It has a population of 435,000 and includes 201 barangays, which are provided free public health service coverage by 13 health centers. The Pasay City Health Office's health information system is paper-based and manual. It starts with data collected by midwives assigned to particular villages and proceed to consolidation at higher levels (city/province to region) until it reaches the National Epidemiology Center at the Department of Health. Due to the manual and tedious nature of data collection and multi-level consolidation (using pencil and paper), the data collected are generally viewed as arithmetically incorrect. Thus the resulting reports are not taken seriously, even by the data collectors themselves. In the end, evidence-based decisions could not be made as the manual system could not provide a clear picture of how the health system is performing at the community level.

One major reason identified for this flawed health information system is the lack of capacity. Midwives assigned to collect health data do so as a matter of obedience and not because they understand the value of the data for their own community. In informal discussions, not a few of the midwives confessed to fabricating data just so they can meet the deadlines for reporting. Knowing that the data they themselves have submitted is inaccurate, it is understandable that they find no value to the reports generated by this manual information system. This in turn only serves to reinforce their habit of submitting incorrect data the next time; and the vicious cycle continues.

Another major reason for the flawed system is the sub-optimal use of technology. Although many health centers have computers, their use of ICT is only for word processing and simple spreadsheet applications.

2 Research Findings

2.1 Situational Analysis

During systems analysis and development entailing countless hours of interaction with community health workers and health center staff, it became more apparent that the project as proposed will not realistically address the needs of end-users and decision-makers on the ground. The following findings will provide the rationale for altering the course of the project to respond to actual needs:

2.1.1 Incomplete Devolution of Health Care Services

The delivery of health care in the Philippines was devolved to local government units sometime in 1998 under the Health Sector Reform Agenda carried out by the Department of Health [HSRA]. In the course of the devolution, not much attention was paid to devolving health information systems as well for enabling local governments to carry out data collection, integration and presentation in a seamless, distributed and coordinated manner. This led to the deterioration of data collection, information processing activities, data quality and reliability at all levels of the health system, particularly at the grassroots. As a result, local government units were left to find ways on their own to make health information systems a reality in their domains

2.1.2 The Tyranny of Vertical Program

Because of the ever present need to create coherent ways of collecting and analyzing data to generate measures of performance, national vertical health programs, each with its own set of logbooks and reporting protocols are created and implemented at different levels of the public health system nationwide. The vertical programs, which include among others, Child Care and Development, Maternal Care, the National TB Program, Family Planning, and the Expanded Program for Immunization, receive aggregated data for analysis, most often in paper format from lower level organizational units. At the health center level, vertical programs utilize numerous log books as data collection tools. Depending on the number of vertical programs present, the number of logbooks to be filled by health center staff will vary but the time-consuming task of filling out the logbooks with repeating information can take an enormous amount of time, sometimes half a day (depending on the patient load of the health center), that can otherwise be devoted to delivering care. And the health workers still have to contend with creating numerous weekly, monthly, quarterly and annual reports derived from the vertical program logbooks, in addition to writing down the logbook entries.

If the authors implemented the original project as proposed, the time-consuming data processing activities that vertical health programs require will overshadow and overwhelm the activities required to carry out SMS data collection and still leave the end users short-changed because of the situational context created by vertical programs.

2.1.3 Health Workers are Not Worker Ants

In the health centers studied and from interviews with health workers (including those from outside Pasay City), utilization of data at the level of their collection is more of the exception than the rule. Like worker ants collecting food, health workers at the community level dutifully and laboriously collect data and write them down in the logbooks. The authors subsequently observe that this practice promotes ?data manufacturing?1 and loss of data integrity, since no subsequent and intrinsic validation is done by using the data for decision making at that

level. This situation can only be obviated through adoption of capacity enhancing measures together with the building up of an appropriate outlook among health workers towards data quality. The collection of huge amounts of health data without feedback to the collectors seems to be the practice not only in the Philippines but in other settings as well, where there are

2.3 Health Workforce Export
Health worker migration to foreign shores (labor export) potentially compromises the quality of health service delivery including data processing and decision-making. As the authors conducted their interviews of physicians running the different health centers in Pasay, more than half have begun preparations for working as nurses abroad. This left the authors with very little choice over which health centers to select as pilot areas. Data collection still leaves the end users short-changed because of the situational context created by vertical programs. It was apparent that an out-of-the-box solution was required. An article in the WHO Weekly Epidemiological Record describes the similar practice of using national vertical programs in other countries [WER].

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2.2 Shifting Course

The original idea was to improve collection at the community level by allowing community health volunteers (called barangay health workers or BHWs in the Philippines) to submit child injury data through short messaging service over cellular networks. This was based on the assumption that BHWs were organic to the communities where majority of child injuries occur. The hypothesis was that once the data is in electronic form, consolidation would then be essentially an automated process and would result in more accurate and timely reports that are useful to the community and to the public health experts. A prototype of this SMS application was quickly created and beta tested with mixed results for the following reasons:

1. Not all BHWs had access to cellphones. This would create significant gaps in the data collection.
2. Among those with cellphones, the BHWs had varying skills in crafting and remembering the standard syntax for reporting (eg., INJ JOSE RIZAL,

4,M,11-04-2004,1345,at home, fell from stairs). But this was assessed to be minor and could be later addressed through capacity-building.

3. Although the SMS application was able to accept submissions and insert to a database, there were valid questions on sustainability as to who will pay for the messages later on when the project's funding has ended.
4. Lastly, upon consultation with the city health office, the research team learned that data submitted by BHWs are not recognized as official by the local government and cannot be accepted for formal analysis.

Based on the above findings, it was decided that the project had to work with officially acceptable data and that the target end users had to be shifted to the staff manning the health center.

3 Fulfillment of Objectives

3.1 General objective

3.1.1 **To determine the feasibility of establishing a community-based child injury surveillance system using mobile phone technology and people-centric strategies**

Due to the reasons stated in the previous two sections, this objective was shifted to the *development of a computer-based information system for health centers using people-centric strategies*.

3.2 Specific objectives

3.2.1 **Design and develop SMS-based data collection system using open source tools (modified)**

The project shifted to the *design and development of an extensible and customizable computer-based information system for the health center level using open source tools*. This is in recognition that the health center is the most strategic location for organizing the health data of the community. As of the date of this report, this computer-based health information system is 95% finished and is already being used in two health centers. Four other local government units have expressed interest in the system and has requested for training and installation.

3.2.2 **Design and develop professional training program for community health workers (achieved)**

The training programs have been delivered and has helped tremendously in migrating the health center staff to the new technology. As of the date of this report, five training sessions have been conducted (2 for community health volunteers [during the first part of the project], and 2 for health center staff).

Numerous one-on-one end user training has also been conducted since the system was first deployed on the fourth month.

Training materials for the administrator of the computer-based health information system were also developed.

3.2.3 Engage community in child injury prevention activities (unmet)

In the earlier part of the project, community health volunteers were oriented on how they can interface with the health center information system. The community health volunteers will be tasked to remind patients in their catchment area for their follow-up in the health center for immunization, maternal care, family planning or anti-tuberculosis treatment. This information, previously unavailable with the manual system, can be generated by the computerized system. However due to the shift in strategy from community to health center, this objective of engaging the community in child injury prevention activities has not been achieved in significant levels. This is because most of the interventions on the latter part of the project were at the health center level where opportunities for community-based prevention activities are less.

3.2.4 Promote use of open source for use in health applications (added and ongoing)

One of the fundamental principles of the project was the development of an application that would be freely available to other developers and users. The open source phenomenon is just beginning to gain ground in the Philippines and the research team feels that making software for health open source would result to better applications and systems.

4 Project design and implementation

4.1 Systems development (ongoing since first day of project)

4.1.1 Rapid Application Development of Computer-based Information System for the Health Center

This component involved the standard systems development lifecycle: project initiation, systems analysis, systems design, software development, testing, and maintenance. It commenced on the first day of the project and is now in the maintenance phase. Some modifications applied to this process were:

1. Rapid application development onsite with quick response to end user comments. The system was designed together with the staff of health center 1. This provided ownership of the application among the staff themselves thus strengthening their stake on the project.

2. Modular design of software allowed addition of features without affecting other modules.
3. Early response to the reportorial needs of the staff enable them to immediately see the benefits of automation. This was important to convince them that the initial difficulties in migrating from manual to computerized systems was worth the effort.

The investigators decided a computerized patient transaction system was needed at the health center level that was responsive to the need of the center but was also flexible enough to be customized as needed by the staff. The software is open source and is released under the General Public License (GPL) to allow as many developers to contribute to the source code. The application will be modular so that features may be added to the application on a case-to-case basis depending on the capability of the local staff to use the new module.

4.2 Training (ongoing since third month of project)

4.2.1 Introduction to Health Information Systems for Community Health Volunteers (2 weeks preparation, 1 day implementation)

This involved initial focused group discussions to assess training needs and level of education. This was followed by research on various structured learning exercises (SLEs) on how to instill new knowledge about health information systems and skills on how to collect data of good quality. A very simple one-page hand-out with easy to remember acronyms and slogans was given to participants. This was offered during the first month of the project.

4.2.2 Introduction to Health Information System for Health Center Staff (2 weeks preparation, 1 day implementation)

The same as the previous item with additional orientation on computer systems and migration issues like initial difficulties. This was followed by regular one-on-one assistance onsite by members of the research team to address technical issues. Request for changes were also attended to during these one-n-one support visits. These were offered beginning on the fifth month (site 1) and the seventh month (site 2) of the project.

4.2.3 Basic Computer Literacy through Computer Games (2 weeks implementation)

A period when the health center staff members were asked to play the games in the computer to familiarize themselves with the components of the computer and to allay their fears of technology. This strategy served several purposes:

1. gradual exposure to hardware and software through non-stressful applications

2. non-threatening introduction to the electronic environment that is enjoyable and fun
3. testing of the network and the operating system with regards to reliability and robustness

This particular strategy was implemented on the seventh month of the project for site 2.

4.3 Promotion and advocacy of open source and data quality (since 2nd month of project)

Members of the reserch team has been invited to talk about the project and other software developed by the unit and has taken each opportunity to inform the audience about this project and about open source method of application development.

1. Tolentino: “Public Health Informatics: Appropriate Technologies for Developing Countries”, Asia Pacific Medical Informatics Association Annual Conference, 6-9 April 2004, Kuala Lumpur, Malaysia
2. Marcelo A: “Community-based Health Information Tracking System (CHITS), a health information management tool for health centers”, 13th AMIC Annual Conference “ICT and Media Inputs and developments Outcomes: Impact of New and Old Media on development in Asia”, 1-3 July 2004, Bangkok, Thailand.
3. Maramba: “Why Health Applications Must Be Open Source”, Philippine Open Source Conference, Manila, 19 August 2004, EDSA Shangrila Hotel, Manila
4. Marcelo A: “The Critical Role of Open Source in the Philippine National Health Information Infrastructure”, Philippine Open Source Conference, 19 August 2004, EDSA Shangrila Hotel, Manila
5. Marcelo A: “Design and IMplementaiton of the Integrated Surgical Information System”, Inter-departmental Grand Rounds, UP College of Medicine, 5 October 2004, Ermita, Manila
6. Marcelo A, Maramba: “Oreintation on the Philippine National Health Information Infrastructure”, to the Secretary of Health Dr. Manuel M. Dayrit, 4 October 2004, Sta Cruz, Manila
7. Tolentino, Marcelo A, Maramba: “Design and Implementation of an Open Source Prototype Telephony and Web-based Critical Event Reporting System for Continuous Quality Improvement Program in Anesthesiology”, Medinfo 2004 Conference, 7-11 September 2004, San Francisco, USA

8. Marcelo A, Tolentino: “A Community-based Chld Injury Surveillance System: A Rapid Data Collection System Using Short MESSaging System (SMS)”, poster presentation, 7th World Conference on Injury Prevention and Safety Promotion (Safety2004), 6-9 June 2004, , Vienna, Austria
9. Marcelo A: Presentation of the computer-based health center information system to the Marikina City Health Office, 18 September 2004, Marikina City

4.4 THE CHOSEN APPROACH

About 70-80% of information systems projects worldwide end up as failures [Heeks]. Facing the possibility of implementing a project that looks feasible and innovative on paper but will never be used, the authors decided to address each problem above from the health informatics perspective and make a radical decision to expand project scope to include not only the development of a child injury surveillance system but also the conversion of paper-based vertical programs into a rationalized and unified information system through horizontal integration. For this project, two health centers in the Pasay City local government unit were selected: (1) the Malibay Health Center, a very busy health center or with a heavy patient load, and (2) the Lagrosa Health Center, with light to moderate patient load.

4.4.1 Ethnographic Investigation

The project team anticipated difficulty in ascertaining the actual information culture at the health center from interviews alone. Together with incremental software development (see below), the project director, trainers and key software development staff spent 6 weeks of working with the health center staff to acculturate themselves with the health center information culture. It also allowed the building of relationships and an environment of mutual trust, in which a lot more information was extracted from the health center workers, not just in terms of information system processes, but also in terms of attitudes and culturally bound practices. An insight into the aspirations of health center staff allowed the project team to carefully craft a multi-level curriculum for capacity building geared towards empowerment and building of self-esteem. Lunch time (group) and individualized encounters of project team members with the health center staff also provided a non-threatening environment and teachable moments for health center staff to absorb nuggets of informatics knowledge and principles.

4.4.2 Capacity Building: Two Carrots and a Stick

The project team incorporated capacity building to present a benevolent face to potential and obstinate change management areas, such as data quality and bad data habits. The free health information system (as carrot #1, and described below) together with formal (certificate) and informal training (carrot

#2) provide a compelling combination of empowering tools to enable the health center to have buy-in and eventually a competency-based stake in the project. The capacity building activities come in two forms: formal and informal.

Formal capacity building includes certificate and competency-based training courses at different levels (from Barangay Health Worker to health center staff to the central health organization in the local government unit). Informal capacity building includes nuggets of health informatics knowledge distributed as the need arises, during lunch time conversations and briefings. Figure 1 shows some scenes from the first Barangay Health Workers Information Systems Training. Conceptually, the training courses involve building up health information systems management capabilities in the respective domains of the health workers, whether it is at the barangay health center or at the city health office.

4.4.3 Spiral Model and Modular Software Development

Initial interviews at the City Health Office revealed an attempt to create a few electronic systems for surveillance. In one of these attempts, the system was not deployed fully because there was no training and orientation of end-users and the computers were pulled out after the data encoding was completed. To avoid the same mishap from happening, the authors incorporated capacity building into the project and adopted the spiral software development model [Clements], a tedious and iterative, but participatory model, and introduced an object-oriented approach to the development of modular software components using a modular software architecture (see below). Each software component (data model, work flow and user interface) goes through several iterations of model validation and user testing. After 5 to 6 iterations (database model validation, user interface testing and work flow optimization), a parallel run is conducted to find out how the component behaves in actual use, in comparison to the paper-based system.

In this setting, the gold standard (and competition) is the paper-based system. If the health center staff, would eventually and willingly leave their paper-based system, the project team would take it to mean that the new electronic system will have generated enough momentum to push the move from paper to digital format. As of this writing, the system has been implemented at the Lagrosa Health Center, and the health center staff have stopped using the paper forms for clinical consults. Implementation at the Malibay Health Center is being held back until most of the systems development issues at Lagrosa Health Center have been resolved and all key software modules have been tested.

4.4.4 Software as an Agent of Change

Change management was approached from a variety of angles. One of the creative ways this was carried out was through the principle of using software as an agent of change (proactive). This concept is a complete reversal of the traditional situation where change is managed because software introduces changes (reactive).

Using this method, the project team introduced, in a controlled manner, critical points of change in various aspects of health center operations where end users are presented with opportunities for enlightenment about certain issues. As an example, the amount of involvement of Barangay Health Workers has been traditionally minimal in health center operations. With the software introducing points of change in (1) electronic data collection and (2) proactive patient management (a known gap) that will eventually strengthen health center coverage of its constituents, but would require more BHW contribution to the effort, the health center staff eventually acknowledged that the health center information system would need BHW involvement to strengthen its programs.

4.4.5 The GAME Engine and CHITS

Out of the need for a modular approach was born the GAME Engine [sourceforge], short for Generic Architecture for a Modular Enterprise, that allows the reuse of software code in other software development projects¹. This software architecture was developed for use by a number of projects being carried out by the Medical Informatics Unit. Since the project was reoriented towards developing a full information system, the benefits of rapid applications development that the GAME engine provides is a welcome development in the face of local IT manpower constraints. The use of the GAME Engine entails using the application's data model as the foundation for creation of software modules. Essentially, two types of data models are used: the GAME Engine internal data model and the health center (CHITS) data model.

Using the GAME Engine, software development is currently being done on a modular basis, avoiding global and potentially catastrophic and time-consuming changes to monolithic code and database structure, and strictly enforces both module independence and dependence, and system security and authentication. This approach also enables implementation of completed modules without waiting for the rest of the application to be completed.

The Child Injury Surveillance Surveillance System, now renamed Community Health Information Tracking Systems, or CHITS, is currently composed of close to 40 software components together with lookup data libraries. It includes ICD10 Diagnosis Coding with its own search engine, and the majority of modules was developed within a span of 3 months of intense software development activity. The Child Injury Surveillance Module is now part of the this bigger application and is appropriately integrated into the big picture at the community level. This change in the project specification also effectively increases the contribution of the Medical Informatics Unit and the University of the Philippines in the overall funding picture. The original SMS portion of the project has been expanded to include clinical reminders which serves several modules. The module, Clinical Reminders, enables health center staff to send SMS messages generated from system templates to patients for followup and medication intake reminders. This appears to have greatest impact in three modules: Child Care for vaccination followups, Maternal Care for prenatal followups and anti-tetanus vaccinations and the National TB Program for the DOTS treatment protocol.

The original proposal called for an SMS-based data collection system. This is still under intense study because of feasibility and sustainability issues.

The GAME Engine modules are both functionally designed to be self-contained and reusable with very minimal modifications. Since the GAME Engine is web-based, hardware requirements are not too exacting and modules are uploaded as files and automatically incorporated into the system. The modules (and also their upgrades) are distributed in compressed format (GZIP) so that they can be easily passed around in 3.5 floppies. The CHITS application currently runs in an intranet environment with a Pentium 4 class server and 3 scaled down Pentium 4 workstations. Although it runs in an intranet environment, it has also been designed with stubs to incorporate source code for running in a distributed network (to link health centers together) to enable data interchange between health centers using ordinary dial-up connections and XML-based web services using SOAP3.

4.4.6 Use of Open Source Software

The software development tools used in this project belong the open source genre [OPENSOURCE]. Software developers and advocates of tools in this category espouse making source code available together with the application itself. In the health care domain, this paradigm promotes transparency and peer review of health information systems. It also allows for equitable use of scarce and potentially costly information processing resources, including software in health information systems.

To help reduce implementation cost and maintenance, the Linux Operating System (Debian [DEBIAN] distribution) running the KDE desktop was selected. Since Linux is known for its stability and security and there are fewer computer viruses for this platform [Granneman], this would potentially reduce technical support calls and system downtime. The engine uses MySQL, a very popular open source database and implements tables using InnoDB for transactions and referential integrity. The software is actually written in PHP [PHP] and makes extensive use of previously published open source code libraries like JPGRAPH [JPGRAPH] for object-oriented graph display and FPDF [FPDF], a PDF-generation engine for creating the summary reports.

To put the software in the public domain, particularly the GAME Engine, the Medical Informatics Unit set up a Sourceforge web site, a popular repository of open source software. This was done to open up the source code to and invite interested developers worldwide to participate in the software development project aside from being able to use it themselves. In anticipation of multilingual (global) and multi-dialect (local) use, the authors incorporated a multi-lingualization engine used in a previous open source disease surveillance system project which was developed for the Mekong Basin Disease Surveillance Project [MBDS].

4.4.7 Horizontal Integration of Vertical Programs

The CHITS project presents an opportunity to solve the dis-integration of vertical programs' paper-based information systems at the community level (health center). Health information systems are deemed complete when they perform the three critical activities (collection, integration and presentation) within one level to enable the end-users to see the whole spectrum of data transformation. The vertical programs, after analysis by the project team, revealed thoughtful and logical implementation on paper with their individual data models mimicking the electronic one, purely and possibly from numerous iterations during implementation. However, their individual data models disregarded the existence of the other vertical programs and created information system islands. The approach taken here was to integrate the different data models into one and present a unified interface and report generation tools to the end-user.

4.4.8 Real Time Output Display

To address issues in data quality, the end users were given strategies in integrating software outputs into their decision making. The software also enables them to see graphs and reports as data is generated in real time. From various discussions over time, the health center staff involved in software development began to see the value of having instantaneous access to health information and even proposed new performance measures to enable them to deliver quality service. Upon further realizing that the computer can aide in numerous calculations, the health center staff began proposing innovations to help them deal with repetitive, redundant or time-consuming tasks through automation. Among these suggestions include date projections for TB therapy for projecting sputum exam dates and setting appointments so the staff will know patients who are supposed to follow up for certain appointment codes everyday. Through this innovation, the health center staff can also determine follow up behavior of specific patients.

4.4.9 Decentralization

To avoid creating a physician-centric health information system, the authors created a system that enables all staff members in the health center (from admissions to laboratory) to contribute to building up the database and maintaining the information system in a distributed manner. In the first pilot health center, a nurse readily serves as a system administrator and creates accounts and assigns permissions for the rest of the staff. He also teaches the staff how to log in and use the different modules of the system (effectively duplicating what the health center physician can do). The bayanihan concept of doing work in consolidating patient data slowly became evident as systematic data entry utilizing the different interfaces for the different modules. The Filipino custom called bayanihan involves sharing the workload in a given task such that village folk can move a whole bamboo and nipa house by carrying the house together (Figure 4).

4.5 INTERESTING DEVELOPMENTS

4.5.1 Personal Realizations

Personal realizations about data quality often came out of lunch time conversations. For example, reporting of prenatal home visits appeared to be manufactured based on need. It is also interesting to note that the end-users themselves verbally express that it will be very hard to cheat when everything is computerized as (1) the system keeps record of who did data entry for a specific module and (2) they do not have access to the raw data in the database.

An interesting outcome is that during one vaccination day (the third parallel testing for the Child Care Module), the mean consult time for each patient was 29 minutes per patient per consult, 1 minute less than the health ministry standard of 30 minutes per patient per consult (a criteria for being included in a quality circle by the Ministry of Health). Given that the end users have not even become proficient with the mouse and the keyboard, and considering that the system is being loaded with new patients, this appears to be a very positive outcome. Succeeding trial runs also enabled them to see the effect of understaffing on consult times (less staff available, longer consult times).

In the course of their exposure to the CHITS application, the staff gained a certain level of confidence to propose innovations to the application, as the project team noted (1) increasing numbers of inputs and suggestions for system improvements (including health center process innovations), and (2) requests for new useful features. Their proposed innovations included among others, the passing of SMS credits from patients (who will be sent clinical reminders) to the health center SMS server¹.

Personal realizations which the Medical Informatics Unit was able to elicit are not totally confined to health center information processing issues alone. Sometimes, more personal ones at the level of personal meaning, mission and vision come up and give the authors insight into motivating factors that can potentially affect project outcome and sustainability. The project team delved into this realm to determine the match between the end-users mental model (inclusive of personal and organizational factors) of their environment and the applications conceptual model [Heeks]. Although Heeks argues that things will not change if the information system were to exactly match the environment, the authors put forth the argument that the software itself can be an agent of change using implicit, camouflaged processes. This strategy, however, still needs to be refined and validated in other deployments of CHITS.

4.5.2 Emerging Partnerships

As the authors were developing the module for the National TB Program, one of the vertical programs implemented at the health center level, the Philippine Coalition Against TB (PhilCAT), learned about the application and signified its interest to take part in the development process for the Directly Observed Therapy Short-Course (DOTS) for tuberculosis eradication. This emerging partnership is set in the local background of a dearth of information systems to aid in

the efficient local implementation of DOTS. In a related development, a Rotary Club chapter, working with PhilCAT, also signified its intention to adopt CHITS (particularly the National TB Program module) for implementation in health centers in a neighboring city (south of Manila) for its Anti-TB project. They intend to cover training and hardware installation expenses. The local government health office of another progressive city east of Manila, also signified their intention to become a pilot area for implementation. These developments bring to the fore one of the significant issues below that of training, technical support and maintenance.

The Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (a government agency) [ASTI] developed a device that incorporates a GSM modem in computer PCI form factor. When the technical developers of the device learned of the full implementation of CHITS, ASTI decided to lend the device for testing in the pilot health center to enable the authors to test it for sending clinical reminders by SMS.

Between July and August, two demonstration sessions were conducted for the city health offices of two other neighboring cities (Paranaque and Marikina). Clearly, more partnerships are emerging and a need for formalizing internal city level project funding has to be put in place for each locality wishing to adopt the system.

4.5.3 The Last Mile for TB Information

In a radical departure from health center tradition, the developers created an interface for Barangay Health Workers (community health workers), who act as treatment partners for TB patients in the community, to be able to enter drug intake data using the health center workstations. To support this activity, the authors developed a two-level certification course for health information management specifically for BHWs. The Level 1 training deals with data quality concepts and roles in the bigger organization. Level 2 training deals with personal record management so that when data is to be merged, there will be some level of standardization that will enable data integration with the CHITS application. Their participation in the health center information system potentially qualifies them for a level 3 certification, working with various health center modules requiring data coming from the community (surveillance and others). What the project team aim to develop using this strategy is a sense of professionalization among the health center staff that their increase in knowledge and skills be recognized as a formal career advancement.

4.5.4 Research Opportunities

The CHITS database offers numerous opportunities for community based health research providing an alternative venue for clinical research. This also provides the Medical Informatics Unit with an opportunity to link community based information systems (primary care) with hospital based information systems (tertiary care) by making patient information digital and portable. One scenario

the project team foresees is a patient coming from the health center bringing his personal health information record in a diskette to the hospital when he goes there for a tertiary care referral. This is similar to one of the models described by Rigby, where patients hold on to a copy of their record [Rigby]. The hospital information system, using the same engine and compatible software, reads the XML-based patient information off the disk into their databases. With this potential data integration within reach, the information system boundaries between levels of health care delivery will be blurred. The developers have already incorporated code for unique patient ID generation to prepare for secure health information exchange among health centers.

4.6 SOFTWARE DEVELOPMENT ISSUES

4.6.1 Privacy and Confidentiality

Since electronic records offer efficiency and seamless integration, it can also enable efficient and seamless access for breaching patient privacy and confidentiality with the same level of efficiency and speed. This is the reason the application is set up as an intranet (not connected to the Internet) with appropriate security measures incorporated in the system (e.g., password authentication).

4.6.2 Technical Issues

The use of the mouse and keyboard initially appeared to be a daunting obstacle to efficient use of the system. A creative approach using computer games was employed to enable health center staff to gain proficiency in using these input devices while having fun during their free time. The use of Linux as the operating system with the KDE desktop apparently did not deter the staff from using the system. As a control, the Medical Informatics Unit left one computer running Windows XP, and the authors observed no apparent show of bias towards any operating system. Hardware issues that can potentially add to end-user frustration include loose power outlets, and loose network cable connectors. Improperly installed Linux workstations can also add to end-user frustration as observed in a few instances when one (out of 3) workstation consistently failed to launch the graphical user interface (KDE desktop) and show the unfriendly root prompt.

4.6.3 Organizational Issues

The transition from paper-based system to electronic records provided the health center staff with an opportunity to re-examine their procedures. The seamless and integrated access to records encouraged the health center staff to use the system and learn about it more. Since the best training methodology could not be determined earlier, the authors proceeded to carry out modular testing and training together. The subsequent parallel runs eventually resulted in less technical queries from the staff to the Medical Informatics Unit, an indication of

deepening understanding of how the system works. This decision to go modular in training the staff proved to be the best choice in the end.

4.6.4 Training, Technical Support and Maintenance

The observation that end users can become effective trainers themselves potentially offers an empowering solution to training staff from other health centers. Monetary remuneration that can be obtained from training others also provides the authors with a sustainable way of propagating the necessary skills and creating a community of users who know how to manage the system. This potential development can relieve the Medical Informatics Unit of the burden of technical support by empowering a user community to help one another in open source fashion.

The system implementation was also carried out in piece-meal fashion before deployment in the other high-volume health center (Malibay). This is to ensure that most physical network and hardware issues have been identified, most bugs have been unearthed and most system functionality is already available. The modular training approach also still needs to be refined, as the authors employ the write-as-we-go method for training module development.

5 Project outputs and dissemination

The following are considered outputs of the project

5.1 Information sharing:

5.1.1 Presentations of computer-based system to other interested local health centers

These are response to requests from other local government units for a demonstration of the computer-based system. One has indicated interest in deploying the system in their city health office (Marikina). This is now in the final phase of the memorandum of agreement draft.

5.1.2 Presentation of computer-based system to the Secretary of Health

The Secretary of Health Manuel M. Dayrit has shown interest in supporting the initiative of the development of the Philippine National Health Information Infrastructure (PNHII). The computer-based system will be a demonstration project of the PNHII.

5.1.3 Presentation of computer-based system to various agencies

The conference in Bangkok allowed the research team to present their initial findings to other teams and share experiences and ideas.

5.2 Knowledge creation:

5.2.1 Software for the Computer-based Information System for Health Centers:

A set of PHP scripts and MySQL dumps already available at the Sourceforge.net website. Search term is 'game-engine'. The software may be downloaded and installed in other servers for free. There is documentation embedded within the application.

5.2.2 Curriculum for introducing the concept of health information systems

A tested training design that introduces the concept of health information systems and the value of collecting data of good quality. Participants evaluation of the sessions have been overwhelmingly positive.

5.2.3 Administrators' Manual

These are documents that provide instructions to persons who will administer the computer-based system within each site/health center.

5.3 Training

5.3.1 Training program: Introduction to Health Information Systems for Community Health Workers

Attended by community health volunteers to get an orientation of how important health information is for the community

5.3.2 Training program: Introduction to Health Information Systems for Health Center Staff

Attended by staff of the health center to make them understand the value of an accurate and timely health information system

5.3.3 Lecture-demo: Students of the Masters in Family and Community Medicine of the UP College of Medicine

Graudate students from the UP College of Medicine had their lecture on health information systems conducted onsite at health center 1.

5.3.4 Lecture-demo of the system to visitors from WHO and CDC

Dr. Tippavan Nagachinta from the Divison of International Health, Centers for Disease Prevention and Control, and another WHO personnel was able to view the software in action.

5.3.5 Lecture-demo of the system to the Marikina City Health office

This has resulted in the drafting of a memorandum of agreement to install the system in Marikina and conduct training there.

5.3.6 Lecture-demo of the system to the National Epidemiology Center

The staff of the NEC viewed the computer-based system and is considering funding an evaluation of the system.

6 Capacity building

The project has been able to build up the research institution by:

1. exposing the staff to the methods and procedures of large international granting agencies;
2. affirming open source as a fundamental philosophy in software development for health;
3. providing infrastructure (workstations) for developing software;
4. and, providing exposure and hands on experience on internationally accepted financial reporting and accounting.

7 Project management

7.1 Administration

Because of the transition on project management from Dr. Tolentino to Dr. Marcelo midway into implementation, delays were experienced in reporting. Endorsements had to be made and Dr. Marcelo had to feel his way into the details of the project causing some delay in producing the required reports. However, all other components of the project like trainings and software development proceeded as usual in the two pilot sites and milestones were delivered on time.

7.2 Scientific management

A significant shift in strategy was made early in the project implementation because of the realizations about the need to shift focus from community health workers to the the health center staff (see section on Research Findings).

7.3 Technical

An evaluation of the project needs to be made at the end of the project to assess whether it was successful or if revisions may be necessary before implementing the system in other sites. Due to the increasing demand on the system however, this evaluation needs to be done as soon as possible.

8 Impact

1. The clear impact of the computer-based system from the development perspective is the possibility of documenting a citizen's health status and needs within a clear auditable application. This essentially puts that citizen into the radar screen of health services and forces the system to respond to his/her needs in a comprehensive manner. In a country currently in fiscal crisis, it is easy for the marginalized to fall off the cracks if the health information system do not catch them and their needs effectively. A computer-based system is a first important step towards documenting and acknowledging the needs of these marginalized poor.
2. There is a common belief that midwives do not have the educational background or ability to learn how to use computers. This project has shown that with adequate preparation and innovative strategies, midwives can learn to use web-based applications and gain aptitude fairly quick.
3. Open source as a development method for health application may now become the norm. This will result in several benefits:
 - Better quality through transparency. The algorithms and formulas are exposed and therefore errors are detected early before dangerous outcomes are experienced by actual patients.
 - Collaborative development. This allows more people to work on the application and develop more features in less time.
 - Lower costs. Since the tools used for development are free themselves, costs may now be redirected to other areas like peopleware (developers/training of end users) where resources are most needed.

9 Overall Assessment

The project, as modified, has shown to be extremely strategic in the development of the field of health informatics in the Philippines. The project has accorded to the research organization a deep understanding of the value of accurate and timely documentation of health in upholding the rights of the marginalized. Where there is no documentation of need, there will be no resources allocated. What began as simply a technology project has gone beyond just software development but also into community organization, immersion, and human rights awareness.

10 Recommendations

To come full circle, a full evaluation of the project (preferably external) and its components must be made. Efforts must be made to make this evaluation happen.

Once the evaluation is in, promotion of the project output may now be made to interested local government units. Now that bandwidth costs have gone down considerably, there is an increased demand from local government units to systematize their operations, and this includes delivery of health services. The project is a big step towards addressing this need on a wider scale, possible even national.

Establish other systems based on the 'game engine' as a proof of concept of its extensibility. At the core of the computer-based system is the generic architecture for modular enterprise. It is possible to use this system for other purposes like real property tax, community tax, etc. It has the potential to integrate the information needs of a local government unit.

Participation of the project into the Philippine National Health Information Infrastructure as a demonstration project. Because of the experience of the project with real-life problems in health centers, it can be a prototype system for government health centers in the near future.

10.1 CONCLUSION

Developing a community based health information system is a challenging task, closely approximating the level of difficulty found in the development of esoteric clinical information systems. By paying close attention to health center events and using purposeful immersion in the end-user's way of life, the authors were able to gain immense insight into their needs and requirements and apply these insights into software code, a process we can call evolutionary software development [Clements].

The authors were originally leaning towards a technology-centric implementation of an information system. With deeper analysis and understanding of the needs and requirements of end users, the authors were able to put technology in its place to serve the genuine needs of community health workers.

The majority if not all of the technology used in this project come from the Internet and are used to run the Internet. Being mature and stable open source technologies, with huge user populations, leveraging these technologies offer extreme value at the lowest cost and have been tested under extremely grueling conditions. With the use of GSM SMS in the Philippines as a very popular messaging system with wide user penetration in the general population, the two key technologies make for a formidable combination with popular support in this project.

Computers are magnificent tools for the realization of our dreams,
but no machine can replace the human spark of spirit, compassion,
love, and understanding. - Louis Gerstner, CEO, IBM

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