International Journal of Infectious Diseases (2009) **13**, 410—418

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Personal digital assistants to collect tuberculosis bacteriology data in Peru reduce delays, errors, and workload, and are acceptable to users: cluster randomized controlled trial

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Received 30 November 2007; received in revised form 18 September 2008; accepted 24 September 2008
Corresponding Editor: William Cameron, Ottawa, Canada

KEYWORDS
Handheld computer;
Personal digital assistant;
Evaluation studies;
Developing countries;
Tuberculosis

Summary
Objectives: To evaluate the effectiveness of a personal digital assistant (PDA)-based system for collecting tuberculosis test results and to compare this new system to the previous paper-based system. The PDA- and paper-based systems were evaluated based on processing times, frequency of errors, and number of work-hours expended by data collectors.
Methods: We conducted a cluster randomized controlled trial in 93 health establishments in Peru. Baseline data were collected for 19 months. Districts ($n = 4$) were then randomly assigned to intervention (PDA) or control (paper) groups, and further data were collected for 6 months. Comparisons were made between intervention and control districts and within-districts before and after the introduction of the intervention.
Results: The PDA-based system had a significant effect on processing times ($p < 0.001$) and errors ($p = 0.005$). In the between-districts comparison, the median processing time for cultures was reduced from 23 to 8 days and for smears was reduced from 25 to 12 days. In that comparison, the proportion of cultures with delays >90 days was reduced from 9.2% to 0.1% and the number of errors was decreased by 57.1%. The intervention reduced the work-hours necessary to process results by 70% and was preferred by all users.

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doi:10.1016/j.ijid.2008.09.015

Conclusions: A well-designed PDA-based system to collect data from institutions over a large, resource-poor area can significantly reduce delays, errors, and person-hours spent processing data.

Introduction

Clinical and research organizations must often collect data from large numbers of patients who are distributed over wide geographic areas. New technologies may play an important role in ensuring that high-quality data can be quickly and reliably collected under these challenging field conditions. Ideally, organizations or individuals that need to record large amounts of data in dispersed locations would be able to electronically capture this data at the point of collection. In clinical and research settings within developed countries, personal digital assistants (PDAs) have shown some promise as a new technology that can increase the quality and efficiency of data collection, though performance has varied between studies.[1–14] This heterogeneity may suggest that the design and implementation of the PDA intervention play a key role in a system's success. In resource-poor settings, initial experiences have demonstrated several situations in which PDAs[15–25] and cellular phones[26,27] are of benefit. However, to date, we have found no quantitative studies of the impact of mobile technologies on the time to collect and process data, the frequency of discrepancies, or the number of person-hours required for data collection.

We worked with an organization that monitors multidrug-resistant tuberculosis (MDR-TB) patients in Peru to implement a PDA-based system and to study the impact of this system on data collection. In this treatment program, patients are required to submit a monthly sputum sample at their local health center. Timeliness and accuracy of reporting laboratory results for these samples is essential to determine if a patient is responding to treatment and, if not, to alert physicians to the possible need for medication changes.[28] We expected that laboratory monitoring of treatment response would result in reduced culture-conversion times and better treatment outcomes for patients, as well as reduced transmission of the disease in the community.

The laboratory monitoring process begins with a smear microscopy test at the local health center. The sputum sample and smear result are then sent to the corresponding regional laboratory for culture (Figure 1). In some cases, the sputum sample is sent directly to the regional laboratory and smear microscopy and culture are performed. The four-member bacteriology team visits approximately 100 of these health centers and five regional laboratories that care for MDR-TB patients. In each health center the team records the smear test result on a paper sheet and in each regional laboratory the team records both the culture result and the smear result sent by the health center on a similar paper sheet. These sheets are then brought to a central office where the culture and smear results are verified, copied onto additional clinical and administrative forms, and then typed into the web-based Partners in Health Electronic Medical Record system (PIH-EMR).[29] In Lima, the team makes at least bi-weekly visits to all 105 sites distributed over 2672 km^2.

The major disadvantages of this paper-based method are the delays in processing and entering laboratory results, data quality issues stemming from multiple opportunities for transcription errors, and the heavy workload involved in the process. A preliminary study found that the mean time from the test result date to entry in the PIH-EMR was 55.3 days. A routine quality control examination found error rates as high as 10.1%, and the bacteriology team was consistently backlogged because of the increasing number of patients on treatment.

At the time of this study many of these laboratories and health centers had neither Internet nor an appropriate web-based laboratory information system; as such, a PDA-based system represented the most appropriate technology to improve the process of monitoring laboratory results. Since

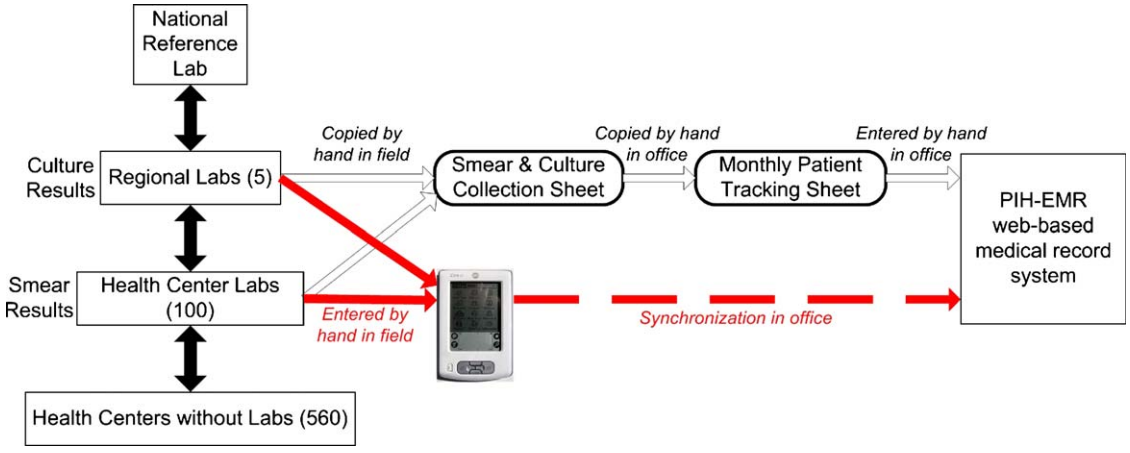

Figure 1 Peruvian laboratory structure, and workflow of the bacteriology data collection team with the current paper system (white lines) and with the PDA-based system (red lines).