THE USES OF MAPPING IN IMPROVING MANAGEMENT AND OUTCOMES OF TUBERCULOSIS CONTROL PROGRAMS: AN OVERVIEW OF AVAILABLE TOOLS

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INTRODUCTION

This report was completed under the USAID-funded Tuberculosis Control Assistance Program (TB CAP). It is intended to help tuberculosis control programs understand the possible benefits of mapping and the options that exist for creating maps. While the focus of this report is on computer-based applications available to create maps, it is important to note that hand-drawn maps can also be an important, appropriate method to present information, especially at the community level. This reports attempts to gather relevant information from a variety of sources to give decision makers information so they can make informed choices about using mapping in their program.

Much work is currently being done by the Public Health Mapping Group, Department of Communicable Diseases, Surveillance and Response, at the World Health Organization (WHO). They would be a valuable resource to programs wishing to incorporate maps into their program.

GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

A geographical information system is a computer-based system where data that are linked to a geographic place (known as geo-referenced data) can be entered, managed, manipulated, analyzed and displayed. [1] The World Health Organization describes how GIS is useful in public health programs:

> "Geographic information systems (GIS) provide ideal platforms for the convergence of disease-specific information and their analyses in relation to population settlements, surrounding social and health services and the natural environment. They are highly suitable for analyzing epidemiological data, revealing trends and interrelationships that would be more difficult to discover in tabular format. Moreover GIS allows policy makers to easily visualize problems in relation to existing health and social services and the natural environment and so more effectively target resources".[2]

Applications of GIS in health include:

- analyses of spatial patterns of health care access
- epidemiology and surveillance;
- monitoring of diseases and planning of interventions
- geographical correlations of health outcomes
- visualization and exploratory analysis of epidemiological data
- environmental and social determinants of human risk during disease outbreaks.
- planning and management
- complex analysis and research.
- advocacy, communication and social mobilization

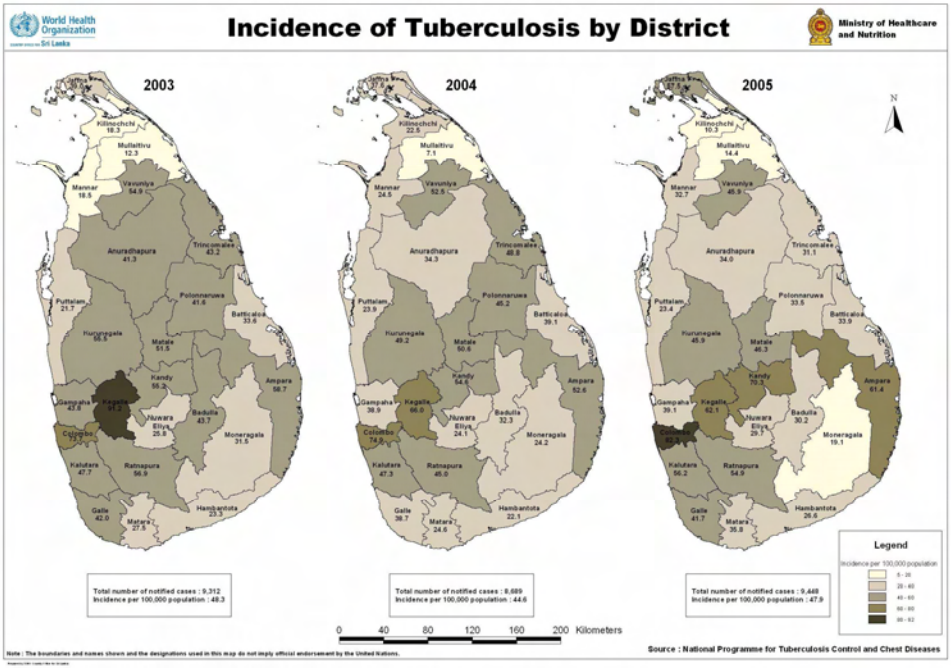
[1] Van de Broek, J, J Sastry, E Hackenitz. Geogrpahical Information Systems: a useful tool in tuberculosis control? unpublished

[2] WHO website: http://www.who.int/health_mapping/en/

There are many ways in which tuberculosis control programs could use mapping to strengthen their program. Some examples include mapping:

- the geographical distribution of TB cases
- "hotspots" of (Extensively) Multiple Drug Resistant (X/MDR) tuberculosis.
- the distribution of resources (facilities, health personnel, equipment such as microscopes)
- the trends over time
- the geographical distribution of different forms of tuberculosis
- tuberculosis treatment success and failure rates in relation to variables such as remoteness (accessibility), MDR tuberculosis hotspots, and perhaps availability of sub-standard TB drugs.
- the distribution of "TB free communities" for raising public awareness and funds to achieve similar results in other communities.
- tuberculosis case notifications to the distribution of annual risk of tuberculosis infection (ARTI)[3].
- tuberculosis case notification and environmental factors, such as distribution of Mycobacteria Other Then Tuberculosis (MOTT),or altitude[4].

The map below obtained from the WHO GIS Map Library shows the incidence of tuberculosis in Sri Lanka by district over a three year period. With this view, it is easy to quickly identify how the patterns of incidence have changed throughout the country over time. [5]



[3] Fourie PB. The prevalence and annual rate of tuberculosis infection in South Africa. Tubercle 1983;64:181-192.

[4] Mansoer JR, Kibuga DK, Borgdorff MW. Altitude: a determinant for tuberculosis in Kenya. Int J Tuberc Lung Dis 1999;3(2):156-161.

[5] http://gamapserver.who.int/mapLibrary/Files/Maps/LK_TB_incidence_2003_5.jpg

It should be noted that for mapping to be used successful underlying data should be *regularly* updated, which can be an enormous effort. Countries struggling with a human resources crisis may have difficulty in devoting staff time to this activity. It may be possible for the country to liaise with a local university or a similar institution,

Examples of Uses of GIS for Tuberculosis Control

Following are several abstracts and images from papers appearing in the International Journal for Tuberculosis and Lung Disease which provide examples of how GIS has been used in TB control.

Tuberculosis transmission patterns in a high-incidence area: a spatial analysis.

Munch Z, Van Lill SW, Booysen CN, Zietsman HL, Enarson DA, Beyers N.

Int J Tuberc Lung Dis. 2003 Mar;7(3):271-7.

SETTING: In the Cape Town suburbs of Ravensmead and Uitsig, tuberculosis has reached epidemic levels, with notifications of 1340/100,000 in 1996. These suburbs are characterised by overcrowding, high unemployment and poverty. It is traditionally believed that tuberculosis transmission takes place mainly in households after close contact with an infectious person. Studies have recently linked tuberculosis transmission to locations outside the household, and have associated these places with a particular high-risk lifestyle. Anthropological studies in some suburbs of Cape Town, in which a very high number of local drinking places (shebeens) were identified (17 per km2), have suggested that social drinking is part of such a lifestyle.

OBJECTIVE: To investigate various risk factors and places of transmission of tuberculosis using a geographical information system (GIS).

Figure 1 Crowding in the area calculated from 1996 census data.

RESULTS AND CONCLUSION: The 1128 bacteriologically-proven cases of tuberculosis studied over the period 1993-1998 were investigated using spatial epidemiological techniques of exploratory disease mapping. Point pattern analysis and spatial statistics indicated clustering of cases in the areas of high incidence. Significant associations of tuberculosis notifications were found with unemployment, overcrowding and number of shebeens per enumerator sub-district. High tuberculosis notifications with unemployment and its associated poverty emerged as the strongest association.

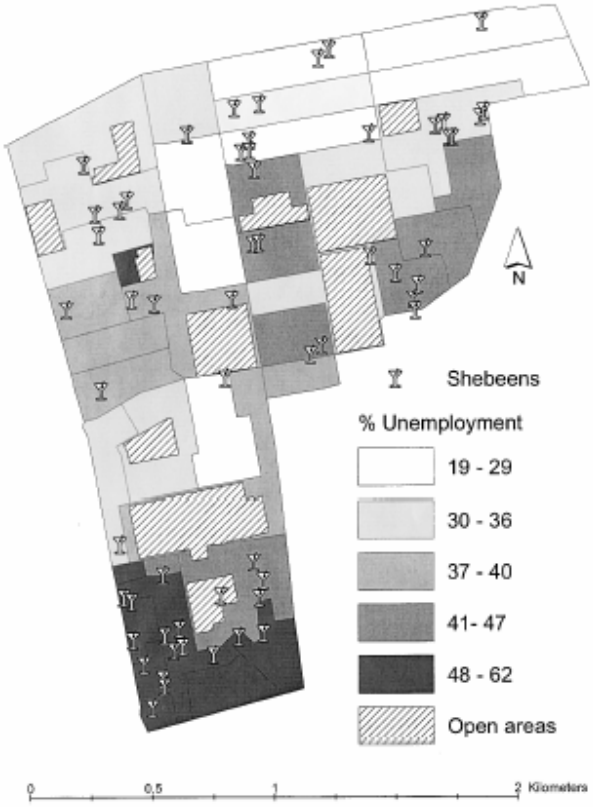


Figure 2 Unemployment calculated from 1996 census.

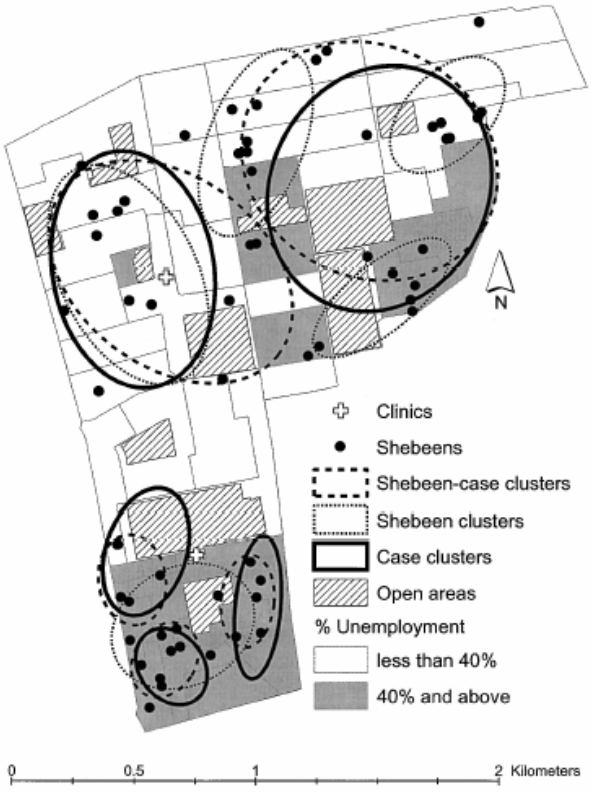


Figure 4 Geographical 'hot spots' of tuberculosis cases.

Tuberculosis risks and socio-economic level: a case study of a city in the Brazilian south-east, 1998-2004.

Vendramini SH, Santos ML, Gazetta CE, Chiaravalloti-Neto F, Ruffino-Netto A, Villa TC. Int J Tuberc Lung Dis. 2006 Nov;10(11):1231-5.

OBJECTIVES: To explore tuberculosis (TB) risks in relation to potential determinants in the city of São José do Rio Preto, São Paulo State, Brazil; to analyze morbidity and mortality indicators in São José do Rio Preto, and to determine the relationship between the risk of TB and socio-economic level (SEL) using a geo-referenced information system (GIS) and the national census for 2000.

METHOD: Standardized incidence rates and TB incidence and mortality rates were calculated. Socio-economic variables were determined using the statistical technique of principal component analysis. Data sources were the São Paulo State Data Analysis System (SEADE), the TB Notification Database (EPI-TB), the Information Department of the Brazilian Health Ministry (DATASUS), and the Brazilian Institute of Geography and Statistics (IBGE). New cases reported in 1998-1999 and 2003-2004 in the urban area of the city were geo-referenced and analyzed.

RESULTS: TB risk in the city is twice as high in areas of lower SEL than in areas with higher SEL.

CONCLUSION: The identification of areas with different levels of risk enables the Municipal Health Department to propose innovative interventions to minimize the risk of disease at both individual and population level.

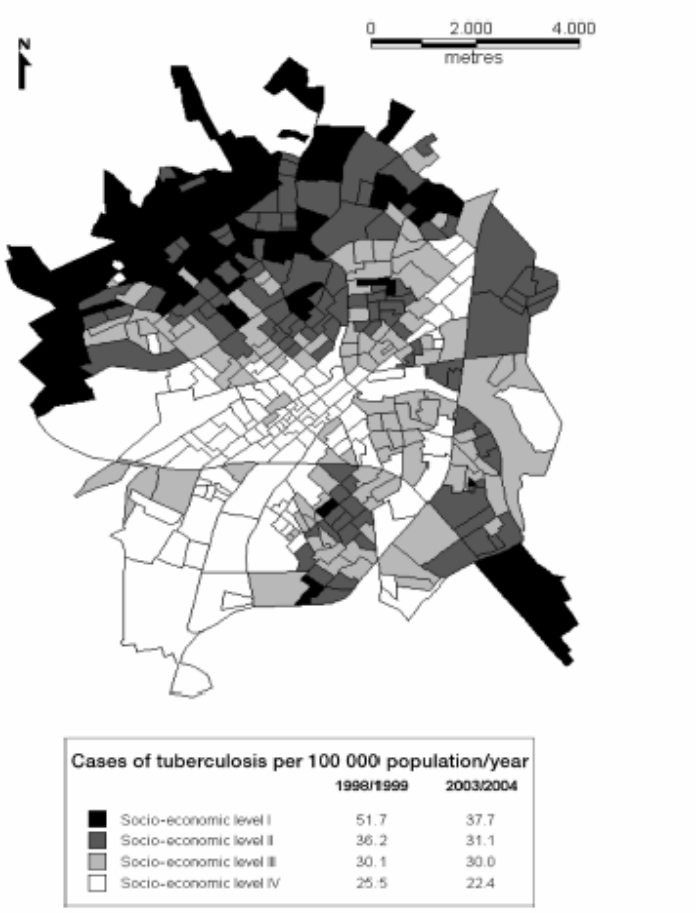


Figure 3 Map of São José do Rio Preto with socio-economic level and TB incidence rates, 1998–1999 and 2003–2004. TB = tuberculosis.

Socio-demographic and geographic indicators and distribution of tuberculosis in Hong Kong: a spatial analysis.
Chan-yeung M, Yeh AG, Tam CM, Kam KM, Leung CC, Yew WW, Lam CW.
Int J Tuberc Lung Dis. 2005 Dec;9(12):1320-6.

OBJECTIVE: To determine the socio-demographic and geographic indicators responsible for the distribution and transmission of tuberculosis (TB) in Hong Kong using geographical information system (GIS) technology.

MATERIALS AND METHODS: All patients with bacteriologically proven TB over a period of 3 years (May 1999-April 2002) residing within Hong Kong Island were studied. Molecular characterization of their sputum isolates by IS6110-based restriction fragment length polymorphism (RFLP) technique was performed. Socio-demographic data were derived from the

2001 Hong Kong population census. Geographic coordinates of patients' addresses were linked to the GIS; large street block groups (LSBGs) were the units of analysis.

RESULTS: Of 2387 patients with bacteriologically confirmed TB, 2332 had valid addresses distributed in 430 LSBGs in Hong Kong Island. Of the five socio-demographic indicators studied, significant correlations were found between the rate of TB in an LSBG and low educational attainment, elderly population and low-income household, but not population density or unemployment. The five socio-demographic indicators were not different between LSBG with clustered cases and those with unique cases.

CONCLUSION: Low educational attainment, old age and poverty were significant determinants of the rate of TB in different parts of Hong Kong, while none of the socio-demographic indicators was related to disease transmission.

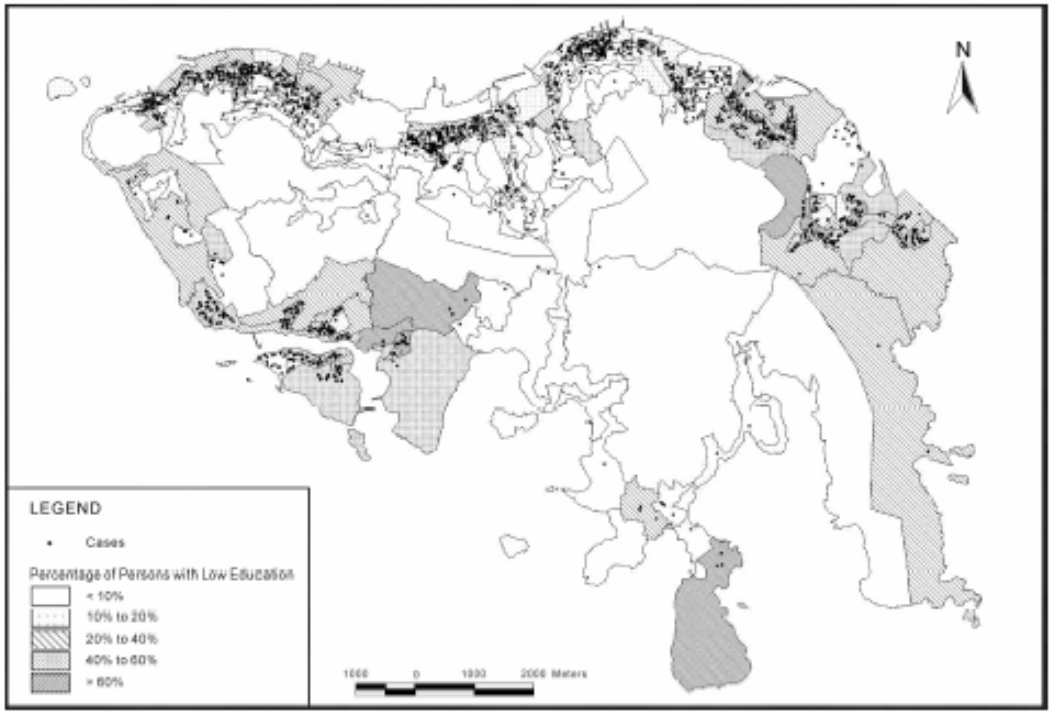


Figure 1 GIS map showing distribution of tuberculosis cases in LSBGs with varying proportions of persons with low educational attainment (<3 years high school education). GIS = geographical information system; LSBGs = large street block groups.

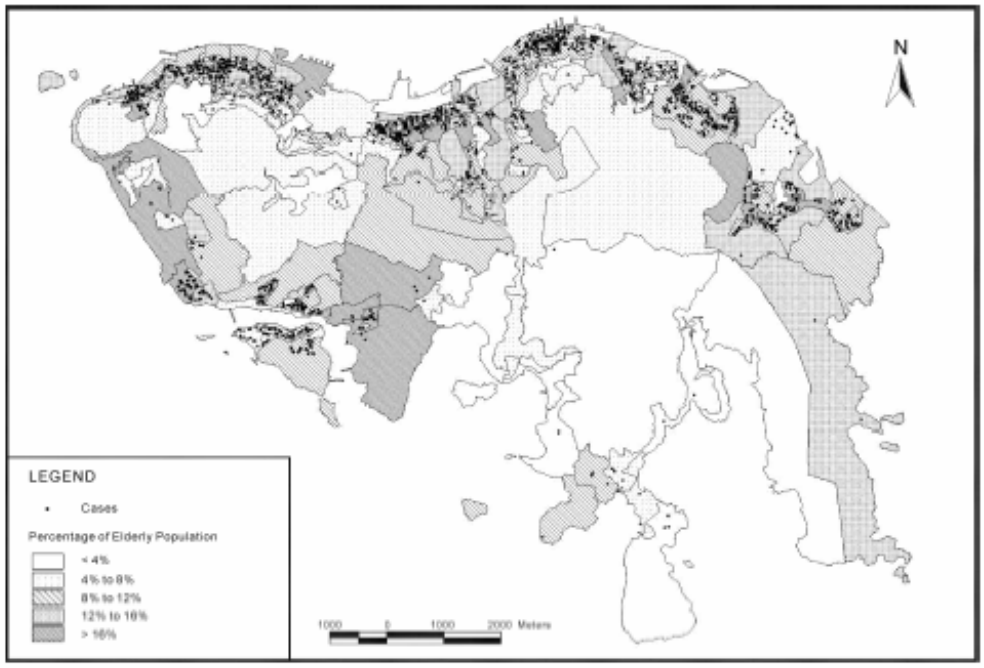


Figure 2 GIS map showing distribution of tuberculosis cases in LSBGs with varying proportions of elderly population (≥65 years of age). GIS = geographical information system; LSBGs = large street block groups.

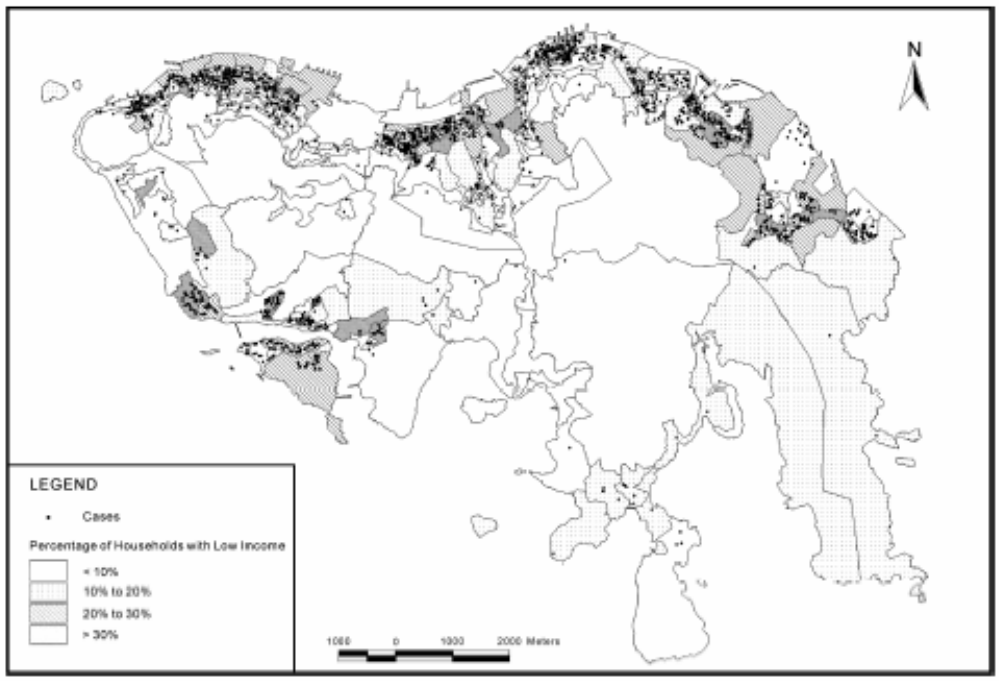


Figure 3 GIS map showing distribution of tuberculosis cases in LSBGs with varying proportions of low income households (≤HK$9999/household/month). GIS = geographical information system; LSBGs = large street block groups.

DATA

Maps are composed of pieces of data layered upon each other. The main type of data used in a GIS is spatial, containing points (e.g. villages), lines (e.g. roads, rivers) and polygons (e.g. regional and district boundaries). Spatial data can have attributes linked to it, such as demographic data or health service statistics that relates to the specific geographic locations. WHO, in the draft document of 2003, "Public Health Mapping: Inventory of Geographic Information" identifies core geographic information that is of use to public health programs.[6]

Map Files	
DIGITAL BOUNDARY MAPS	Global boundary map Regional boundary maps Sub-national Administrative
GEOGRAPHIC FEATURES	Road network map Rivers, lakes Parks Land use / Forests Elevation
COMMUNITIES	Location of cities Location of settlements by type Urban areas
HEALTH SERVICES DATA	Location of health services by type Health district boundaries Health care catchment areas Location of laboratories NGO intervention areas
SOCIAL SERVICES	Location of schools by type Location of water supply points by type Location of trading areas/markets
Data Files	
DEMOGRAPHIC DATA	National population estimates District population estimates Village/Town/City population estimates Population density distribution model

Geographic information required to create maps is commonly stored in "shapefiles", which is a data format for spatial data developed by ERSI, makers of the ArcView software which will be described below. Several other software applications make use of shapefiles, allowing for easy transferability between programs. Shapefiles spatially describe points, polygons, and lines. A shapefile is actually a set of files that work together to create a map with all its features. The main file extension is .shp and its associated files' extensions are .shx, .sbn, .shx and .dbf.

Shapefiles also can contain data on population or other variables, and can therefore provide numeric data that become part of the map display. Numeric data can be displayed either as

[6] World Health Organization, "Public Health Mapping: Inventory of Geographic Information- Draft Document", Public Health Mapping Group, Department of Communicable Diseases, Surveillance and Response, WHO January 2003

color/pattern (choropleth) maps or as dot density maps with the dots randomly distributed within geographic regions.[7]

Obtaining data

Obtaining accurate, complete data in developing countries can be one of the main obstacles in introducing mapping into a health program. Spatial data can be difficult to obtain for individual countries. Sometimes data can be downloaded free off the internet, sometimes it can be purchased, and sometimes other organizations will allow others to use their data. Most mapping applications come with some data loaded into the application, and for the purposes of health programs in developing countries, the HealthMapper application, developed by WHO, contains the most relevant data.

Two good websites are good places to start to obtain mapping data. WHO's GeoNetwork OpenSource is designed to allow geographically referenced thematic information to be share between different organizations (http://www.who.int/geonetwork/srv/en/main.search). The US Centers for Disease Control also maintains a very good list of resources for creating public health maps (http://www.cdc.gov/EpiInfo/maps.htm). It links to a variety of data sources, as well as other sources of information about GIS.

Once the core geographic data have been obtained, it is possible to link it to other existing data. Another option is for programs to input their own spatial data, using a global position system.

GLOBAL POSITIONING SYSTEM (GPS)

It is possible to plot precise locations on a map using the technology of a global positioning system (GPS). GPS is a navigation system that uses signals from several of the nearest satellites orbiting the earth to provide information on where you are in the world. A handheld GPS receiver records the longitude, latitude, and altitude of a particular location and assigns the location a unique code or number. This information is stored as a record that can then be transferred to a computer database. To create maps from GPS data, the data must be put into data management software. Handheld GPS receiver units can now be purchased relatively inexpensively (under $100 US).

GPS could be used to plot the locations of health providers or multi-drug resistant TB patients in a particular community, to understand the spread of the drug-resistant strain. It could help calculate the distance traveled by patients for DOTS by plotting the locations of DOTS facilities and patients. These data could be analyzed to see if the distance traveled was related to adherence rates. If it was found that patients who had longer distances to travel defaulted on treatment more, the program could decide to create more facilities, and could use the maps to determine the most needed locations.

Example

The follow abstract describes a study testing the use of GPS in tuberculosis control in South Africa.

[7] Epi Map user's guide

Linking the global positioning system (GPS) to a personal digital assistant (PDA) to support tuberculosis control in South Africa: a pilot study.

Dwolatzky B, Trengove E, Struthers H, McIntyre JA, Martinson NA.

Int J Health Geogr. 2006 Aug 16;5:34.

BACKGROUND: Tuberculosis (TB) is the leading clinical manifestation of HIV infection and caseloads continue to increase in high HIV prevalence settings. TB treatment is prolonged and treatment interruption has serious individual and public health consequences. We assessed the feasibility of using a handheld computing device programmed with customized software and linked to a GPS receiver, to assist TB control programs to trace patients who interrupt treatment in areas without useful street maps. In this proof of concept study, we compared the time taken to re-find a home comparing given residential addresses with a customized personalized digital assistant linked to a global positioning system (PDA/GPS) device. Additionally, we assessed the feasibility of using aerial photographs to locate homes.

RESULTS: The study took place in two communities in Greater Johannesburg, South Africa: Wheillers Farm, a relatively sparsely populated informal settlement, and a portion of Alexandra, an urban township with densely populated informal settlements. Ten participants in each community were asked to locate their homes on aerial photographs. Nine from Wheillers Farm and six from Alexandra were able to identify their homes. The total time taken by a research assistant, unfamiliar with the area, to locate 10 homes in each community using the given addresses was compared with the total time taken by a community volunteer with half an hour of training to locate the same homes using the device. Time taken to locate the ten households was reduced by 20% and 50% in each community respectively using the PDA/GPS device.

CONCLUSION: In this pilot study we show that it is feasible to use a simple PDA/GPS device to locate the homes of patients. We found that in densely populated informal settlements, GPS technology is more accurate than aerial photos in identifying homes and more efficient than addresses provided by participants. Research assessing issues of, confidentiality and cost effectiveness would have to be undertaken before implementing PDA/GPS - based technology for this application. However, this PDA/GPS device could be used to reduce part of the burden on TB control programs.

MAPPING APPLICATIONS

While there are a host of mapping software applications that exist, there are three applications that are most commonly used in health programs. These are ArcView, HealthMapper and EpiMap, which will be discussed below. They all use the shapefile as their format for data, which appears to be the most common data format available.

ArcView
ESRI

Description
ArcView is part of an integrated collection of GIS software products produced by the company ESRI. It is full-featured GIS software for visualizing, analyzing, creating, and managing data with a geographic component. It can be purchased separately or with other GIS products.

ESRI also produces a free "lightweight" GIS data viewer called **ArcExplorer**. With it, one can perform a variety of basic GIS functions, including display, query, and data retrieval applications. As it is free software, the installation package can be included on CDs with program data so that others can view the data effectively.

User friendliness
ArcView is capable of a multitude of functions which could be overwhelming to a new user. Training would most likely be needed, but once the fundamentals are mastered, it is fairly user-friendly.

Data
The data included in ArcView are more geared toward North America and Europe, and thus spatial data must be obtained elsewhere. External data can be easily linked to map data.

Cost
The cost for a single use license is quoted as US $1,500 if purchased on the internet directly from the company. This includes one year of maintenance, which includes technical support, updates, and other benefits. It may however be possible for developing countries to obtain the software for a reduced price.

Technical requirements
ArcView Version 9.1 has the following technical requirements:

- Platform:PC-Intel
- Operating System: Windows 2000 or Windows XP (Home Edition and Professional)
- Memory: 512 MB RAM
- Processor: 1 GHz

Health Mapper
World Health Organization

Description
HealthMapper, developed by the World Health Organization, is a free surveillance and mapping application that "aims to address critical surveillance information needs across infectious disease programs at national and global levels". It is a user-friendly data management and mapping system customized specifically for public health users. The system facilitates data standardization, collection and updating of data on epidemiology and on interventions and provides immediate visualization of data in the form of maps, tables and charts.[8]

Data
HealthMapper includes a database of core baseline geographic, demographic and health information, including the location of communities, health care and education facilities, accessibility by road, access to safe water and demography. The system supports a range of infectious diseases in over 60 countries in all regions of WHO.[9]

HealthMapper includes main layers on natural and environmental features and infrastructure which are in the format of shapefiles. They include: administrative and health boundaries, elevation (Digital Elevation Model), lakes and rivers, transportation networks, land cover classifications/forests. Other additional layers, such as urban areas or national parks, exist for several countries but are not available for all. In addition to the map files, baseline and program data relating to a geographic area are stored in an Access database file (using the extension .mdb).

The data included in HealthMapper have been developed by the Public Health Mapping Group based in the Department of Communicable Disease Surveillance and Response of WHO. The maps have been collected through a collaboration with WHO regional and country offices, WHO member states and various national institutes and WHO partner programs. National level population figures come from UN Statistics and are available for each country.[10]

The HealthMapper manual explains how they obtain the data used in the application: "For most countries, files with location of communities – towns, villages, settlements – are available at the Public Health Mapping Group. Many countries have provided existing village surveys, whereas in other countries or regions village location data has been collected by WHO partner programs or through local government bodies. In some cases, public-domain gazetteers have also been used to complete the village lists. Where available, locations of health facilities, schools and safe water supply have also been included in the geographic database. Administrative boundaries have been collected from a variety of sources including the Digital Chart of the World, the African Data Sampler and national geographic institutes. The collection, standardization of these maps has been

[8] WHO website
[9] WHO website
[10] WHO, HealthMapper User manual: Data Manager

carried out mainly through the Public Health Mapping Group, with the support of other WHO departments, regional and country."[11]

HealthMapper allows programs to link their own public health indicators of interest and has a feature to create data entry forms so data can be entered directly into HealthMapper. For example, users can enter their data against any available geographic feature such as a village, health facility, district, region, or country and continue to update and maintain their data. HealthMapper can create reports of program data.

HealthMapper can be also linked with an external database, which is useful if data is managed in different software. The following database file formats can be imported:

- DBase II, IV and V
- Excel , 3, 4, 5
- Excel 95, 97 and 2003
- Excel 97-2003&5.0/95 workbook
- Access 97 (.mdb)

This linked data can be displayed on a map and any updates to the database will be automatically reported on the map. It is also possible to open other layers (in Shapefile format) and images into HealthMapper. This is useful if there are other digital maps which are not included in the standard HealthMapper layers that you wish to combine with other thematic maps in HealthMapper.

User-friendliness

HealthMapper is very user-friendly, and comes with a very good, easy-to-understand user's guide that is available in many different languages. As the application is geared toward health programs, it focuses on a select group of functionalities. Users thus do not have to wade through many options that they will never need to use.

Cost

This application is provided free of charge upon requesting the software from WHO. Once approved, the software can be downloaded from the internet or the application could be sent on a CD-Rom. Potential users must fill out a licensing agreement and specify which country data they require.

Technical requirements

- IBM or 100% IBM-compatible microcomputer with Pentium or equivalent processor
- 32 MB RAM minimum
- 10 MB of available space on a hard disk for the core software
- additional 20 MB (approx.) per country
- Microsoft Windows-compatible mouse
- Microsoft Windows-compatible SVGA card and monitor
- Microsoft Windows-compatible printer (recommended)
- Windows 95, Windows NT or Windows 98

[11] WHO HealthMapper User Manual: Data Manager

Epi Map (part of Epi Info)
US Centers for Disease Control

Epi Info is a public domain software package designed for public health practitioners and researchers. It provides for easy form and database construction, data entry, and analysis with epidemiologic statistics, maps, and graphs. The primary applications within EpiInfo are:

- MakeView - a program for creating forms and questionnaires which automatically creates a database
- Enter - a program for using the forms and questionnaires created in MakeView to enter data into the database
- Analysis - a program for producing statistical analyses of data, report output and graphs
- EpiMap - a program for creating GIS maps and overlaying survey data on to them
- Epi Report - a tool that allows the user to combine Analysis output, Enter data and any data contained in Access or SQL Server and present it in a professional format. The generated reports can be saved as HTML files for easy distribution or web publishing. [12]

The latest version of Epi Info is Version 3.3.2 which was released on February 9, 2005. The application can be downloaded directly from the internet. Users with older versions can also download patches to update their version. The DOS manual and/or programs have been translated from English into 13 additional languages. The programs, documentation, and teaching materials are in the public domain and may be freely copied, distributed, and translated.

Data
Epi Map does not come with any pre-loaded data. All data would have to be obtained elsewhere. As mentioned above, the Epi Info website has links to sources for downloadable data.

User-friendliness
This application is also fairly user-friendly, and comes with good resources for support. Tutorials are available for download from the website, including the Epi Info Community Health Assessment Tutorial which covers creating a survey, entering data, analyzing the results as graphing, mapping, and presentation methods.

Cost
This application is available free of cost and can be downloaded directly from the internet.

Technical Requirements

- Operating System: Windows 98/NT 4.0/2000/XP

[12] CDC website

TRAINING MATERIALS, COURSES AND CONFERENCES

There are several options to learn more about GIS applications through training materials, courses and conferences. The ESRI company, makers of ArcView software offer a selection of self-study workbooks. The books may be found at http://www.gis.com/education/self_study.html. Note that it may be possible to purchase used copies of the books at a substantial discount from online vendors such as www.amazon.com.

There are also opportunities to receive training online through distant learning programs. Information on various programs can be found at http://www.gis.com/education/online.html. The University GIS Centre, Sweden, offers a Master's program in Geographical Information Systems (GIS) free of charge (no tuition) (http://www.giscentrum.lu.se/luma-gis/index.htm) . The program is fully Internet-based (distance learning) except for the presentation and defense of the final thesis. It is flexible in terms of study tempo and learning methods and would take 2 years to complete for a full-time student. The website lists the following requirements: minimum of a Bachelor's degree (at least 3 years university studies, in any discipline); access to a computer (at least 10 hours a week) - see section "Technical Prerequisite"; and any sort of Internet connection (at least 1 hour a week).

The Association for Geoinformation Technology organizes a regular conference called HealthGIS. The 2008 conference held in Bangkok Thailand focused on the use of GIS in the health sector for exploring the various causative factors for diseases. There was also a focus on how to use GIS for better planning of health care systems. More information can be obtained at http://e-geoinfo.net/hgis.html.

CONCLUSION

The three GIS applications described would be appropriate in different settings. If a TB program was already making use of Epi Info for all of its data management, it could make sense to start by using Epi Map. However, of the three applications, Epi Map has the least amount of functionalities. If the TB program wanted to do more than was capable in Epi Map, it could switch to ArcView and would be able to use the same data files, since they are all compatible.

For those TB programs new to GIS and not using Epi Info, HealthMapper would be a very good place to start. The application is easy to use and very importantly, already contains key country data. As mentioned above, obtaining accurate data can be one of the biggest challenges to mapping. As with Epi Map, switching to ArcView at a later point in time would always be possible as different needs arise.

ArcView appears to be the leading for-purchase GIS software used in health programs. Countries with previous experience with mapping and who need a broader range of capabilities may want to invest in ArcView and arrange for training of the users.

RESOURCES AND FURTHER READING

Useful websites

World Health Organization
http://www.who.int/health_mapping/en/

Centers for Disease Control
(http://www.cdc.gov/EpiInfo/maps.htm

IMMPACT (Initiative for Maternal Mortality Programme Assessment)
http://www.abdn.ac.uk/immpact/resources/gis/whatis.php

IMMPACT Global Positioning System (GPS) User Manual
http://www.abdn.ac.uk/immpact/resources/gis/downloads/Venture GPS manual 20050727.doc

IMMPACT's Basic Guide to GPS Data Management in Epi Info 6.4
http://www.abdn.ac.uk/immpact/resources/gis/downloads/IMMPACT Basic Guide to GPS data management in Epi Info 2020050719.doc

Other sources for information

Directions Magazine: The Worldwide Source for Geospatial Technology:
http://www.directionsmag.com/
Has reviews, discussion lists, articles about GIS software

International Journal of Health Geographics. Open Access journal:
http://www.ij-healthgeographics.com/

GIS software

ERSI (ArcGIS software): http://www.esri.com/products.html
Product Review: http://www.directionsmag.com/article.php?article_id=639&trv=1

MapInfo : http://www.mapinfo.com/
Product Review: http://www.directionsmag.com/product_reviews.php?feature_id=131

Intergraph (Geomedia software): http://www.intergraph.com/geomediasuite/default.asp
Product Review: http://www.directionsmag.com/product_reviews.php?feature_id=86

HealthMapper (based on ArcView)
http://www.who.int/health_mapping/tools/healthmapper/en/index.html

Epi Info
http://www.cdc.gov/EpiInfo/maps.htm

Books

Putting People and Health Needs on the Map, World Health Organization, WHO Press, 2007.

Journal Articles

Busgeeth K, Rivett U. The use of a spatial information system in the management of HIV/AIDS in South Africa. Int J Health Geogr. 2004 Jul 7;3(1):13.

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