Blaya, Joaquin
HST.958J
Term Project Final Report
Presented May 3, 2005

Abstract

Partners In Health (PIH) currently implements an electronic medical record (EMR) system in Peru that provides a model and shows the need for a nation-wide system. It provides functions including maintaining patient records, prescription order entry system and viewing of images. Specifically in the collection and management of tuberculosis (TB) laboratory tests, PIH is working with the National Institute of Health (INS) to implement the PIH-EMR as a national TB laboratory system. However, the current process at PIH of collecting bacteriology test results needs improvement if it is to provide a model system.

This project sought to replace the current paper based system at PIH by using handheld technology and the current PIH-EMR. This entailed an in-depth analysis of the current work and information flow for bacteriology results within the government health system and PIH. A handheld tool was developed and implemented, with input from the users, to digitize the bacteriology results at the field sites and interface with a local database. The next steps in the include creating a reliable connection to the PIH-EMR server and data validation checks, as well as planning and performing a study to quantify the effects of the intervention.

Background

Tuberculosis Laboratory Tests

There are currently three lab tests performed for tuberculosis (TB) patients: Acid-fast bacillus (AFB) smears and cultures or drug sensitivity tests (DST) for first or second line TB medications. All tests can be performed on different sample types including feces, urine and cerebro-spinal fluid, though a sputum sample is by far the most common. The sample is collected and placed in a tube with a mucolytic agent such as N-acetyl cysteine to disrupt the thick, proteinaceous matrix included in respiratory secretions (Isenman, 2000).

A smear is performed by smearing a part of the pellet on a glass slide for fixation, staining and microscopic examination. This process can be done at all laboratories in Lima, and is mostly performed at the immediate health center where the patient has given their sputum sample. A smear result can be known within a single day though it is modestly less sensitive than culture because of a higher false negative rate.

A culture should then be performed on all samples, where bovine serum albumin is added to the pellet, it is suspended and placed in a growth medium for the slow growing *Mycobacterium tuberculosis*. The time to find out the result of this test can be from 25-60 days. All TB patients, and especially Multi-Drug Resistant TB (MDR-TB) patients, should have a monthly smear and culture performed.

Drug Sensitivity Tests (DST) are performed only for MDR-TB patients when they are beginning treatment in order to determine the appropriate medication regimen or if their treatment is failing in order to change their medication regimen. For this test, bovine serum albumin is added back to the pellet and equal aliquots are put on a plate with culture medium containing the different drugs and concentrations for which this *M. tuberculosis* strain is being tested. After 18-21 days in most cases visible colonies may be identified in the different sections. By comparing the number of colonies on a drug section with those on the control quadrant, the resistance of that strain may be estimated (Isenman, 2000).

PIH-EMR

A web-based electronic medical record system (PIH-EMR) was developed to manage the current multidrug-resistant tuberculosis (MDR-TB) patients in Peru (Fraser et al., 2002), model their medication requirements (Fraser et al., 2004) and provide clinical tools (Fraser et al., 2004). It has been able to provide many functions including: (1) an electronic patient registry to maintain patient information for over 2000 patients (2) a web-based nurse order entry system for TB medications that, in an initial evaluation, was shown to significantly drop error rates and had good user (nurse) satisfaction (Choi et al., 2004), and (3) a method for electronically maintaining chest X-rays. Further, a previous project provided a PDA to a single nurse to statically view the EMR system as a test of giving healthcare workers a low cost, portable system to view records (Yasin, Choi & Fraser, 2002), however, it had limited functionality in that only a few records could be viewed and there was no input method. The PIH-EMR also maintains all smear, culture and DST lab results for all of PIH patients. As such this system provides a model and displays the need for a nation-wide electronic laboratory result system.

However, the current methodology for collecting and recording bacteriology test results is extremely inefficient and error prone. There are three different tests for tuberculosis, smear, culture and drug sensitivity test (DST) usually done from a sputum sample. Within the government health system, a patient goes to a health center able to do a smear test. If a culture is required the sample is sent to a district laboratory and if a DST is required it is sent to the Instituto Nacional de Salud (INS [National Institute of Health]). The results from these tests are

compiled on a sheet of paper and sent back to each health center. Each of these institutions has access to internet connectivity and therefore if an EMR was in place, a system for digitization and communication of the bacteriology results could be developed to automate this process. This project will analyze the current information flow for this process and place a model system for collection and digitization of bacteriology results within PIH.

Workflow Information

Partners in Health (PIH) collects and stores tuberculosis bacteriology data for their 2000 MDR-TB patients (Choi et al., 2004) from over 90 health centers in the 11 reference laboratories of Lima, Peru. Since all PIH patients are treated through the public health system, the PIH Bacteriology (BK) team must visit all sites with an MDR-TB patient. Each patient should have a monthly smear and culture performed, therefore the team visits each site at least once a week.

At each site, the BK team records test results by hand on a paper sheet. This sheet is then brought to PIH headquarters where the information is recopied unto a permanent register; the register is photocopied and then entered into the EMR system. There are no patient identification numbers, therefore, during this digitization, the data entry person must manually select the patient by name.

Current Work Flow

There were two models of collecting information. A single site model, where the BK team is able to collect both the smear and culture information from the same regional laboratory and whose information flow appears in Figure 1. A dual site model, where the BK team collects the primary smear results from a local health center. They then collect the culture and secondary smear results from the regional laboratory. These secondary smear results are compared to those from the health center to ensure that the correct information was communicated between the institutions. The information flow for this can be seen in Figure 2 (a) and (b).

Since a smear result can be read in a single day, the full smear test information can be copied in one visit. For a culture, the initial information of that test (sample date & ID) is written down in the first lab visit. On subsequent lab visits, the lab register is scanned to see if the test has been read and if so, the result information (date of culture start, result and date it was read) is written down. This usually occurs 25-60 days after the initial information was written down.

Single Site Model

When the smear and culture tests were performed at the same laboratory, the BK team could go to that lab's register to hand copy record smear and culture results to a BK & Cultivo

Patient Tracking sheet. If the lab register was unavailable, they could also ask for the original physician's order to get the same information. As explained above, the smear result will be read in one lab visit, where it will take multiple lab visits to receive a culture result. Back in the office, each smear or culture is transcribed unto a PIH order identical to the physician's order used by the Ministry of Health (MINSA). In this process, the individual must look up the patient's health center in the PIH-EMR to place it in the order. From this order, a reduced set of information is hand copied to the patient's monthly tracking sheet for both smear and culture, after which the order is placed in the patient's clinical history file. From this monthly tracking sheet, the information is entered by hand into the PIH-EMR.

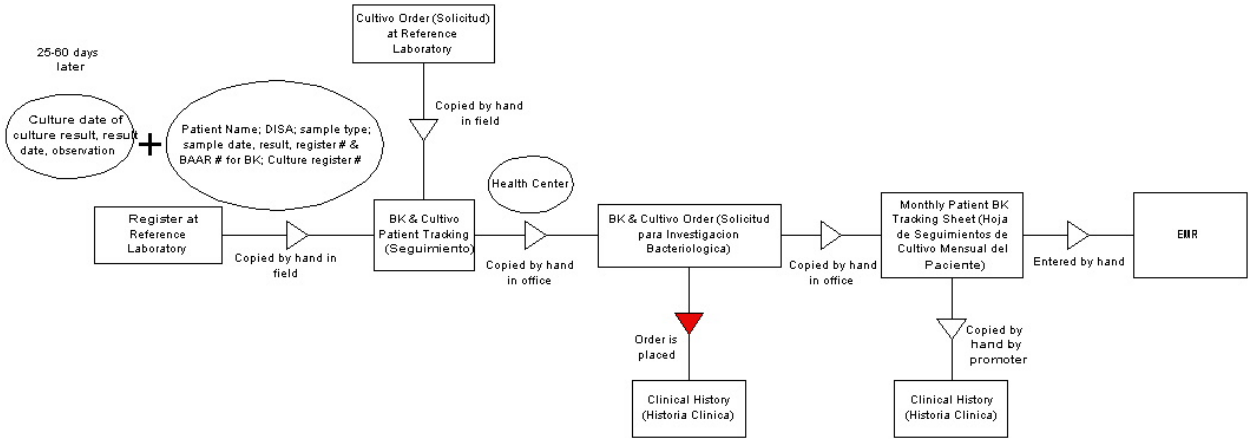


Figure 1 Current workflow for single site model

Dual Site Model

For the dual site model, the BK team first goes to the local health center's laboratory and copies the complete smear test information unto a smear patient tracking sheet. If the BK team does not have access to the lab register, they go directly to the clinic and ask to see the patient's clinical history. In the clinical history, they will copy the smear test information from the physician's order into a PIH order, thus bypassing the smear patient tracking sheet. Once back in the office, the same procedure as in the single site model occurs, where the information is hand copied to a PIH order, then a reduced set of information hand copied to the monthly patient tracking sheet and finally hand entered into the PIH-EMR.

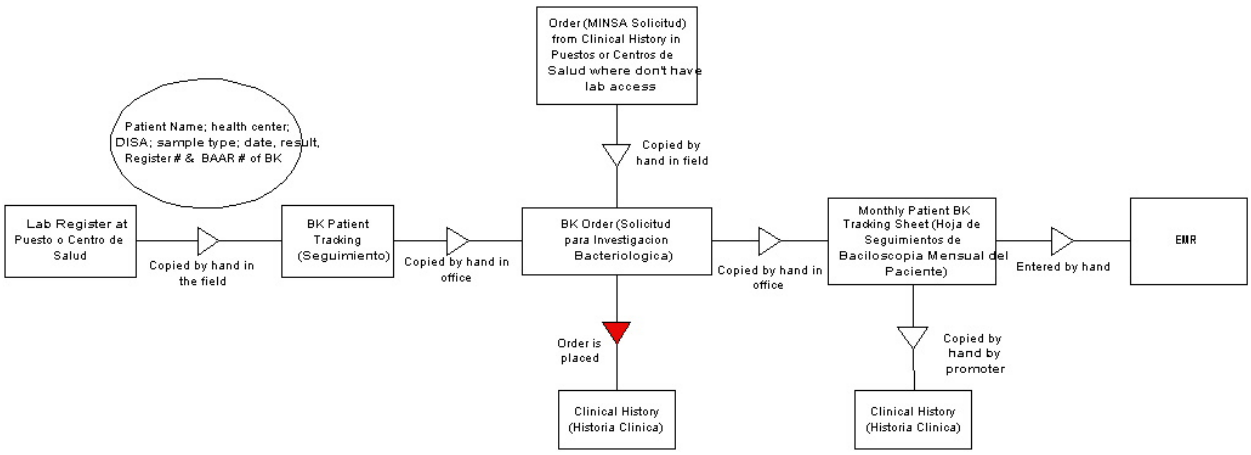


Figure 2 (a) Current workflow for dual site model: smear result

For culture results, the BK team usually goes to a DISA (Health District) or a Reference Laboratory. From the lab's register they will copy the initial culture information (sample date & ID). Afterwards, they will go to that culture's original order, which was sent by the health center, and write down a second copy of the smear result that was performed at the health center. This information will be checked against the original smear result from the health center to ensure that the information between the health center and reference lab is identical. As explained above, the initial culture information is read in the first lab visit, where it will take multiple lab visits to receive its result.

Back in the office the procedure is identical to that described previously where the information is hand copied to a PIH order, then a reduced set of information hand copied to the monthly patient tracking sheet and finally hand entered into the PIH-EMR. The one key difference is that the initial and secondary smear information received from the health center and reference laboratory, respectively, are checked to be identical. This is done either from the patient tracking sheets or the PIH orders.

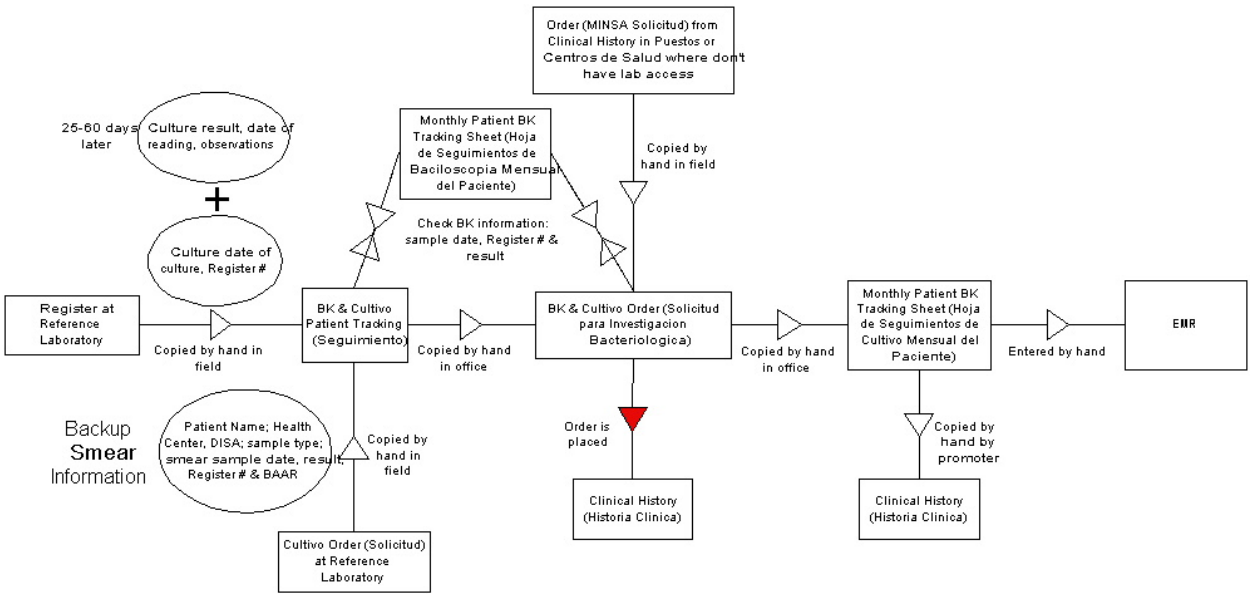


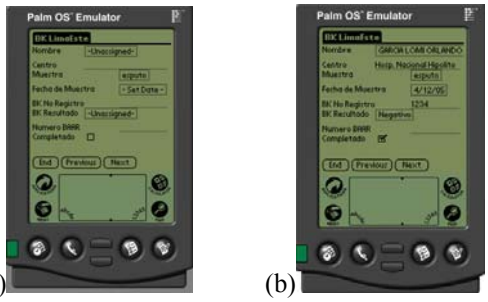
Figure 2 (b) Current workflow for dual site model: culture and secondary smear result

Currently, the entire process, from taking a sample to entering data into the PIH-EMR, takes 30-40 days, though the exact times for each task, points of inefficiency, and main sources of error are unknown. For example, recording results directly from DISA laboratory might decrease error rates and amount of time between taking of sample to entering data into EMR.

Proposed Work Flow

We conducted an intervention beginning in March 2005 to automate the collection of the bacteriology results for both the single and dual site models. With the new system, they will collect results in the field with a handheld computer (Palm Zire 31), during their daily sync the information is downloaded to the PIH-EMR from where they can review the data, as well as view and print the forms which were previously hand copied. For the single and dual site models the updated information flows can be seen in Figures 4 and 5, respectively.

In all the forms, the user chooses the patient by last name from an alphabetized lookup list. Once choosing the patient, their health district (DISA) and health center are automatically filled in with the values in the PIH-EMR. The rest of the form has the same information as the current paper-based and the same information sources are used. Examples of the formed, empty and filled in can be seen below in Figure 3.



(a) (b)
Figure 3 Handheld form for smear results (a) empty (b) filled in

Single Site Model

In a single site model, the user fills in a single form (CX-BK form) with both the smear and culture information. The proposed workflow can be seen in Figure 3. On the first visit, the patient information with the DISA and health center filled in automatically, complete smear information and the initial culture information (sample type & ID) are entered. On a subsequent visit, when the culture result is known, that information is filled in. At the office, the handheld is synced to the PIH-EMR using Microsoft Access linked tables. All of the information entered that day is uploaded to a temporary culture-smear table in the PIH-EMR and an updated patient and laboratory list, as well as a copy of the records that need to be on the handheld are downloaded. In the PIH-EMR, data quality checks will be performed and once the information has been verified it will be moved to the permanent bacteriologies table. This will be discussed further in the Next Steps section.

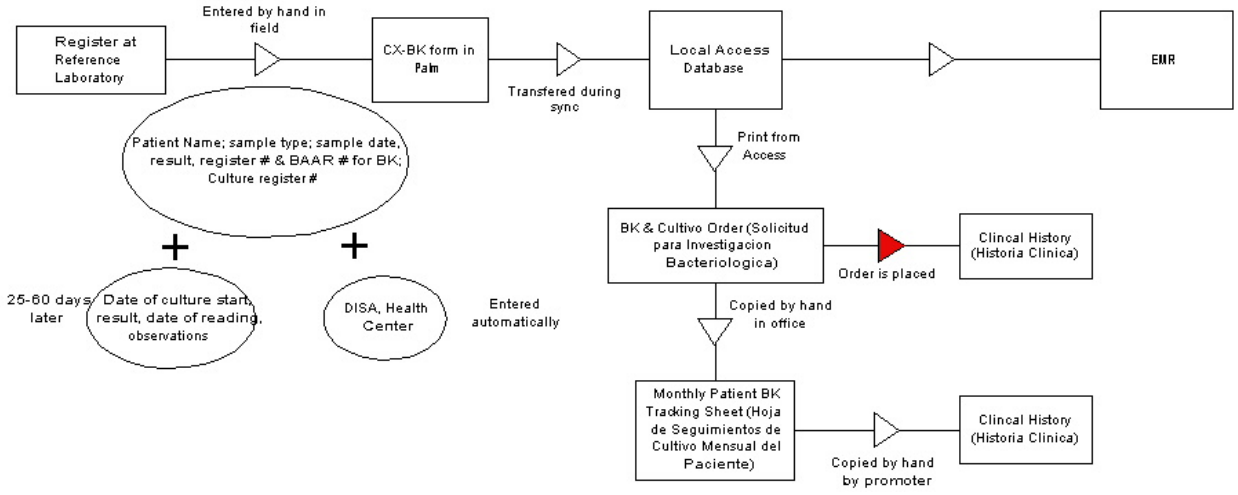


Figure 4 Proposed workflow with handhelds for single site model

Dual Site Model

Here a user will have two forms. The first to input the smear result from the health center (BK form) and the second to input the culture and secondary smear result from the reference

laboratory (CX-BK form). The second form is identical to the single site form. The workflow for these two forms can be seen in Figure 4 (a) and (b), respectively.

For smear results, the user will fill in the BK form in a single visit from either the lab register or the physician's order. At the office, the handheld will be synced with the PIH-EMR in the process described previously, but in this case the information will be sent to a temporary table of smear results

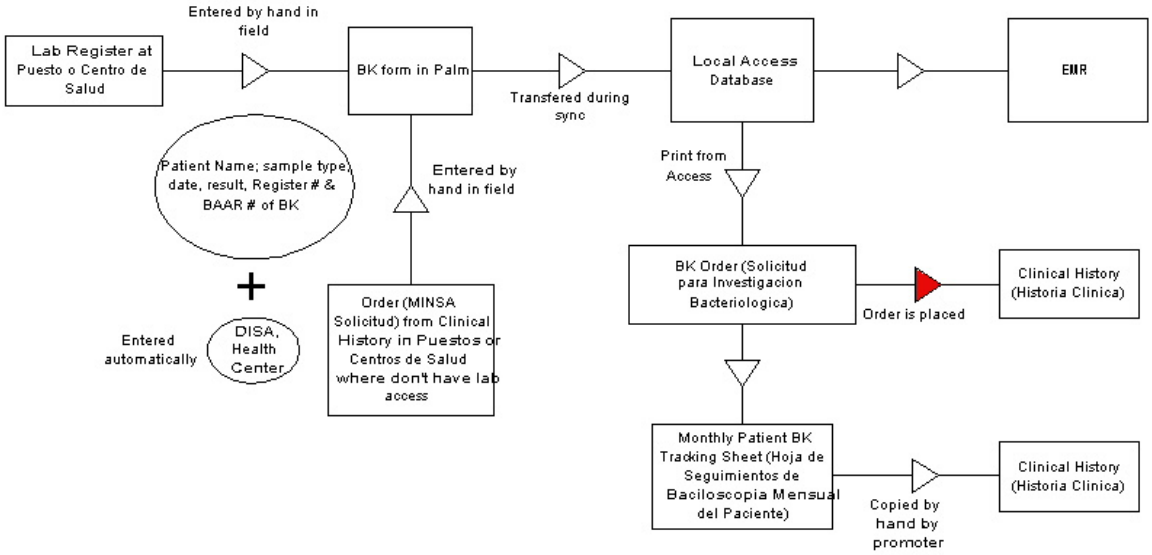


Figure 5 (a) Proposed workflow with handhelds for dual site model: smear result

At the reference laboratory, the BK team will use the same CX-BK form as in the single site model. Here they will fill in the initial culture information from the lab register and the secondary smear results from the original physician's order sent to the reference lab. On a subsequent visit 25-60 days later, they will fill in the culture results. This information will be uploaded to the same temporary culture table as the single site form. In this case, however, an additional data quality check is performed where the backup smear results from the reference laboratory in the culture-smear table will be checked against the original smear results from the health center in the smear table. The full workflow can be seen below in Figure 4 (b).

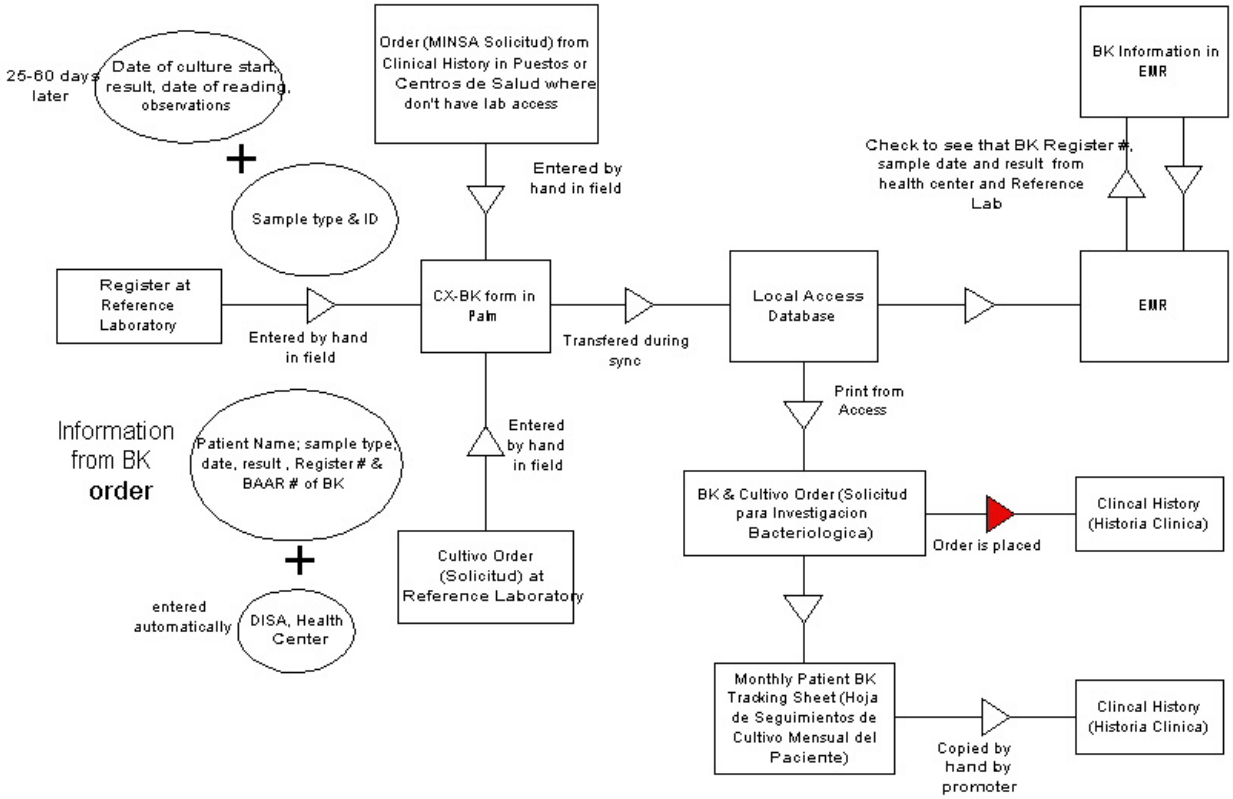


Figure 5 (b) Proposed workflow with handhelds for dual site model: culture and secondary smear result

Data Validation

This system would also automate data quality checks currently being performed by the BK team. They include:

1. Duplicate data of the same test result
2. In the dual site model, verify that the primary and secondary smear results are identical (Sample date, number and result)
3. Checking that every culture has a corresponding smear
4. Checking that every smear has a corresponding culture
5. That the result has been entered for every smear and culture whose initial information was entered
6. That every active PIH patient has given their monthly sample

Proposed Benefits and Areas of Concern

The major benefits of implementing a handheld bacteriology collection system are:

1. Reduction of errors in patient records

   By moving the digitization of BK results to the initial point of contact at the health center or reference lab, the number of copying errors will be reduced. Currently, the original BK

result is hand copied 3 times before it is entered into the PIH-EMR. A handheld system would eliminate these 3 hand copying steps.

2. Lowering time and costs of collecting bacteriology results

   Currently, if one BK team member spends the morning in the field collecting information, they will spend that entire afternoon hand copying each record to PIH orders. Another 1-2 hours hand copying the information from the orders to the patient's monthly record and another 1-2 hours entering that information to the EMR. By digitizing the BK results at the laboratory site, the BK team member will be able to automatically print all of the orders and update the EMR, thus saving approximately half the time currently being spent in collecting bacteriology results.

3. Reducing time to digitization of patient information

   Due to the amount of time and effort required processing the bacteriology information collected from the health centers and laboratories, the current time to digitization can vary from 25-50 days. The handheld system will digitize the information the same day it is collected.

4. Integration of quality control into BK team

   The handheld will contain up-to-date information about the patient's current status, health center and if they have submitted their monthly sputum sample. Therefore the team will be able to correct any outdate information in the EMR and more closely monitor their patients. Further, currently the BK team checks that the result of a smear performed at a health center is sent correctly to the reference lab by collecting the smear result from both locations and checking them at the office. With the new system, this process would be automated and the check performed 2-20 days faster.

5. Standardization of laboratory test identifiers

   Though currently not implemented, this system another step in instituting coded medical data as a standard. The current PIH-EMR laboratory system provides a data model structure for standardization and flexible reporting. LOINC codes, universal identifiers for laboratory and other clinical observations, could be implemented to increase inter-operability between laboratories, as well as the public and private health systems.

6. Better quality of care to the patient

   By providing faster and more reliable bacteriology results, the quality of care provided to the patient should increase. Concurrently, faster response times to patient needs and an increase in patient survival rate would be expected.

Though providing these benefits, there are areas of concern where particular attention should be given:

- Data security

  As patient data will be stored in the handheld the data must be secure. The handheld will be locked each time it is turned off and will need a password to turn it on. In addition the individual patient data forms will also need a password to be opened. This should make the data more secure than the paper records that are currently carried by the BK team.

- Data loss

  If the handheld is lost then data that has been collected that day may need to be re-collected but the data from the day before will be secure as the Palm will connect to the computer each afternoon. If there are problems with the desktop computer then again the data should be less than 1 day old before it is transmitted to the PIH-EMR.

- Data quality

  As described earlier we are incorporating checks for data quality in the system and will perform formal evaluations of data quality to detect any problems with the system.

Next Steps

Thorough workflow studies of the BK team and their bacteriology results method has bee performed. With this and the involvement of the BK team the handheld system has been implemented, tested and they have been trained in its use. Further the connection to a Microsoft Access database on the local computer has also been established. The key parts of the system that still need implementation include:

1. Reliable and secure method of synchronizing handheld with PIH-EMR
2. Creation of pages in the PIH EMR to perform data validation checks and provide BK team an interface with the bacteriology results
3. Planning and performing a study to quantify proposed benefits. This would also incorporate the development of appropriate parameters to measure the proposed benefits.

References

Choi, S. S., D. G. Jazayeri, et al. (2004). "Implementation and Initial Evaluation of a Web-based Nurse Order Entry System for Multidrug-Resistant Tuberculosis (MDR-TB) Patients in Peru." Proc. Medinfo 11: 202-206.

Fraser, H., D. Jazayeri, et al. (2004). "An information system and medical record to support HIV treatment in rural Haiti." BMJ In press.

Isenman, Michael D. Clinician's Guide to Tuberculosis Lippincott Williams & Wilkins: New York, 2000 pp. 26-30.

Yasin, Z., S. Choi, et al. (2002). "Improving Access To TB Medical Records In Remote Clinics In Peru Using A Personal Digital Assistant Based Application." Proc AMIA Symp: 1207.