EVALUATION OF THE USE OF THE SMARTPHONE SYSTEM IN ETHEKWINI METROPOLITAN AREA, SOUTH AFRICA

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USAID FROM THE AMERICAN PEOPLE | TUBERCULOSIS PROGRAM SOUTH AFRICA

ACRONYMS

DR-TB	Drug Resistant Tuberculosis
ETR	Electronic TB Register
GeoMed	Software Company
GIS	Geographic Information System
GPS	Global Positioning System
MDR-TB	Multi Drug Resistant Tuberculosis
XDR-TB	Extensively Drug Resistant Tuberculosis
NDoH	National Department of Health
SOP	Standard Operating Procedures
SP	Smartphone
URC	University Research Co

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Summary

This evaluation has reviewed the experience of an mHealth pilot in eThekwini Metropolitan area, KwaZulu-Natal, South Africa. The pilot was started in May 2011 to test the feasibility of using smartphones (SP) to collect information on contact tracing in households of TB index cases. The evaluation was based on the analysis of the reliability and use of the information that was collected, and on the interview of tracing teams and managers of eThekwini District.

The Electronic TB Register has provided the roster of TB index patients whose households had to be visited. Between May 2011 and January 2012, the tracing teams searched the location of 6685 households of index cases, of which 3394 (51%) were traced. Of the 9016 family contacts living in these households, 5146 (57%) were at home at the time of the visit, while most of those who were absent were at school or at work. During the visit, information was recorded by the tracing teams on the characteristics of the households, GPS coordinates, presence of TB symptoms and other variables. Specimens that were collected from the contacts that had TB symptoms were placed in cooler boxes and sent to the laboratory. The results of the tests were communicated back to the suspect cases. HIV counseling and testing was offered, health education was provided, pregnant women were referred to antenatal care services and children were referred to immunization services.

The mHealth pilot was sponsored by the US Agency for International Development South Africa TB Program, which is administered by University Research Co., LLC (URC). GeoMed, a South African IT company programmed the software to enter the data onto SP and to transmit it via a cellular phone network to a server. The information was transformed into tables, graphs and maps via an internet web portal, to inform managers on the performance of TB tracing.

The data files related to the SP system were analyzed to validate the reports produced by GeoMed. A preliminary analysis identified missing values, inconsistencies and duplicated records, which pinpointed to a series of problems to be fixed. After cleaning the data, the final analysis produced a list of estimates that were compared with the reports produced by the GeoMed database. With the exception of the laboratory results that were not recorded because of technical and other problems, the estimates derived from the raw data were almost the same as those ones produced by the database, confirming its reliability.

The interviews with the tracing teams and managers have confirmed that the SP is well accepted and is preferred to collecting data on paper forms. Positive characteristics mentioned by interviewees included efficiency and speed in data collection, timely availability of indicators for managers and assurance of privacy of the recorded data. Teams were satisfied with the training and supervision.

Besides testing the SP system, the tracing teams have provided several services. There were 761 (15%) contacts who were symptomatic for TB and 449 (59%) of these suspects provided sputa that were sent to the laboratory. Of the 5146 contacts who were at home, 3805 (74%) were counseled for HIV testing, of which 1434 (38%) were tested for HIV, of which 252 (18%) tested positive. Of the 2896 women who were present, 90 (3%) were pregnant, of which 47 (52%) were referred to antenatal care services.

Overall the tracing teams had a positive experience with the use of SP. This will be even smoother when the problems experienced in this first phase will be tackled during the preparation of the next phase. The GeoMed system problems can be easily corrected and the teams can be retrained in correctly entering the laboratory results. Other problems were contributed by many factors that were

not always under the control of the project, including human relationships and leadership to elicit collaboration among institutions. The problem of untraced households requires novel strategies to tackle stigma and locate the households through the collaboration of community leaders and community health workers.

Introduction

South Africa has one of the highest TB burden in the world. According to WHO (1), in 2010 South Africa had the third largest number of new TB cases (0.4-0.6 million) after India and China, having only a fraction of their population. Of 22 high burden countries, TB incidence it is declining in 10 and remaining stable in 11 countries, but it still increasing in South Africa.

This high incidence is creating difficult challenges to the TB program, which besides the high burden of sensitive TB has also to tackle the increasing number of resistant cases. Health facilities are overburdened with large numbers of patients and inadequate infection control measures. In poverty-stricken communities, people often do not have the means to go to hospital for regular check-ups or treatment, contributing to high defaulter rates. As a consequence, extensively drug-resistant TB (XDR-TB) (2-3) has grown rapidly over the past decade, fuelled by the maturing HIV epidemic, a faltering control program and primary TB transmission (4-6).

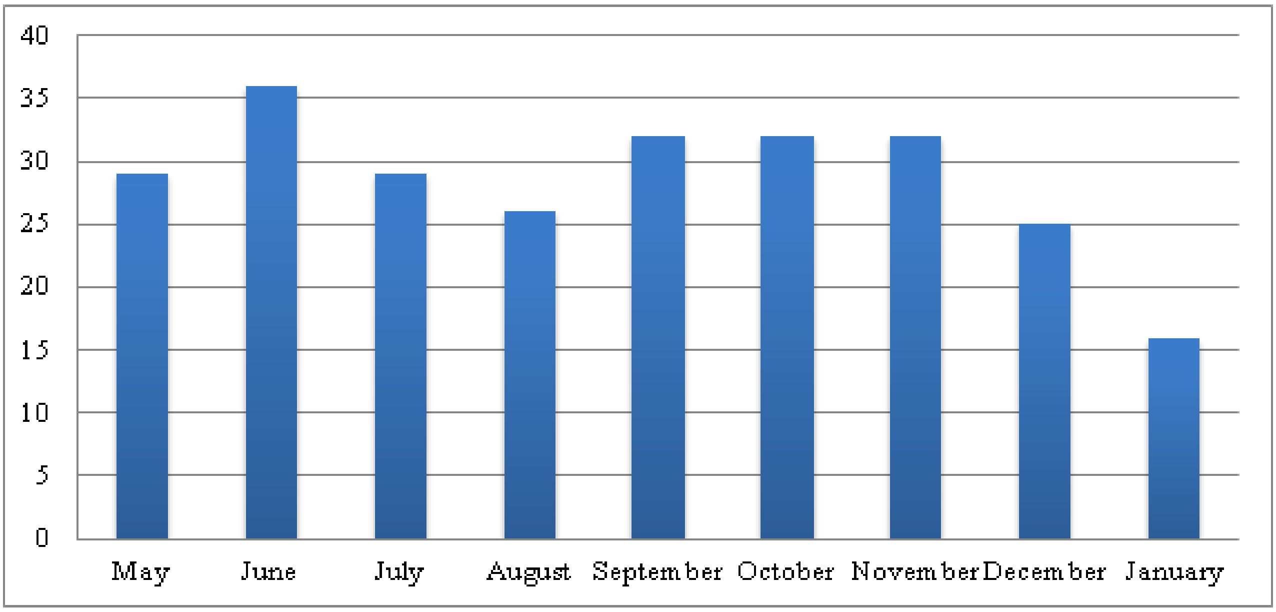
There is an overwhelming need to improve the management of TB in communities in South Africa. The Department of Health’s move towards community-based management of MDR TB (7) is a positive development, and needs to be supported with appropriate tools. At present, the weakest link is the delays in receiving information to make real time management decisions.

The USAID South Africa TB program, administered by University Research Co., LLC (URC), in collaboration with the South African National Department of Health, has developed an innovative home-based information system. A synergistic combination of Google™ Earth and smart phone technology, the mHealth system (Annex I) is used for remote data gathering, patient information management and workforce management (8).

A pilot study on the use of Nokia Model 5230 smartphone (SP), provided by the National Department of Health (NDoH), to collect data at the household level has been ongoing in the eThekwini Metropolitan Area since May 2011. In November 2010 the NDoH launched the intensive case finding project with the objective of actively finding TB cases at community level. A Monitoring and Evaluation working group (WG) composed by NDoH, eThekwini District DoH, Provincial DoH, NGOs, and National Health Laboratory Systems (NHLS) was established. The WG decided to use SP to have good quality real time data for an effective monitoring. EThekwini Metropolitan Area was chosen because it had the highest TB case load and the lowest TB treatment outcome in South Africa. It has to be noted that for sustainability purpose, it was decided that the eThekwini District was directly responsible for the pilot and that the external support was to be kept at the bare minimum such as provision of GeoMed technical support, SPs and initial training. The District was also responsible for maintaining contacts with the laboratory and for supervising the activities of the tracing teams.

The objective of this first phase, which was limited to the case finding and diagnosis, was to carefully evaluate the problems arising from the introduction of the SP system within the mainstream routine intensive case finding. The results coming out from this initial phase were to be used for the planning of the next phase which will include the monitoring of TB treatment. The objective was to trace and test family contacts of TB cases, treat those who were positive for TB and collect information on risk factors for TB transmission. The pilot has been integrated within the routine public health services, providing an operational testing ground for the feasibility of supplementing and eventually replacing the traditional paper forms with an mHealth system. The SP data entry program was developed by GeoMed, a software company based in South Africa. During this initial phase, all the smear positive TB patients in the eThekwini Metropolitan Area that were recorded in the electronic TB register were enrolled in the pilot. A total of 43 SP have been allocated to 43 teams to visit the households. To be noted that the 43 teams were not employed in a full time manner to the activities of contact tracing and they were deployed at different points in time (Figure 1).

Figure 1 Number of active tracing teams between May 2011 and January 2012



Electronic data capture has been used by studies (3-4) to collect household data in a more efficient and cheaper way than the traditional paper forms, but its use in routine settings needs to be assessed. Concerns regarding feasibility relate to possible perceptions by users that the electronic systems are more difficult to use than the traditional paper forms, leading to low uptake, as well as transmission and software problems, unreliability of the data and limited use of the information.

Although at the moment the SP system has been collecting information on the households of the TB index cases and the contacts in eThekwini Metropolitan area, no analysis of its reliability and use has been carried out. The literature has reported that staff have no major problems in using the SP, which is considered an improvement compared to the paper system (9). However, this impression requires verification and statistical outputs coming from the SP system need to be validated. Evaluating this experience provides critical information on its advantages and disadvantages, reliability and usefulness of the data collected, and on the needed modifications. These are critical elements to be taken into consideration for the next phase, which will cover the monitoring of the treatment compliance.

Objective

The primary objective was to evaluate the m-Health system which is being used to trace contacts of TB patients in the eThekwini Metropolitan Area. This has been done by assessing the objectives and scope of the SP information system, the data structure, the relevance and reliability of the data being collected and their use. These steps have been a pre-requisite for the identification of problems in the information system and to inform the future data collection strategy and the relative Standard Operating Procedures (SOP).

Questions assessed

The evaluation has tried to reply to the following questions:

- What are the specific objectives and scope of the m-Health system in eThekwini?
- Is the collected information relevant to achieve the specific objectives?
- Are the indicators clearly defined and collected according to specific criteria?
- Is the information reliable and useful?

Methods

The evaluation, which was conducted between the 8th and the 31st of January 2012, was based on the review of the project documents, the analysis of the raw data and the interview of the users. The analysis of the data allowed a comparison of the statistical outputs coming from the original records with the reports produced by GeoMed. The data entered into the system between the 15th of May 2011 and the 9th of January 2012 was obtained from GeoMed. The preliminary work was to study the file structure and the relationships linking different files, and to join them into master files to be analyzed. Missing values, duplications, inconsistencies and other problems were identified and the data were cleaned. This allowed a final estimation of the indicators that were then compared with the reports coming out of the GeoMed database.

The analysis of the data was integrated with the interview of the eThekwini District managers and the tracing teams to check their experience during the pilot, and to identify users' felt needs. The questionnaires that were self-administered were based on routine questions used to assess the opinion of the users of SP. Of the total 43 tracing teams, representatives of 25 members attended the interview. After the completion of the self-administered questionnaires, a focus group discussion was conducted to get a better understanding of the most important issues facing the tracing teams.

The main result was to document the data structure, assess its reliability, identify problems and suggest solutions that should be implemented in the next phase.

Results related to the database

Data collection

The 6685 households to be visited were derived from the TB cases recorded in the Electronic TB Register (ETR.Net) since May 2011. The eThekwini Metropolitan Area coordinators sent to the SP of the tracing teams the list of names and addresses of the households to be traced. Each team, composed of one professional nurse, one lay counselor and one community health worker had a daily schedule of home visits (see Table 2). During the initial visit, besides collecting the information and identifying TB suspects, the staff provided HIV counseling and testing and health education. TB suspects were identified according to the presence of standard symptoms that are associated with TB. Sputa were collected and stored in cooler boxes that were left in defined collection places (e.g. clinics), where the specimens were stored until they were collected by the laboratory staff. The laboratory returned the test results to the clinic where they were collected by the tracing teams that communicated the results to the households. In case of TB diagnosis, the tracing teams ensured that the affected contacts started treatment.

During the above mentioned initial visits a battery of information was recorded through the SP. This included the variables related to the households' characteristics and the family contacts of the TB index cases, the GPS coordinates, presence of symptoms for TB and specimens collected.

File structure

There was no written documentation on the data structure and on how the tables extracted from the database were generated. The data was organized in a relational database with normalized tables, which had the objective to provide specific outputs for the average user. GeoMed provided the data in several excel files (tables exported from their database), which concerned characteristics of households and family members. Before any analysis could be done it was necessary to join the different variables that were scattered across files into a common dataset related to the individual households and family members. This required an understanding of the relationships between the files that were extracted from the database, what were their identification keys for joining files, what was the meaning of each variable whose acronyms were not always self-explanatory. As there was no written documentation on the above, substantial time was spent in trying to make sense out of the information received.

Annex II provides a snapshot of the complex web of relationships linking the individual files/tables. The links across files show that it is not always possible to directly join files because two files might be indirectly related through a third one. The joining of files was not straightforward because the name of the identification keys of each household and of households' members required the understanding of indirect linkages across inter-related files. This required careful validation to ensure that the joined files contained the same information of the individual files, as the more variables were joined into the master file the possibility for errors and inconsistencies increased. Therefore, the construction of flat files for the analysis was laborious and required validation against the individual files in order to make sure that the flat files reflected the full information of the original data.

The lack of system documentation poses a serious risk to the sustainability of the system. In the future, GeoMed should provide documentation of the files' architecture and structure, a description of the relationship across tables and the definition of the meaning of each variable. GeoMed should also consider the programming of the extraction of the data into flat files containing the information related to the households, the index cases and the contacts, the lab results and other files that could be made accessible to advanced users for further analysis. In this context, GeoMed should consider downloading the individual tables in excel format and assigning a unique identifiable numeric key for each household and each family member to allow the advanced users to join the different files.

Data quality

Some files had several duplicated records, although the frequency was small and it did not affect the overall results. In table 1, which provides an example of such duplications, the columns represent the type of tests carried out, the identification key of the contacts and the time when the records were entered respectively. It can be seen that the first two records have the same identification key (6d12d50d-ff0f-4c41-97c6-dcce78d90613), in which the first record is a valid one while the second record (in shaded grey) is redundant, but (unless eliminated) it counts when totals are calculated. The last column shows that the two records were entered on the same day with an interval of less than one minute between the two entries. Most records in Table 1 have one duplicate but there is one record (e.g. fc7abdf0-4b35-43da-bcc4-422ed59c08e4) that is repeated several times. It can be seen that 9 of these duplicates were recorded on the 25th of May 2011, 5 duplicates were entered on the 26th of May 2011 and 6 duplicates were entered on the 6th of June 2011 at different time intervals. It is unclear how these duplicates were generated, but the most likely explanation is that they might have been due to software problems. It is also unclear how these duplicates are dealt with by the queries extracting the statistical outputs. Although these duplicates occur only in a few files, they should be dealt with by GeoMed in order to avoid including them in the production of statistics. Rules should be established on which record should be considered valid, especially in the presence of test results.

Table 1 **Duplicated records**

test	type_of_test_sputum	tbstr_client_fk	tbstr_client_tstamp
GeneXpert	Smear positive	6d12d50d-ff0f-4c41-97c6-dcce78d90613	2011-10-24 17:04:28.55
Culture or DST		6d12d50d-ff0f-4c41-97c6-dcce78d90613	2011-10-24 17:05:08.367
		ab182d0d-6453-4b12-833c-7daba130e74a	2011-06-06 11:41:05.928
Smear Microscopy	Results pending	ab182d0d-6453-4b12-833c-7daba130e74a	2011-06-06 11:41:05.861
		32eb892e-f00e-4418-bf99-7e24aee408ba	2011-08-30 12:55:31.391
Smear Microscopy	Smear negative	32eb892e-f00e-4418-bf99-7e24aee408ba	2011-08-22 10:04:25.003
Smear Microscopy	Smear negative	32eb892e-f00e-4418-bf99-7e24aee408ba	2011-09-26 12:29:08.811
Smear Microscopy	Smear negative	fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:30:17.452
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:16:32.549
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-05 12:34:50.454
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-05 12:35:09.701
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:14:36.747
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-26 11:32:47.976
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-07-20 17:46:07.389
Culture or DST		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:33:58.695
GeneXpert	Results pending	fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:33:43.354
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:32:12.384
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:15:42.318
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:32:52.687
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:14:36.855
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-26 11:32:47.828
Smear Microscopy	Smear negative	fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-26 11:30:07.452
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:16:17.435
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:14:36.965
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:14:52.082
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 10:15:12.2
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-26 10:43:13.586
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-06-06 19:32:22.507
		fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-25 12:39:30.055
GeneXpert	Smear positive	fc7abdf0-4b35-43da-bcc4-422ed59c08e4	2011-05-26 10:43:13.567
		d8df7c26-354d-4af0-944f-5bcdadfdeafd	2011-06-08 20:16:53.205
Smear Microscopy	Results pending	d8df7c26-354d-4af0-944f-5bcdadfdeafd	2011-06-08 20:16:53.282
		848c5708-dad9-4d18-93f3-d262ce8e4bbe	2011-05-25 07:53:34.652
		848c5708-dad9-4d18-93f3-d262ce8e4bbe	2011-05-25 07:50:04.211

Other problems were related to values beyond acceptable ranges and inconsistencies across related variables. An example of values out of range included negative values and values well beyond 100 in the case of age. An example of inconsistency is provided in Box 1, which represents the frequency distribution of the presence and absence of contacts during the first visit. At the top of Box 1, the variable "presence of contacts" shows that 3847 contacts were absent and 5169 were present. However, at the bottom of Box 1 it can be seen that when the variable "presence of contacts" is cross-tabulated with the variable "location of contacts during the first visit" there is an inconsistency for a few cases that were categorized as being present according to the first variable while instead they were in hospital (1), at school (5), at work (11) or in other places (6) according to the second variable.

Box 1 Example of inconsistency between two inter-related variables

	PRESENCE OF CONTACTS
ABSENT	3847
PRESENT	5169
	9016

	location of contacts during the 1st visit						
	At Home	Died	Hospital or	Other	School	Work	Totale
ABSENT	0	16	104	627	1784	1316	3847
PRESENT	5146	0	1	6	5	11	5169
	5146	16	105	633	1789	1327	9016

This is an unexpected finding, because this type of inconsistency is usually present when paper forms are used and data are entered manually. GeoMed should use skip logic to avoid such inconsistencies. Nonetheless, these types of inconsistencies are part of the experience gained during the pilot and are usually more frequent with the traditional data collection on paper and the manual data entry.

TB among contacts

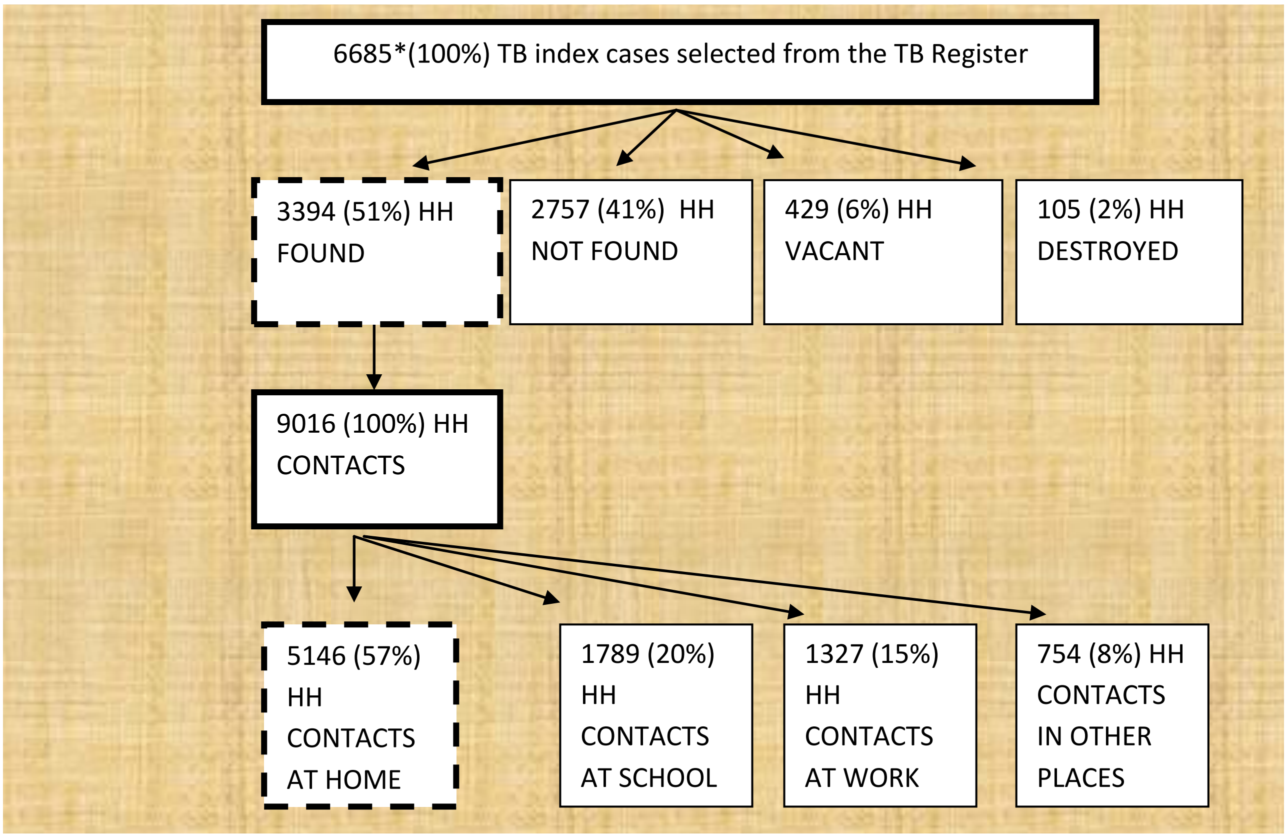
Box 2 provides a representation of what happened during the pilot. In May 2011, 6685 TB index cases provided the roster to identify the households to be visited. Of these initial number, 3394 (51%) were found, while 2757 (41%) were not found, 429 (6%) sites were vacant and 105 (2%) had been destroyed. The high proportion of untraced households could be due to the fact that patients gave the wrong address because they did not want to be traced, the address was difficult to find or these households were located in informal settlements. It cannot be excluded that the traced index cases might have differed in some characteristics from the untraced ones, but this hypothesis could not be tested.

As far as the traced households are concerned, most index cases were still on treatment and more than half of the contacts were at home. Of the 3394 traced index cases, 2932 (86%) were on treatment, while the rest were completed/cured (7%), defaulted (2%), dead (5%), failed or never started (<1%). The traced households provided 9016 potential family contacts but only 57% were present while the rest were mainly at school or at work.

Workload

After the data were cleaned from inconsistencies and duplications, the statistical outputs were compared with the GeoMed database reports. Table 2 provides a comparison between the workload estimated from the GeoMed report and from the validation. These estimates are useful to monitor the tracing program in terms of targets of households visited and time taken to assess them. It can be noticed that the estimates from GeoMed is very similar to the estimates of the validation. There was a high variation among teams in terms of the number of households they tried to trace and the average time spent per tracing. The number of attempted tracings per team varied between 7 (Phone 45/West Area 1) and 380 (Phone 5/North Area 2).The average time spent in minutes per attempted tracing varied between 1.1 minutes (Phone 45/West Area 1) and 16.5 (Phone 46/West Area 1). This variation is explained by the fact that some teams are more seasoned than others and some teams might have covered areas where most households could not be found and vice versa. Overall, the average time spent per household assessment was 11 minutes.

BOX 2 Selection of households



* Of the 6685 TB index cases, 177 (2.6%) were MDR TB and 1 was XDR TB. The XDR case was on treatment and there were no contacts who were TB suspects. Of the 177 MDR, 73 (41%) were traced, of which 65 (90%) were on treatment, 4 (5%) were dead and 4 (5%) were cured/completed. Sixty five MDR TB (37%) were not found, 39 MDR TB (22%) had not yet been visited.
Of the 73 traced MDR, 6 (8%) had 9 contacts who were TB suspects, of which 4 were 1-8 years old children and 5 were adults (3 provided sputa and 2 were referred).

Table 2 Number of visits by the tracing teams and time taken per visit

Tracer Team	GEOMED		VALIDATION	
	Visits	Average minutes	Visits	Average minutes
Admin Handset - West	70	3.9	70	3.9
Phone 10 - North/Area 3	238	0.6	347	3.2
Phone 11 - West/Area 1	156	8.9	157	8.9
Phone 12 - West/Area 3	122	10.1	134	9.9
Phone 13 - South/Area 5	223	6.2	250	5.1
Phone 14 - South/Area 1	223	9.5	243	9.6
Phone 15 - South/Area 5	233	5.0	236	4.9
Phone 17 - North/Area 6	107	6.8	108	6.8
Phone 18 - South/Area 2	75	11.9	76	11.8
Phone 19 - North/Area 5	48	8.6	60	7.8
Phone 1 - North/Area 4	51	5.9	51	5.9
Phone 20 - South/Area 5	90	6.1	90	6.1
Phone 21- South/Area 2	207	9.0	216	9.3
Phone 22 - North/Area 4	229	6.5	250	6.3
Phone 23 - replaced by 43	15	11.5	15	11.5
Phone 24 - South/Area 1	214	6.1	215	5.6
Phone 25 - North/Area 2	241	4.7	248	4.7
Phone 26 - West/Area 3	126	2.7	191	3.8
Phone 27 - North/Area 6	150	4.6	161	4.7
Phone 28 - North/Area 5	148	5.6	153	5.6
Phone 29 - North/Area 3	144	10.0	145	9.6
Phone 2 - West/Area 4	95	16.9	97	13.8
Phone 30 - North/Area 2	246	1.3	253	1.4
Phone 31 - South/Area 2	258	8.9	266	8.7
Phone 32 - South/Area 6	158	9.7	170	8.8
Phone 33 - South/Area 3	102	7.4	104	7.4
Phone 34 - West/Area 2	48	3.8	48	3.8
Phone 35 - West/Area 2	78	10.2	78	10.2
Phone 37 - South/Area 2	102	9.4	104	9.5
Phone 38 - West/Area 2	53	6.9	54	6.9
Phone 39 - South/Area 4	342	4.8	345	4.8
Phone 3 - North/Area 4	123	6.5	124	6.5
Phone 40 - South/Area 4	341	3.6	342	3.6
Phone 41 - South/Area 3	178	5.3	179	5.3
Phone 42 - South/Area 7	150	6.7	158	6.8
Phone 43 - South/Area 6	243	8.3	276	8.5
Phone 44 - South/Area 8	189	6.3	190	6.3
Phone 45 - West/Area 1	7	1.1	7	1.1
Phone 46 - West/Area 1	11	33.1	16	16.5
Phone 48 - North/Area 1	63	4.6	63	4.6
Phone 4 - West/Area 1	66	6.5	68	6.5
Phone 5 - North/Area 2	360	5.0	380	5.1
Phone 6 - Not functional	19	7.3	19	7.3
Phone 7 - West/Area 4	114	5.7	122	5.9
Phone 8 - North/Area 4	84	10.7	92	10.6
Phone 9 - West/Area 2	47	7.6	58	8.5

The GeoMed reported numbers and the validated numbers were almost coinciding, although there were a few exceptions. Table 3 shows that most numbers in the second column (GeoMed) were very similar to the numbers in the third column (validation). The first discrepancy were the 14,537 "clients registered" versus the 12,410 found by the validation. This difference was probably due to the fact that the higher number included also the index cases whose households were not found. To be noted that if "client registered" were to include only the contacts and exclude the index cases, the number would be reduced to 9016.

On a similar note, the total number of "contacts found" was 8,385 according to GeoMed versus 9016 according to the validation. To be noted that if "contacts found" were to include only those who were present in the household, the number would be 5416. The above mentioned discrepancies show the need to clearly define the inclusion and exclusion criteria for each variable.

It should be noted that the number of suspects who were confirmed positive for the sputum test according to the GeoMed report were 22 while only 7 contacts were confirmed positive by analyzing the raw data. This difference is due to the fact that the 22 positive tests from the database report were a mix of index and contacts. This reliability problem could be due to the query used by the database to extract the report. Another major difference was found in the number of pregnant women who were referred to clinics, who according to GeoMed report were 25 versus 47 in the validation, resulting in 28% (25/89) and 52% (47/90) coverage according to GeoMed reporting and the validation respectively. These problems are easy to fix but require on the part of GeoMed to conduct regular internal validation of their reports to identify and correct these problems that might hamper the credibility of the database.

Table 3 also shows that besides identifying suspect TB cases to be tested, the tracing activities had also the benefit to provide other services. Besides collecting sputa from 449 suspects, 3805 contacts were counseled of whom 1434 (38%) accepted to be tested, 252 (18%) of whom were found to be HIV positive. About half of the pregnant women were referred to clinics. The SP system was limited to recording the information on the referrals but no information was available on the outcomes of referrals.

Table 3 Differences between GeoMed and the validated data

Number of	GeoMed	Validation
Teams	45	43
Households visited	3739	3394
Households not found	2558	2757
Clients registered	14537	9016 contacts + 3394 index =12410
Contacts found	8385	5146 contacts + 3680 absentees = 9016
Suspects found	803	761
Suspects sputum collected	448	449
Suspects confirmed positive	22	7
Suspects started on TB treatment	22	6
Children started on IPT	57	31
Persons counseled	3791	3805
Counseled persons HIV tested	1426	1434
Tested persons HIV positive	252	252
Pregnant woman	89	90
Pregnant woman referred	25	47

One major problem was the inconsistent information about the number of sputa collected from the suspects. Table 4 represents the sample of TB suspects among contacts of TB index cases that were invited to provide sputum. This sample was cross-tabulated against the following two inter-related variables that were found in the data sets: “sputum collected” and “decision taken”.

Although these two variables should have given the same number of total sputa collected, this is not the case. The first variable “sputum collected” (in the rows) gives a total (end of the ‘Yes’ row) of 467 sputa, while the second variable “Decision Taken” (in the columns) gives a total (end of the ‘Take sputum’ column) of 359 sputa. The cell in the lower right hand corner of Table 4 provides a consistent number of 347 sputa for both variables. The cell on the upper left corner of Table 4 provides a consistent number of 153 for “no action” (first column) and for “no sputum collected” (first row).

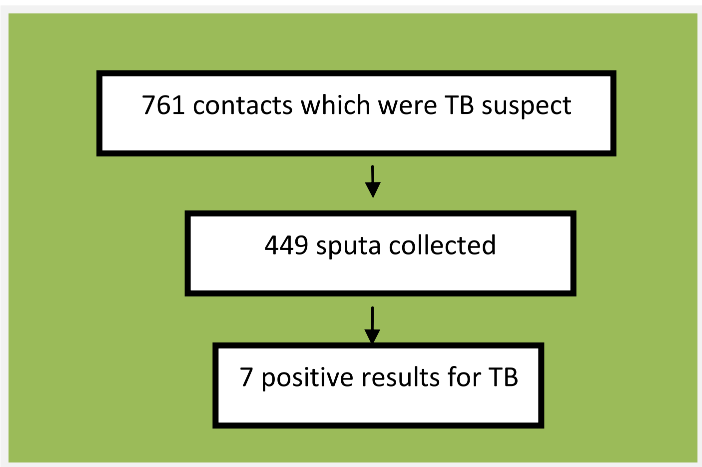
There are 18 inconsistent cases for which sputum was collected, although “No action” was taken and there are 12 inconsistent cases for which sputum was not collected according to the variable “sputum collected” in the rows while the “Decision Taken” was “take sputum”. The numbers in the middle of Table 4 are likely to be correct because the 245 cases for which “Decision Taken=referral” could have been split into 143 for which sputum was not collected and 102 for which it was collected.

Table 4 Inconsistencies between two inter-related variables on the specimens collected

		Decision	taken			
		No action	Refer	Take sputum	TOTAL	
Sputum collected	No	153	143	12	308	
	Yes	18	102	347	467	
TOTAL		171	245	359	775	

After a final data cleaning, the suspects were 761 and the sputa collected were 449. Box 3 shows that there were 761 suspects corresponding to 15% of the 5146 contracts who were found at home. Of these suspects, 449 (59%) provided sputa while the remaining suspects did not, mainly because they could not expectorate.

Box 3 Sputa and test results



Chronic Degenerative Diseases

The prevalence of chronic degenerative diseases is to be viewed with caution, because it was based on simple questioning, which has a low validity. The results in table 5 show that there were no significant differences between the GeoMed report and the validation. It has to be noted that the prevalence was based on the assumption that people knew if they were suffering from these diseases, but this is unlikely to provide a valid answer that would require a series of clinical algorithms to be tested in the local language. That the replies might not reflect the true prevalence for these diseases is suggested by Table 6, which shows unrealistically high prevalence rates of 48% hypertension and 20% diabetes for the age of 65 years and above (95% CI in brackets).

Table 5 Prevalence and treatment of Chronic Degenerative Disease

	GeoMed Report		Raw Data	
	#	%	#	%
Hypertension	373	8%	377	8%
Hypertension treated	310	83%	309	82%
Diabetes	149	3%	149	3%
Diabetes treated	126	85%	125	84%
Silicosis	34	1%	31	1%
Silicosis treated	5	15%	4	13%

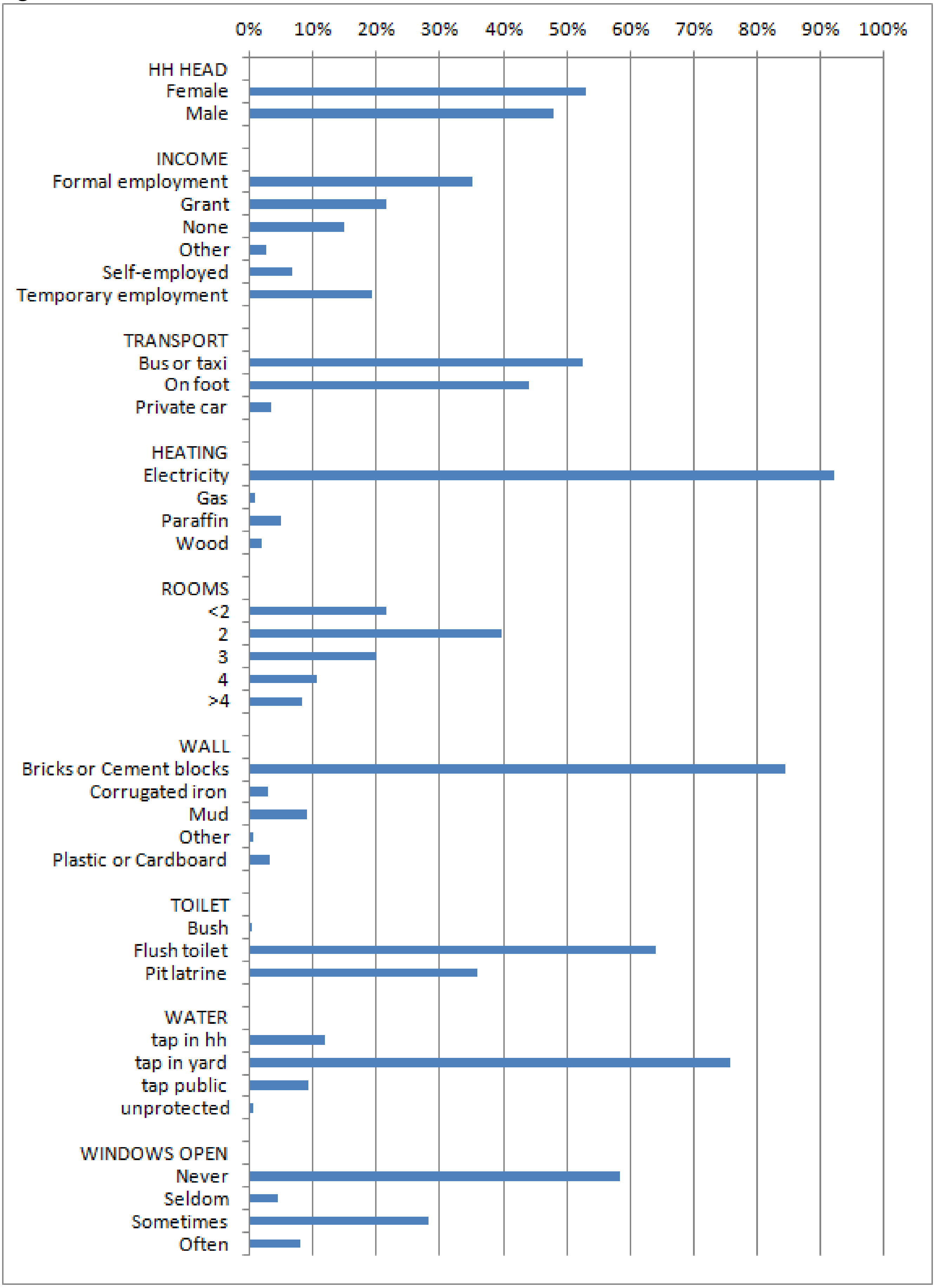
Table 6 Prevalence of Chronic Diseases by age

	<15	95%CI	15-44	95%CI	45-64	95%CI	65+	95%CI
Hypertension	1.4%	(0.8%-2.1%)	1.8%	(1.3%-2.3%)	28.0%	(24.6%-31.4%)	48.1%	(41.9%-54.4%)
Diabetes	0.6%	(0.2%-1.1%)	1.0%	(0.6%-1.4%)	9.7%	(7.5%-12.0%)	19.8%	(14.7%-24.8%)
Silicosis	0.4%	(0.05%-0.07%)	0.8%	(0.5%-1.1%)	0.9%	(0.2%-1.6%)	0.0%	

Demographic, clinical and socioeconomic characteristics

The sociodemographic characteristics of the head of the households reflected their urban location (Figure 2). One third was formally employed and the rest was self-employed, temporary employed or were receiving grants, with 15% having no income. Over 9 out of 10 household had electricity, about 2 out of 10 had 4 rooms or more, most houses were built of concrete, while very few possessed a private car. More than half of the households had access to tap water and flush toilet. Only a minority was keeping windows open for ventilation because of security concerns.

Figure 2 **Household variables.**



Differences between index and contacts

The main differences between index cases and contacts are reported in Figure 3 and Table 7. Figure 3 shows the age distribution for index and contacts cases, with the spikes indicating that age was rounded up or down to the nearest digit. This rounding is commonly found in surveys carried out in developing countries where exact age might not be known. The age distribution of the contacts follows the same pattern of the general population with higher proportion of children and young people, while the index cases have a concentration of cases in the productive age group, which is expected for HIV/AIDS and TB. There was a higher proportion of women among contacts, while males were more frequent among the index cases.

Figure 3 Proportional age distribution

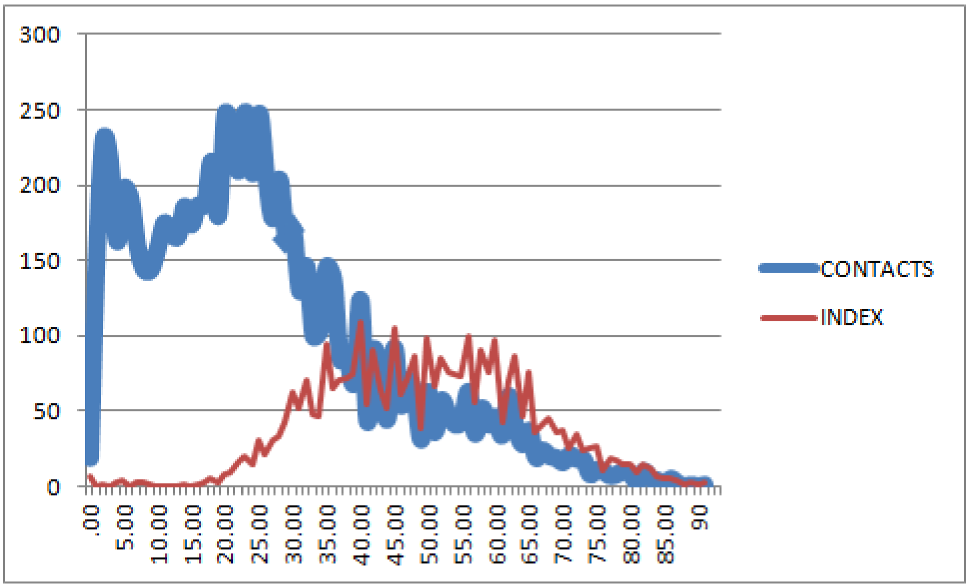


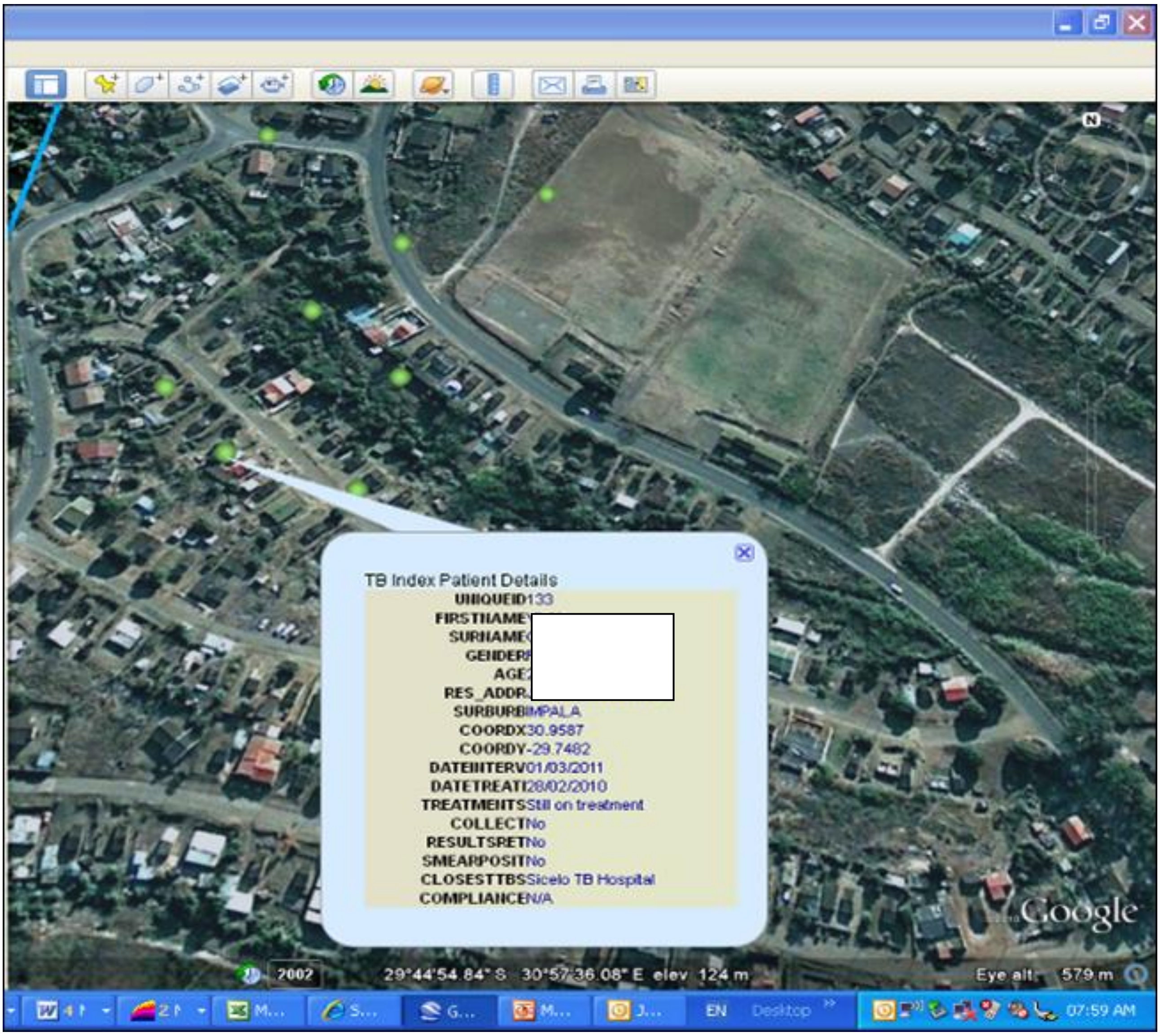
Table 7 Sex of index and contacts

	Index	Contacts
Females	1536 (46%)	5091 (56%)
Males	1812 (54%)	3925 (44%)
	3348	9016

GIS Mapping

One of the most attractive features of the SP system is its link with Google Earth Mapping, which allows tracing teams to plot household cases on maps. This provides a visual representation of the location of the TB index cases and contacts, with the possibility of identifying unusual concentration of cases in limited geographic areas. However, because a high concentration of cases might be the results of population density, the study of clustering would require a population base to estimate the incidence. This is not always easy because the population censuses have had their problems in correctly estimating populations for small geographic areas.

Figure 4 GIS mapping



Results on the use of the SP by the tracing teams

This section deals with the information that was collected from the tracing teams. The assessment was based on self administered questionnaires that were filled by 25 members of the tracing teams and on the focus group discussions with the tracing teams and the managers. The results of the analysis are in Tables 8 and 9, which were compiled by Dr Christopher Knudson. The tracing team members who were interviewed had an average age of 40 years, the majority had a university degree, had been members of tracing teams for less than 1 year and very few had used SP before.

Table 8 Characteristics of the sampled tracing team members

Demographics		
Respondents		
Total number	25	
Age		
Average	40.4	23 respondents
Range	23-59	
Education		
University or higher	16	64%
Secondary & matric	5	20%
Secondary, no matric	3	12%
No reply	1	4%
Primary language		
Zulu or Xhosa	17	68%
English or English/Zulu	7	28%
No reply	1	4%
Months on contact team		
Average	11.16	25 respondents
Range	3 - 24	
Used smartphone before		
% Replied yes	8%	24 respondents
Team role		
Supervisor	12	48%
Non-supervisor	13	52%

Training and supervision

The tracing teams had a positive experience with the training on the use of the SP. Seventy six percent of interviewees were satisfied with the training they received, although only the first batch of tracing teams was formally trained, while the newcomers were trained by their own colleagues. There was a felt need for more formal training to be provided together with training modules and a manual, with additional training in the areas of clinical and laboratory aspects of TB.

The training did not cover the recording of the results of the sputum tests. This was due to the fact that this information was not supposed to be entered by the team, as it should have been automatically updated by creating a link between the SP information system and the laboratory information system. This will require an official clearance by the National DOH to allow further discussion between GeoMed and the programmers of the laboratory to solve technical problems.

Formal training curriculum and training materials will have to be produced, with greater emphasis on how to deal with the problems experienced during the present phase. The tracing teams were satisfied with the supervisory support, with most of them getting regular feedback, meeting with supervisors to discuss problems and identifying a suitable person to suggest improvements to the system.

Table 9 Results of the interviews of tracing team members

	#	total	
Training/feedback			
Overall satisfaction with training	19	25	76%
Satisfaction with specific training on contact tracing	16	25	64%
Received feedback from supervisor:	22	24	92%
.past week	6	21	29%
.past month	13	21	62%
.past 6 months	0		-
.never	2	21	10%
Had a meeting witgh management to discuss SP problems:	17	24	71%
.past week	0	17	-
.past month	12	17	71%
.past 6 months	3	17	18%
.never	2	17	12%
If you had suggestions on improvement do you have somebody to talk to ?	11	22	50%
Smartphone caracteristics			
Isier than paper	23	23	100%
Faster than paper	19	21	90%
Difficulty in seeing the screen	2	24	8%
Size of screen satisfactory	22	24	92%
Problems with keypad	1	24	4%
Have you ever run out of battery ?	13	24	54%
Have you ever had a problem saving data ?	6	19	32%
Have you ever problems sending data ?	10	22	45%
Have you ever had other technical problem ?	12	22	55%
Access to technical support	9	13	69%
Access to charger/spare parts	14	24	58%
Have you ever replaced SP ?	7	24	29%
How long did it take to replace SP ?			
-<1week	1	6	17%
-1-2weeks	1	6	17%
-3-4weeks	2	6	33%
->1 month	2	6	33%
Was your smartphone ever stolen	0	23	0%
How frequently do you need to use paper as back up ?			
-often	1	19	5%
-sometimes	8	19	42%
-seldom	11	19	58%
Data collection			
Some information being collected should be excluded	12	23	52%
Some information is missing and should be added	10	19	53%
Would like to receive some outputs from the data being collected	21	24	88%
-maps	11	21	52%
-statistics	8	21	38%
-reports	13	21	62%
-other	1	21	5%
Feels that the information collected improve contact tracing objectives	23	24	96%
Other Issues			
Takes steps to keep data private	23	24	96%
Has been trained in infection control	19	24	79%
Provided with masks N95	18	25	72%
Wears the mask:			
-all the time	5	25	20%
-for certain tasks (MDR patients, colecting sputum, initial assessment, taking blood sample)	15	25	60%
-never	5	25	20%
Provides info on TB control to families	25	25	100%
Workload advantages in using the SP			average
How easy is it to use SP between 1 and 10 (1=very difficult, 10= very easy) ? (24 responses)			8.8
How many minutes do you save per recorded patient by using SP vs paper ? (18 responses)			13.6

Management

Managers were positive about the use of SP, but several stumbling blocks remained to be solved. As in the adoption of any new technology there might be expectations that quality of data will be automatically solved and the technology will provide all the answers. During the focus group discussion with eThekwini District TB management, the impression was that the project was coming from outside the DOH and it was up to URC and GeoMed to fix all the problems and to produce statistics to instruct decision making.

SP is a useful tool to speed up data entry and processing of information but it will be up to management to know what to do with the statistics coming out of the system. It would help to redesign the management information strategy and to strengthen the collaboration among key players (e.g. laboratory) to use the information to improve the activities of the TB control program.

Communication between GeoMed and the Laboratory had been not ideal. The major weakness is that at the moment there is no progress in tracing the laboratory results to enter them into the SP system. Communication has also affected the relationship between tracing teams and district TB managers on one side and GeoMed on the other side. The tracing teams felt that insufficient help had been coming from GeoMed and the management could not solve the problem on how to integrate the lab results into the management system. Because of this situation there was a felt need to assign a full time manager to deal with the SP system.

Tracing Teams

There was a unanimous agreement that the SP was a more efficient tool compared to filling paper forms. On a scale from 1 (very difficult) to 10 (very easy) the interviewed tracing teams gave an average score of 9 and they estimated a shorter time per recorded case by using the SP compared with the paper forms. In terms of having problems with the screen, 92% had no problem and found the size satisfactory and the keyboard easy to use. Major felt advantages included speed and security in storing the information.

Several technical problems were experienced by the tracing teams. These included running out of battery, difficulty in scanning barcodes and in retrieving records, system freezing at the end of data entry for the index cases, loosing information when the battery was low or the network signal was week. Other problems included difficulties in capturing GPS coordinates in isolated rural areas and in sending data. There were instances when in the middle of an interview the SP had an automatic reset, with subsequent loss of data and the need to start all over again. There was inability to retrieve records to enter corrections and there were no replacements of the SP when it needed repair. When teams had technical problems with the SP they had to use paper forms to collect data, which involved returning to the household for a second time to scan the barcode and enter the data into the SP.

The focus group discussion brought up the issue of the untraced households, which affected 4 households out of 10. The major reason for not being able to find the households included non-residents leaving a fake local address in order to attend a Durban clinic, patients giving a wrong address because of stigma and or because of leaving in informal settlements. A solution could be to alert the clinics about these un-traced patients so that when they return to the clinic they will be asked for the correct address. Another solution would be to involve the community health workers in accompanying the patients to their households to take the GPS coordinates.

The focus group discussion brought up other concerns that management needs to consider. There were security concerns especially for female team members operating in isolated areas. These problems could be reduced through security training and the involvement of community leaders. Tracing teams expressed the need to have 4x4 vehicles to reach difficult areas, and to be provided with a few supplies such as boots, raincoats, hats and water supplies.

Discussion

The objective of the evaluation was to summarize the experience of the first seven months of the SP pilot. The evaluation has identified both positive and negative aspects of the pilot experience, the major implementation problems, their potential causes and the actions required to solve them. The reports from GeoMed database were reliable, with the exception of the laboratory results that require solving the communication problem between the actors involved. The evaluation has served the purpose to sound specific alarm bells which need to be switched off by taking corrective actions.

Objectives and scope of the SP system

The specific objective of testing the feasibility of using SP in a routine setting to speed up data collection and transmission has been achieved. The results confirm that the users prefer to record data into SP than on paper and GeoMed has produced a software providing timely reports. The pilot was also successful in identifying technical problems and the under-utilization of information for action. The former can be easily solved while the latter, which is a common problem affecting many information systems, requires an information strategy. The major problem of missing data on the test results was due to expectations not being met, but it can be expected that in such a pilot, which was using routine health services and was supported by minimal external resources, problems were bound to happen. The aim of this pilot-testing was to identify these types of problem so that solutions will be applied in the following phase.

Relevance of collected information

The information which was collected was relevant to the scope of the pilot, which was limited to the intensive case finding. The information that has been collected up to now has covered the initial baseline of the traced contacts, while the follow up will be the objective of the next phase. The information about TB symptoms and sputum collection is relevant to identify suspect cases to be tested. The information on the household is relevant to identify potential risk factors for TB transmission, such as crowding conditions and socioeconomic status. Some variables (e.g. household use of electricity) have shown low variation, suggesting that their use is limited as a proxy of socioeconomic status that might be used to identify household at higher risk for TB. The information on the services provided during contact tracing and on the prevalence of chronic degenerative diseases is not specific to TB control but it has been requested by the National DOH in relation to the effort to integrate data collection into Primary Health Care. A further aspect which has not been sufficiently considered is the potential problem of validity for certain variables (e.g. prevalence of chronic diseases) that might require further thoughts in the second phase.

There were some issues with a few indicators that might not have been completely in line with the logframe of the TB control program. Once the logical framework will be straightened out in the next phase it will be possible to review which information might be left out and which might be added to fill the gaps. Each piece of information should be justified in terms of its use to make the TB control activities more efficient and effective. The lack of clarity about objectives and scope of an information system is frequently associated with the addition of all sorts of variables that might not always be justifiable and which overload the system.

Definition of indicators

More documentation should have been provided on the overall information strategy and the definition of indicators. The indicators related to the TB control program included the prevalence of suspect cases among contacts and the proportion of suspects providing sputa. Some other indicators were not within the domain of TB and they should have been defined in terms of numerator and denominator, validity and use. This is especially relevant for some indicators the meaning of which was not always straightforward. For example the two indicators related to child health services: "epi" and "epi referral", are not defined and they can be affected by subjective interpretation. Similarly, the origin of the data source (e.g. child immunization card?) should have been specified. In the planning of the next phase, definition of indicators and data sources should be established according to international standards to reduce inter-observer variation.

Data Reliability

Overall, the information produced by the SP system was reliable. The reliability of the data has been assessed by running frequency distributions, checking for duplicates and cross-tabulating inter-related variables. Most of the reporting from GeoMed coincided with the results produced by the validation. Duplications and inconsistencies can be easily fixed. The duplications are entered in time intervals that are too short to be caused by repeated manual entries and they are more likely to be due to SP technical problems. GeoMed should set rules to decide which of the duplicated records is to be accepted. One decision could be to accept the last record according to the time when it was recorded, but this would risk losing important information in case a test result might have been recorded before the latest duplicated record. Therefore, there should be a hierarchical information structure in which priority is decided about which type of information (e.g. test results) should be accepted independently from the time of data entry.

GeoMed should carry out routine internal validation of the reports produced through queries. Out of range values such as age which is negative or beyond 100 should not be accepted by the system, prompting the data collector to re-enter the data. Cross-tabulations between inter-related variables, such as "sputum collected" and "action taken", should be used to identify inconsistencies and to apply the required skip logic. The main advantage of the SP system is to program the data entry in such a way that redundancies are eliminated and irrelevant questions are skipped to avoid contradictions. This will decrease the chance of producing tables that are clearly at odds with reliability and risk to decrease the credibility of the database.

SP

Overall the SP has been widely accepted as a method of data entry but its potential is still to be fully tapped. Although there are minor technical problems, the SP is preferred to collecting data on paper, but the software processing the data and producing the reports has to be straightened up to tackle the problems identified by the evaluation. There is need to revisit the way the SP system can be regularly validated to avoid duplicated records, inconsistencies and under-recording of lab tests.

The technical problems experienced by the tracing teams can be easily fixed by GeoMed by identifying the causes and by producing clear instructions on how to use the system. The causes of the crashes experienced by the SP in the middle of interviews can be investigated if the tracing teams are instructed to enter the report option that will enable GeoMed to trace what happened at the time of the crash. The SP has introduced a section that is deputed to the data entry of the ID number written on the lab request and this is to be included in the instruction manual and it should be emphasized during the training. Another area to be clarified during the training is the use of the option to retrieve a record. The difficulty experienced with the scanning of barcodes can be due to the wear and tear of the barcode kept by the household, which requires a practical solution.

Use of the information

The major problem was the missing information about the laboratory results. At the beginning of the project, discussions were held among stakeholders to automatically link the results of the laboratory tests with the SP system. As it was planned to have an automatic update of the laboratory results, there was no data entry on the SP by the tracing teams. However the automatic update did not materialize and no information was available on the results of the tests. During the evaluation, an attempt was made to retrieve the missing information on the laboratory tests by tracing it on the suspect registers. But a few registers had been lost and only 28 positive cases were found, of which only 5 were matching the contacts in the GeoMed database. Another attempt was to send the list of suspect cases found in the GeoMed database to the Laboratory for the retrieval of the test results from their own database. The list had detailed information on names, age, dates of birth, dates when the specimens were collected, which should have been sufficient to retrieve the test results, but there was no response. While trying to resolve the issue of the automatic update, the temporary solution for the next phase will be to train the tracing teams to enter the data onto the SP system when they report back the results to the contacts.

The use of information will require careful thoughts during the planning of the next phase. The mHealth system has several applications in the health sector, but its attractive features risk to become an aim in itself instead of being considered a mean to improve the effectiveness of program activities. It is therefore necessary for the next phase to clarify the logical framework behind the main components of the TB tracing system including diagnosis, treatment and referral. This would help to define the role of the information system in monitoring inputs, outputs, outcome and impact in line with the TB control strategy.

As in any information system, the technical problems are compounded by the complexities of human interactions and effectiveness in communication. Technical problems are relatively easy to fix, but the collaboration and coordination of the data owners require leadership, communication, willingness to take the extra efforts to help one another, sense of direction to achieve the common good and other skills that are usually in short supplies.

Next Steps

An information strategy should be produced during the planning of the second phase. Project management should go back to the drawing board to brainstorm about the objectives of the data collection, the type of information matching the objectives, the resources available and the need to prioritize. For example, because of scarcity of resources there might be a need to prioritize action on defaulters and MDR and XDR TB cases, which would yield higher returns per Rand spent. After such priority cases are successfully monitored it will be possible to expand the system to include also the less problematic cases of drug sensitive TB.

Once the scope and objectives are clarified it will be possible to build a logical framework at the basis of the data collection. If the data collection system has a main focus on management, the indicators should be more action-oriented and less geared towards epidemiological objectives. This means building the logframe around indicators related to the chain of inputs and outputs linking the TB control activities to the outcomes and impact. This might need to exclude unrelated information which although interesting would overload the system.

In this context, all the variables presently collected should be matched with the indicators suggested by the logframe to identify what could be excluded and what needs to be added. Many could question the usefulness of collecting household variables if they are not justified by the scope and objectives of the monitoring system. For example, the household variables might be considered not very relevant to TB control activities unless a clear rationale for their use is specified. An example of such rationale would be to use the households' information to build a deprivation score. This could be followed by further analysis on the relationship between such score and risk for TB transmission, default and other negative outcomes. This could then be used to identify households that are at higher risk and require extra resources to monitor treatment compliance.

Once the indicators are selected according to a clear rationale, it will be necessary to discuss their measurement methodology. For example, prevalence indicators (e.g. hypertension), besides being not very relevant in terms of TB control, require a valid measurement methodology. Just asking for the presence of diseases might be associated with low validity because people might not have knowledge about these medical conditions. Therefore, if it is decided that prevalence of these disease needs to be collected a methodological review of valid survey methods used to measure such prevalence will be needed.

During the next phase there should be a review of each piece of information that is presently collected. This would help to check about definition, relevance versus the logframe and the methodological validity of the measurement methods. The discussion with management and the tracing teams has already brought to light certain problems related to collecting specific variables.

At the moment, six symptoms are used to classify suspect TB cases, of which general illness and chest pain seems to be lacking specificity and therefore should be taken out. The question about the frequency with which the household members experience hunger, besides being not very relevant for the main objective of the monitoring system, might create false expectations for food subsidies. The question about the experience of a TB death in the household should exclude any death related to the index case. The question about pregnancy should be skipped in case of children below 10 years of age.

Recommendations

GeoMed should fix the identified problems, produce documentation on data structure and variables definition and find a method to internally validate the statistics produced.

An information strategy should be discussed with management. This will require clarification of scope and objectives of the data collection, logframe, indicators, measurement methods, validation and use of the information. This should be part of the management process to clarify what information should be collected in the next phase, how and for what reasons. The discussion should also encompass roles and responsibilities of the various role players.

Revise the list of variables accordingly. Extra information needs to be added during the second phase to improve the effectiveness of the mHealth data collection system. Indicators are proxies of a logical chain linking inputs and outputs and can be used to identify impending management problems and bottlenecks that may break this logical chain and cause a failure in achieving the expected outcomes and impact. While the information collected during the first phase has been related to the baseline characteristics at the time of diagnosis, the data to be added in the following phase will concern the treatment compliance and the follow up visits. Therefore, management indicators to be collected during the follow-up will need to have a clear purpose in term of triggering action. Last but not least, management needs to tap the value added potential of using timely information to identify problems requiring immediate action.

Training needs to cover a few key areas more effectively. These include the data entry of the ID number that is attached to the lab request, the handling of specimens and the proper labeling of the cooler boxes, the provision of a SP instruction manual and other training materials. Other areas to be strengthened are the follow up visits and the tracing of defaulters that will be critical for the success of the second phase, which will be geared towards the full monitoring of treatment compliance. An area to be covered because of felt needs is related to training to improve security in unsafe areas, such as identification of risk factors that will be useful to prevent a dangerous condition from deteriorating further.

District management needs to build a sense of ownership for the project. One solution would be to appoint a manager to lead daily activities and liaise with the tracing teams, the national lab and GeoMed. He/she should be supported by a technical monitoring specialist who will have the responsibility to follow up the update of the information retrieved from the SP system, identify problems and initiate solutions, interpret the quality of the data and use the information to help the managers to take actions.

Communication between district management and the National Health Laboratory needs to be strengthened. This might be achieved by the already mentioned appointment of a full time project manager and the proactive follow up of the action agreed with the lab. An MOU could be drafted to clarify roles and responsibilities of everybody involved.

Conclusions

There are very few documented validations of the use of SP in routine clinical settings and this validation has provided sufficient value added information on the application of this technology in monitoring TB control activities at the household level. This pilot has used scarce resources and has been integrated in routine activities carried out by the DOH and thus it has provided a first building block for a further expansion of the SP system to monitor the full management process of the TB control program in the eThekwini Metropolitan Area.

The technology has been well received by the tracing teams that have found it preferable compared to collecting data on paper forms. The data entry and transmission has run relatively smoothly except for a few technical problems requiring attention. The use of SP has been limited to the data entry of the diagnostic phase of the TB program and its untapped potential is still to be fully exploited.

The main weakness is the scarce use of the information by management that needs to take a proactive approach to discuss what to do with the data produced by the system. The second phase should test the capacity of using the information to speed up management action and should be geared at proving that indeed the use of information can make a difference. In this context, the next phase should try to integrate an economic evaluation of the SP by comparing its costs with the cost of the traditional information system.

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ANNEX I Mobile health (mHealth) to support TB-DRTB and HIV-AIDS programs

Definition and general considerations

MHealth has no standard definition, but it is commonly used to indicate any utilization of mobile technology device in health care settings. A WHO survey[1] defined mHealth as 'medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices'. Of the 112 countries included in this WHO survey, 93 countries were implementing mHealth projects, suggesting that the use of this technology is being rapidly adopted. However, its impact and effectiveness has not been evaluated as only 12% of mHealth projects have undertaken such as evaluation.

WHO also found that the largest barrier to scaling up or continuing mHealth projects was competition among health priorities. The second largest barrier was lack of clarity about how to use mHealth applications to influence relevant health outcomes. As there is no significant evidence that mHealth can improve performance of current health systems, makes adoption of the new technology difficult to justify.

Moving toward a more strategic approach to planning, development, and evaluation of mHealth activities will greatly enhance the impact of mHealth. WHO will support the use of mHealth in Members States to maximize its impact.

To better exploit the potential of mHealth in enhancing the effectiveness of health care programs, another coordinating body the mHealth Alliance, hosted by the UN Foundation, Vodafone Foundation & Rockefeller Foundation & Gates Foundation was launched in 2009.

Reasons for Mobile Health

The potentials of mHealth are further suggested by its high coverage in developing countries. Use of mobile phones around the world has been increasing more rapidly than any other technology. Today there are over 5 billion mobile subscribers worldwide, of which nearly 2/3 are in developing countries. Soon 90% of the world population will be within coverage of wireless network and mHealth will be able to revolutionize the ability of government services, corporations, NGOs and citizens to deliver, access and use health information to promote well being, combat diseases and respond to medical emergencies.

The strategic objective for mHealth is to:

- Improve access to general and emergency health care services;
- Improve efficiency of health service delivery;
- Improve disease surveillance and control;
- Enhance collection of vital statistics on births and deaths to refine public health interventions;
- Improve monitoring and evaluation of health system activities for enhanced planning and decision making; and
- Improve community interventions.

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[1]WHO Report 2011; mHealth: New horizons for health through mobile technologies based on the findings of the second global survey on eHealth. http://www.who.int/goe/publications/ehealth_series_vol3/en/

mHealth and TB program

The role of mHealth in TB management can support planning, monitoring and evaluation. Geo mapping of TB cases can be used to identify "hot spot" area to allocate human and financial resources and the combined use of SP can guide and support the interventions at community level. The use of SP is especially value added to monitor TB treatment through the real time data collection and transfer of data compared with the traditional paper system. The information can be made available to decision makers at different level (Eg: National/ Provincial/District/Subdistrict and Health facility) through secured web based reporting and mapping.

There are several advantages in using mHealth. They include intuitive use of the data entry onto SP, skip logic to avoid inconsistencies, built-in decision support, notifications & reminders, data accuracy, access to data trough a web portal, increased patient confidentiality, and integration with the rest of the health information system by linking with the electronic TB and DR TB registers and with the laboratory information system.

To address the dual epidemic of TB and HIV/AIDS we need new monitoring and evaluation tools. The decision by the National South Africa DOH to move from a curative to a preventive approach trough community intervention is promising. The mHealth system used in eThekwini Metropolitan area pilot project can help to lead the way on community level M&E systems.

At the moment TB and MDR TB patients are monitored at health facility level according to the WHO methodology. But the major drawback of this system is the quality of the information and the timeliness with which it is made available (quarterly indicators). Paper based data are collected at facility level where they are captured in the electronic TB register (ETR) and the Electronic Drug Resistance (EDR) TB registers by nurses or data capturers. Reports are automatically generated but errors can be generated as well at different level of the data collection and data processing system.

What is missing at the moment is a community Monitoring & Evaluation system that will be able to timely support TB patients and their families. The only consistent DR TB household contact investigation is ongoing in UMzinyathi district since 2006. The families of MDR XDR TB index cases are visited regularly every six months. This activity has allowed the identification of early transmission of TB and DR TB and the provision of HCT in the family. The M&E tool used is a paper questionnaire. The same questionnaire has been used to prepare the one adapted by GeoMed, SA IT company to be used with SP in eThekwini.

EThekwini Pilot project

In March 2011 the SA Minister of Health launched a TB intensive case finding campaign focused on hot spot area such as eThekwini Metropolitan area. The mHealth system to support the campaign was designed with the following characteristics: 1) GPS mapping of households by utilizing Google Earth software; 2) collecting large amount of information on TB and HCT indicators; 3) collecting quality and real time data onto smart phones; 4) securing data storage; 5) guaranteeing confidentiality of the information; 5) monitoring the access to the data; and 6) producing easily accessible reports for different levels of the health system.

ANNEX II Relationships across files of the GeoMed database (Compiled by Dr Christopher Knudson)