Paperless registration during survey enumerations and large oral cholera mass vaccination in Zanzibar, the United Republic of Tanzania

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Problem Field trials require extensive data preparation and complex logistics. The use of personal digital assistants (PDAs) can bypass many of the traditional steps that are necessary in a paper-based data entry system.
Approach We programmed, designed and supervised the use of PDAs for a large survey enumeration and mass vaccination campaign.
Local setting The project was implemented in Zanzibar in the United Republic of Tanzania. Zanzibar is composed of two main islands, Unguja and Pemba, where outbreaks of cholera have been reported since the 1970s.
Relevant changes PDAs allowed us to digitize information at the initial point of contact with the respondents. Immediate response by the system in case of error helped ensure the quality and reliability of the data. PDAs provided quick data summaries that allowed subsequent research activities to be implemented in a timely fashion.
Lessons learnt Portability, immediate recording and linking of information enhanced structure data collection in our study. PDAs could be more useful than paper-based systems for data collection in the field, especially in impoverished settings in developing countries.

Une traduction en français de ce résumé figure à la fin de l'article. *Al final del artículo se facilita una traducción al español.* الترجمة العربية لهذه الخلاصة في نهاية النص الكامل لهذه المقالة.

Background

Accurate, complete and timely data documentation is a major challenge in conducting field research. Traditionally, studies begin with information recorded on paper followed by double data entry to detect keypunching errors.[1] This complicated and time-consuming approach is fraught with difficulties when dealing with large data sets, limited availability of qualified staff, expensive equipment and frequent power interruptions. A paper-based system may also delay the availability of clean data sets needed for subsequent research activities, including mass vaccination and disease surveillance with linkage to vaccination status.

Hand-held computers, also known as personal digital assistants (PDAs), are increasingly being applied in developing countries to computerize health information.[2–4] PDAs have been used for health surveys,[4,5] patient assessments and follow-ups,[3,6] and they have been combined with other information technologies in demographic surveillance systems.[2] In studies in developing countries in which paper questionnaires have been compared directly to PDAs, improved data precision, decreased collection time and fewer errors have been found.[7] The advantages of PDAs are that fewer individuals are required, and that cleaned data sets are available immediately after field work.[8]

We programmed, designed and supervised the use of PDAs for a survey enumeration followed by a large mass vaccination campaign in Zanzibar. In this paper we report our experiences with direct entry of data into PDAs and provide recommendations for future use.

The project

Zanzibar, in the United Republic of Tanzania, consists of two main islands, Unguja and Pemba, where outbreaks of cholera have been reported since the 1970s. Our project (registration number NCT00709410), known as "Pre-emptive use of cholera vaccination in high-risk populations in Zanzibar" or CHOZAN, which is short for "cholera in Zanzibar", consisted of mass cholera vaccination in high-risk populations of approximately 50 000 individuals for the purpose of assessing vaccine effectiveness and potential herd protection.

Hardware and software

We used 30 iPAQ 214 Enterprise Hand-held (Hewlett Packard, Palo Alto, United States of America) PDAs with a 4-inch (10.2-centimetre) touch screen display and a Microsoft Windows Mobile® 5.2 operating system (Microsoft Corporation, Redmond, USA). Each PDA had a 2200 milli Ampere hour (mAh) lithium ion rechargeable battery that provided at least 6 hours of usage, and a backup battery was provided for each operator. We developed data entry systems using Visual Basic. Net (Microsoft, Seattle, USA). To upload and manage the data on a desktop computer, we developed another system using Microsoft Visual FoxPro® 7.0.

Survey enumerations

The survey was conducted from 3 November 2008 to 31 December 2008. Survey instruments included questions on

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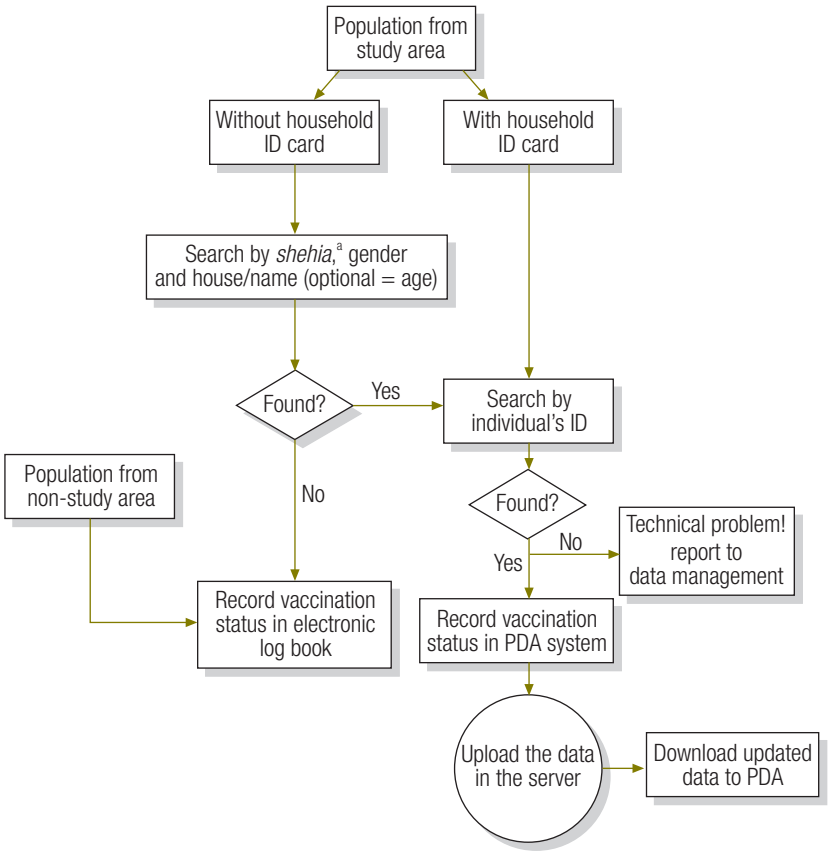
the following: household-level socioeconomic markers, basic demographic information, health utilization behaviour and recent travel. We provided training on the use of PDAs to 24 field workers with at least a secondary school education and no previous experience in direct data entry or hand-held computers. Sample screens of the PDA survey enumerations are available at: https://trdrdcsys.ivi.int/pda/pic1.asp. Data entry fields included option buttons, check boxes or spaces where data could be inserted. Drop-down menus, skipping of fields and fields requiring data were programmed into the system to prevent errors during navigation through the questionnaire. The data collected in the PDAs were uploaded into a central computer at the end of each work day. Further checks were performed in the central computer immediately after uploading the data.

Vaccination registration

After the survey enumeration was completed and the database was cleaned, household identification (ID) cards were printed and distributed in early January 2009. All healthy, non-pregnant residents of the study sites who were ≥ 2 years of age were invited to participate in the mass vaccination campaign. The first round of vaccination was conducted from 17 to 26 January 2009, and the second one was conducted from 7 to 16 February 2009. This ensured a minimum of 12 days between doses. There were nine vaccination outposts in each of the islands.

We downloaded into the PDA basic individual information from the population database. The vaccination registration system included two modules: one with and the other without an ID card. The flow of the vaccination registration system is shown in Fig. 1. If the individual brought the ID card, the PDA registrar used the "ID card" module (the sample screen of the vaccine registration is available at: https://trdrdcsys.ivi.int/pda/pic2.asp). It then provided basic information on the individual that was verified before registering the person's vaccination status. If the individual came without the ID card, the ID-search module (a sample screen of the PDA is available at: https://trdrdcsys.ivi.int/pda/pic3.asp) was used to search for the person. It took approximately 10 seconds to generate the list of potential candidates. A touch on the target individual brought up a PDA screen for vaccination registration.

Fig. 1. **Flow diagram of vaccine registration for mass oral cholera vaccination campaign, Zanzibar, United Republic of Tanzania, 2009**



ID, identification; PDA, personal digital assistants.

[a] *Shehias* are small administrative ward subdivisions in Zanzibar.

At the end of each vaccination day, the PDAs were collected from all vaccination posts. The data from the PDAs were then merged into a single database on the designated computer, and a report was produced. The merged database was downloaded into each of the PDAs so the vaccination status of a given individual could be pulled up from any one of the PDAs as a protection against duplicating a vaccination.

Quality control and data integration

The PDA system included automatic check functions and a response confirmation feature in the data entry programs. At the end of each day, rigorous checking was performed; an error list was created and sent for resolution the following day. During mass vaccination, vaccination data were linked directly to the population data in the PDA. This allowed for immediate and correct linking of the data at the point of contact.

Data security and audit trail

The survey enumeration included identifiers and was considered a source document for the population base. The database was downloaded and backed up daily. For data security, the PDAs were password-protected and locked in secured locations. Only investigators conducting the study had direct access to the database, the backed up data and the PDAs. We kept the data from each day's activities stored in the desktop computer. A trail of all changes made to the data, the date of each change and the identity of the individual who introduced the change were all recorded.

PDA acceptability and performance

After training and home practice, field workers were able to handle the PDAs

Box 1. **Summary of main lessons learnt**

- Personal digital assistants (PDAs) allow one to digitize information at the initial point of contact between interviewers and respondents.
- Immediate response by the PDA system in case of error while digitizing data in front of the respondents ensures the data quality and reliability.
- A PDA system helps produce quick data summaries and allows one to carry out subsequent research activities in a timely fashion.

efficiently in 2 to 3 days. During survey enumerations, 31 213 residents of Unguja and 16 723 residents of Pemba were enumerated. Each field worker was able to complete approximately 20 household interviews in one day. During vaccination, 29 507 two-dose vaccine recipients were registered. No major problems were associated with the use of PDAs except for difficulty in reading the screen under direct sunlight. Data could be efficiently entered with a stylus. Questionnaire skip patterns were easily navigated, and missing data were eliminated. The entry of erroneous or inconsistent data was prevented through in-built checks in the PDA. The logistics of collecting the PDAs daily to download data and charge batteries were less complex than those involved in using paper forms.

Cost comparison

Paperless and paper-based systems require a similar number of field staff and supervisors for data collection and they entail similar training costs. The paperless system in our study involved the cost of 30 PDAs (12 000 United States dollars, US$), 1 central computer and printer (US$ 2500), software (US$ 500) and PDA system development (US$ 20 000). This added up to a total of US$ 35 000. In contrast, a paper-based system would have required US$ 17 000 to US$ 22 000, since we would have needed to employ a much larger staff for a longer period (about six data entry clerks and one supervisor for 4 months, at an overall cost of approximately US$ 7000 to US$ 10 000). Another US$ 10 000 to US$ 12 000 would have been needed for computers, printers, photocopiers, power backup facilities, paper, filing cabinets and the rental of a larger office space. Finally, development costs would have been the same for a paper-based system as for the PDA system.

Evaluation and lessons learnt

To our knowledge, we have been the first to use PDAs for direct data entry during a survey enumeration followed by mass vaccination. PDA data collection was reliable and provided rapid data summaries, and field workers were able to use PDAs easily (Box 1). The data were promptly and accurately linked as well as easily accessible for integrated analysis and report generation. We did not experience any hardware problems and we lost no PDAs or data.

Implementing paperless data management required a large initial capital cost for the purchase of hardware. However, this was offset by savings on expenses that would have been incurred if paper questionnaires had been used. We are still generating savings because the programmed PDAs continue to be used for subsequent study activities. The major challenge involved in paperless data entry was the need for expert programming capability to design, develop and implement an efficient system. Visual Basic.Net, which we used to customize our PDA software required some development time but provided a user-friendly system. Another challenge was to train inexperienced field workers to use a hand-held device. Field workers took the PDAs home to become familiar with the technology, and any problems they encountered were reported and resolved in the next training session.

The PDAs made it possible to digitize information at the initial point of contact between the respondents and interviewers and provided data immediately after survey enumerations. This shortened the transition time to vaccination and subsequently to disease surveillance. The PDAs are now being used to update the population database and, at treatment centres, to conduct surveillance of diarrhoeal diseases. Our experience suggests that people with little education and no experience in the use of a computer are easily able to use a PDA. ■

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الملخص

التسجيل بدون أوراق خلال تعدادات المسح والتطعيم الفموي الجموعي الضخم ضد الكوليرا في زنجبار، جمهورية تنزانيا

المشكلة تتطلب الدراسات الميدانية الإعداد المكثف للمعطيات والإمدادات المعقدة. ويمكن باستخدام الحواسيب اليدوية الشخصية تجاوز الكثير من الخطوات التقليدية الضرورية في نظام إدخال المعطيات الورقي.

الأسلوب قام الباحثون ببرمجة وتصميم الحواسيب اليدوية الشخصية والإشراف عليها في حملة ضخمة للإعداد وللتطعيم الجموعي.

الموقع المحلي نفذ الباحثون المشروع في زنجبار، جمهورية تنزانيا المتحدة، وتتألف زنجبار من جزيرتين رئيسيتين هما أونغوجا وبيمبا، ويتم الإبلاغ عن الكوليرا فيهما منذ السبعينات.

التغيرات ذات الصلة لقد مكن استخدام الحواسيب اليدوية الشخصية من رَقْمَنَة المعلومات في النقطة الأساسية للتواصل مع المستجيبين للدراسة. وقد ساعدت الاستجابة الفورية التي أبداها النظام عند حدوث خطأ ما على ضمان جودة وموثوقية المعطيات. وتزود الحواسيب اليدوية الشخصية الباحثين بمعلومات سريعة سمحت لهم بإجراء أنشطة بحثية تالية وتنفيذها في الوقت المناسب.

الدروس المستفادة لقد أدى كل من إمكانية حمل الحواسيب اليدوية الشخصية، والتسجيل الفوري وربط المعلومات إلى تعزيز بنية تجميع المعطيات في الدراسة. ويمكن للحواسيب اليدوية الشخصية أن تقدم المزيد من الفوائد أكثر مما تقدمه النظم الورقية في التجميع الميداني للمعطيات، ولاسيما في المواقع التي تعاني من الفقر في البلدان النامية.

Résumé

Enregistrement sans support papier dans le cadre des dénombrements pratiqués à des fins d'enquête et des campagnes de vaccination massive par voie orale contre le choléra menés au Zanzibar (République Unie de Tanzanie)

Problématique Les essais sur le terrain exigent des opérations de préparation des données de grande ampleur et une logistique complexe. L'utilisation d'assistants numériques personnels (PDA ou organiseurs) peut court-circuiter nombre des étapes qu'impose traditionnellement un système de saisie des données sur support papier.

Démarche Nous avons programmé, pensé et supervisé l'utilisation de PDA pour un dénombrement de grande ampleur dans le cadre d'une enquête et pour une campagne de vaccination de masse.

Contexte local Le projet a été mis en œuvre au Zanzibar, en République Unie de Tanzanie. Zanzibar se compose de deux iles principales, Unguja et Pemba, dans lesquelles des flambées de choléra sont notifiées depuis les années 1970.

Modifications pertinentes Les PDA nous ont permis de numériser l'information au point initial de contact avec les personnes interrogées. Une réponse immédiate du système en cas d'erreur a contribué à garantir la qualité et la fiabilité des données. Les PDA ont fourni des synthèses rapides des données permettant de mettre en œuvre sans délai des activités de recherche faisant suite aux premières.

Enseignements tirés La portabilité, l'enregistrement immédiat et la mise en relation des informations a permis de mieux structurer la collecte des données dans notre étude. Les PDA pourraient être plus utiles que les systèmes à support papier pour la collecte des données sur le terrain, notamment dans les zones pauvres des pays en développement.

Resumen

Registro digital de las enumeraciones encuestales y vacunación oral masiva contra el cólera en Zanzíbar, República Unida de Tanzanía

Problema Los ensayos sobre el terreno exigen una amplia preparación de los datos y una logística compleja. Los asistentes personales digitales (PDA) permiten sortear muchas de las medidas tradicionales que requieren los métodos de anotación de datos en papel.

Enfoque Procedimos a programar, diseñar y supervisar el uso de PDA para el trabajo de enumeración de una gran encuesta y la posterior campaña de vacunación masiva.

Contexto local El proyecto se llevó a cabo en Zanzíbar, en la República Unida de Tanzanía. El territorio de Zanzíbar se reparte fundamentalmente en dos islas, Unguja y Pemba, en las que se vienen notificando brotes de cólera desde los años setenta.

Cambios destacables Los PDA nos permitieron digitalizar la información en el punto inicial de contacto con los encuestados. La respuesta inmediata del sistema en caso de error nos ayudó a reunir datos de mayor calidad y fiabilidad. Los PDA generaban resúmenes rápidos de los datos que permitían emprender nuevas actividades de investigación en el momento oportuno.

Enseñanzas extraídas La transportabilidad, la inmediatez del registro y la vinculación de la información mejoraron la recopilación de datos estructurados en nuestro estudio. Los PDA pueden ser más útiles que los sistemas basados en papel para reunir datos sobre el terreno, especialmente en los entornos empobrecidos de los países en desarrollo.

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