Using Participatory Mapping to Assess Service Catchment and Coverage

— Guidance from the Iringa Participatory Mapping Exercise —

MEASURE Evaluation
SPECIAL REPORT

Cover photograph by MEASURE Evaluation shows project staff reviewing and revising the process for using maps to identify service catchment areas prior to survey implementation.

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Guidance from the Iringa Participatory Mapping Exercise

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Contents

Acronyms

AIDS	acquired immunodeficiency syndrome
APR	annual program results
C&T	care and treatment
GIS	geographic information system
GPS	global positioning system
HIV	human immunodeficiency virus
OVC	orphans and vulnerable children
PEPFAR	U.S. President's Emergency Plan for AIDS Relief
PMTCT	prevention of mother-to-child transmission
SAPR	semi-annual program results
SOP	standard operating procedure
USAID	U.S. Agency for International Development
VCT	voluntary testing and counselling
VMMC	voluntary medical male circumcision

Introduction

Effective program planning requires matching services with service needs. Program efficiency is enhanced when resources are targeted to or focused on program priorities, including areas of greatest need, underserved locations, or vulnerable populations.

Geographic information systems (GIS) can be an effective decision-support tool to provide policy makers, program planners, and other stakeholders with maps of the spatial distributions of needs and service coverage, showing where services are matched to needs and where there are coverage gaps. While such maps are easy to interpret, they are only as good as the data on which they are based. Some data may be readily available—for example, the locations of fixed facilities such as hospitals or clinics. Other data may need to be collected—for example, the size and location of groups who need specific services and the effective catchment area of program sites.

The technology for identifying geographic locations—primarily global positioning system (GPS) devices—is relatively inexpensive and easy to use. However, using this technology to identify priority populations and their locations, service catchment areas and service coverage can be costly and time consuming. Population-based surveys which ask people what services they use, where they obtain them, and their perceptions of service accessibility often include respondents' locations and can be linked to the locations of service outlets. Such surveys provide direct estimates of coverage as well as insights into subpopulation sizes and needs. However, in addition to being time intensive and costly, population-based surveys seldom provide detail beyond large sub-national areas (e.g. provinces or states). Another approach to estimating catchment areas and coverage is to use data on clients' place of residence from client records or registers. However, these data are often incomplete and are rarely available in a geo-located format.

This working paper describes an alternate, low-cost method for estimating catchment areas and coverage. This innovative methodology produces computer-generated, district-level maps of catchment and coverage patterns for facility-based and outreach HIV services, using easily replicable methods that do not require large, complex data collection efforts. The approach, successfully piloted in Iringa Region, Tanzania, uses open-source GIS software to link program reports and publicly-available demographic data with additional data collected through key informant interviews using printed maps. The pilot aimed to provide district and regional health authorities, the U.S. Agency for International Development (USAID) Mission in Tanzania, and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) implementing partners working in the region with improved understanding of HIV service coverage prior to scale-up of prevention, care and treatment activities.

Methodology Overview

Trained data collectors conducted site visits at facility-based and outreach HIV service sites in Iringa. The purpose of the visits was to collect site locations and interview staff. GPS coordinates were collected for the facility (in the case of facility-based services) or the office of the community-based organization (CBO) or nongovernment organization (NGO) (in the case of outreach services). At each facility, a key informant was asked to name the services offered and to mark on detailed district-level paper maps the communities where the majority of their clients came from for each service type. Similarly, CBO/NGO staff members were asked to mark the communities their outreach workers and volunteers visited. The paper maps were photographed and the digital images were then converted to GIS-ready digital files. Program service statistics and small area population estimates were collected separately.

The team used GIS software to draw geographic catchment areas of each facility and service. Next the team used the same software to link the catchment areas with population data to estimate the catchment population for each service. The estimated catchment population was combined with service statistics to estimate service coverage.

The process required multiple data collection tools. Below, we discuss each of the tools, describe the site visit process, and detail the three GIS related tasks: data processing, mapping catchment areas, and calculating coverage estimates. Facility services investigated include services for voluntary counselling and testing (VCT), prevention of mother-to-child transmission (PMTCT), care and treatment (CT), and voluntary medical male circumcision (VMMC). For outreach services, the team investigated service reach for orphans and vulnerable children (OVC) programs, home based care (HBC) programs, and condom distribution.

Data Collection

Data collection included development and training on the data collection tools, followed by site visits where key informant interviews were used to identify HIV program reach.

Tools

Prior to fieldwork, the team (1) developed data collection tools and (2) trained staff to use them. Data collection tools included:

- printed district maps
- survey forms
- list of facilities/organizations to be visited and their locations
- GPS devices
- digital cameras
- standard operating procedures (SOPs)
- a standardized coding protocol

Step 1: Tool Development

The district maps and survey forms were used in key informant interviews to collect information on services offered and the reach of those services. The team began with survey maps from the Department of Survey (the most recent, available maps with the needed topography including roads, rivers, administrative boundaries, and village locations dated back to 1970). The team first scanned the paper maps and imported the digital images to a GIS. Using the GIS software, the team added a coordinate grid overlay to allow the survey team to pin-point specific locations on the map when filling out the survey form in the field. In addition, georeferenced points were added to the maps to simplify the georeferencing process conducted when images of hard-copy maps which had been marked up during site visits were imported back into the GIS (see the Data Processing section of this working paper). Maps were printed on PVC, a durable paper-like waterproof plastic, to allow them to be re-used at each service delivery point. Figure 1 is an example map from Kiolo District. Note the space for the code in the top left, and the grid (A1-AJ26).

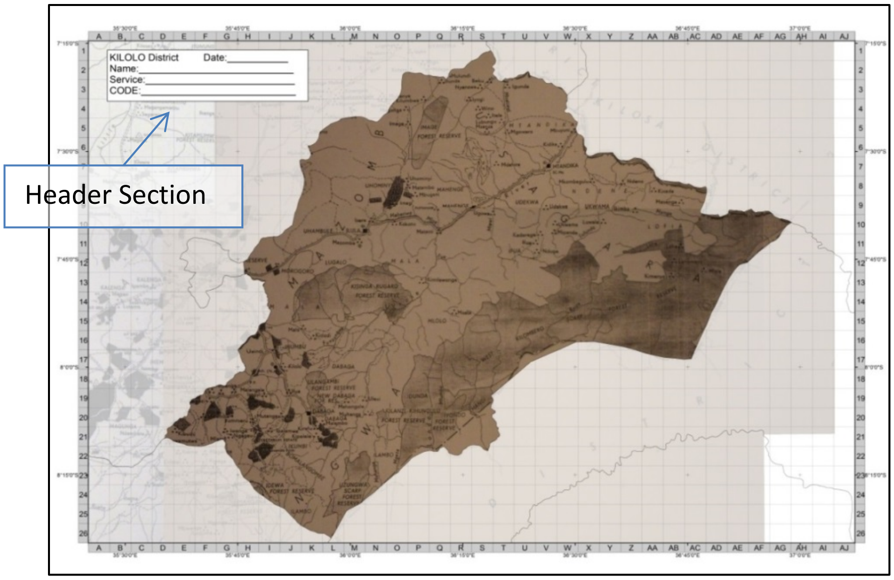
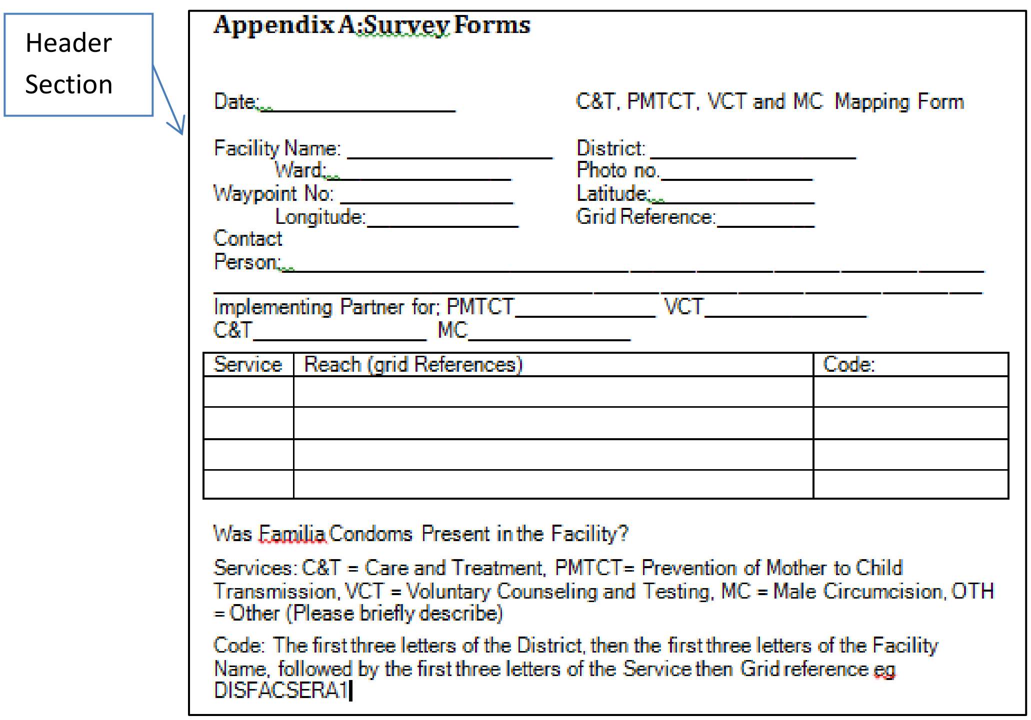


Figure 1: Map of Kiolo District printed on PVC.

The survey form was designed to be used in conjunction with the hard-copy map. The form included basic information about the service delivery points and provided reliable back-up data in case a map image was lost or unusable. Figure 2 shows an image of part of the survey form used during field work.



Appendix A:Survey Forms

Date:_______________ C&T, PMTCT, VCT and MC Mapping Form

Facility Name: _______________ District: _______________
Ward:_______________ Photo no._______________
Waypoint No: _______________ Latitude:_______________
Longitude:_______________ Grid Reference:_______________
Contact Person:_______________

Implementing Partner for; PMTCT_______________ VCT_______________
C&T_______________ MC_______________

Service	Reach (grid References)	Code:

Was Familia Condoms Present in the Facility?

Services: C&T = Care and Treatment, PMTCT= Prevention of Mother to Child Transmission, VCT = Voluntary Counseling and Testing, MC = Male Circumcision, OTH = Other (Please briefly describe)

Code: The first three letters of the District, then the first three letters of the Facility Name, followed by the first three letters of the Service then Grid reference eg DISFACSERA1

Figure 2: Image of survey form used during field work.

The maps and the survey forms were linked using a standardized code. The code used three letters for district name, three letters for site name, three letters for services examined, and four letters based on the space on the grid where the site was located on the map. The diagram in figure 3 illustrates an example of our standardized code.

The SOPs provided clear instructions for the site visits and data processing to maintain uniformity of data collection, coding and georeferencing.

IRI IRI PMT AP20			
IRI	IRI	PMT	AP20
Iringa District	Iringa Regional Hospital	PMTCP Service	AP20 Map Grid

Figure 3: Example of standardized code.

In the example above, the code IRI IRI PMT AP20 would identify PMTCT services offered at the Iringa Regional Hospital located in grid AP-20 on the Iringa District map.

Step 2: Training on Tools

The data collectors were trained prior to fieldwork. The two-day training focused on reading and explaining the district maps, procedures for conducting key informant interviews, marking facility or CBO/NGO office location and service reach on the map, filling out the survey form—including use of the standardized code, and photographing the map with a digital camera so it could later be imported and processed within a GIS. Data collectors were also trained to use a GPS device to collect each service delivery point's geographic coordinates.

Site Visits

Survey teams, composed of two trained data collectors, visited each of the 258 U.S. government-supported service delivery points offering HIV services in Iringa Region. Once a team arrived, they followed the SOPs summarized below.

Part 1: Pre-Interview

On arrival at the site, prior to the interview, each member of the survey team had specific tasks to complete.

Interviewer 1 collected GPS coordinates while standing in front of the main entrance of the health facility or NGO/CBO office; he then compared the coordinates from the GPS device the master list. If the newly collected coordinates were the same as those on the master list, the site coordinates were marked as verified. If the newly collected coordinates were different, then the updated coordinates were recorded. Interviewer 1 also filled out the header section for the map and survey form (figures 1 and 2).

Interviewer 2 introduced the survey team and mapping activity to the site manager, who helped identify the appropriate key informant to interview for each service. In some cases, the key informant was the manager, while in others she or he designated another staff member involved in HIV service provision.

Part 2: Interview

The key informant interview was conducted jointly by both members of the survey team. The mapping exercise process and goals were reviewed and the district map explained. In explaining the map, the survey team identified nearby landmarks with which the key informant was familiar, such as major towns, roads, and other features near their site. After the key informant was familiarized with the map, the service site was located and marked.

The key informant was next asked to list the HIV services provided at the site. For each facility-based service, she or he was asked to use small stickers to mark the villages the majority of their clients came from on detailed maps. Similarly, for outreach services, CBO/NGO staff members were asked to mark the villages their outreach workers and volunteers visited. If a village was not on the map, the survey team helped the key informant estimate its location through the use of contextual features on the map (e.g. roads, rivers, administrative boundaries and other landmarks). After all villages for a service had been located, the survey team photographed the map with a digital camera. As a back-up to the digital image, the team also recorded on the survey form the grid references for the services covered. The photographed map image was later georeferenced and digitized in a GIS (described in Data Processing section below). Figure 4 presents a photograph of a completed map.

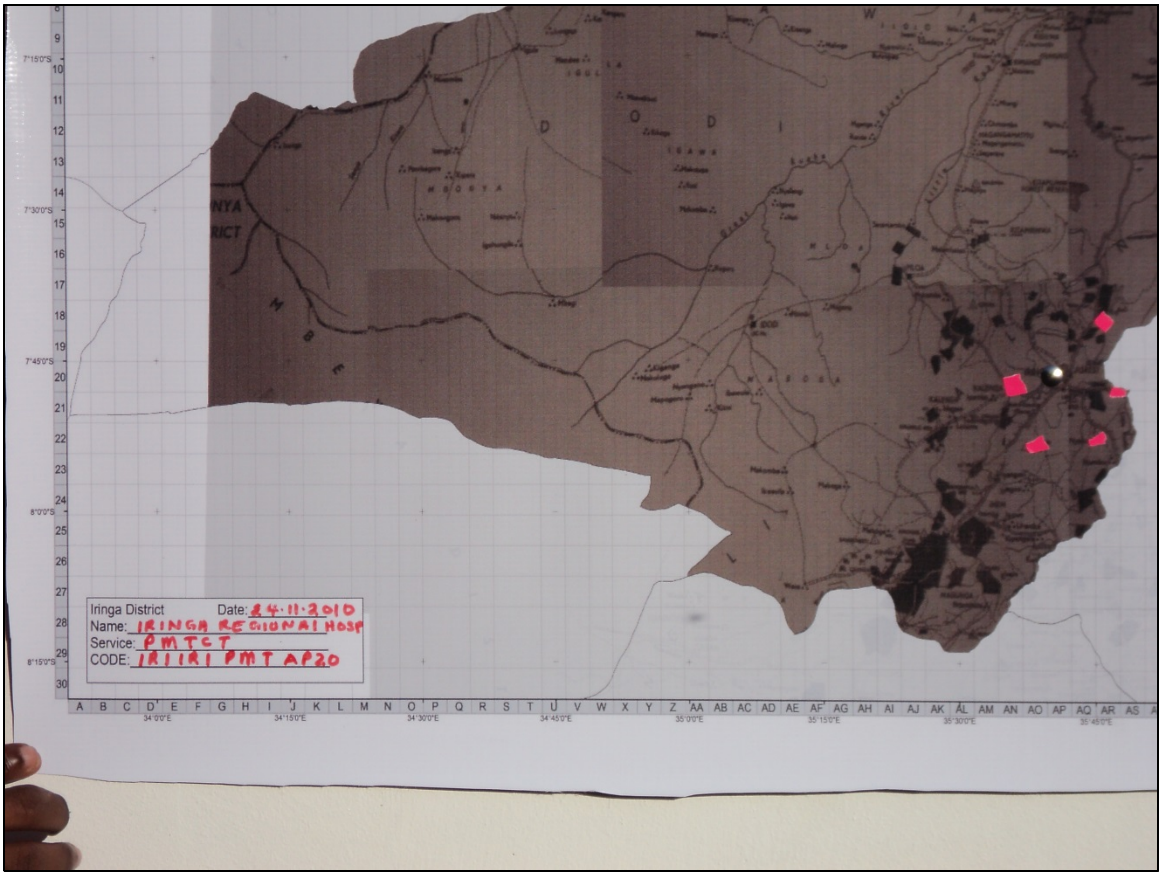


Figure 4: Photograph of map with collected data

Once all the data were collected for the first service, the map was cleared of stickers and the process was repeated for each additional HIV service the site provided. The survey team reminded the key informants that different services might draw clients from different locations.

Part 3: Post Interview

After the interview was completed, the survey team thanked the key informant and director for their participation and informed the manager that the maps would be put online on a passwordprotected site and could be shared with them. The team then requested permission to take a photo with a sign showing the site name for documentation purposes, as well as to upload all photographs into the GIS. Prior to leaving the site, the survey team reviewed the codes and photo numbers on the forms and master list to ensure each tool could be linked for data processing.

Geospatial Data Processing and Analysis

After data collection, the data was entered into a GIS to create geo-located catchment areas and coverage estimates. The main GIS tasks included: data processing, catchment area analysis, and coverage estimation. We used QGIS v1.7, an open source platform, for these tasks; most other GIS platforms would be equally capable of performing them.

Data Processing

Data processing included georeferencing the map images and digitizing both the site locations and reach for each health service. Georeferencing and digitizing methods were standardized during training and included in the SOP.

Step 1: Georeferencing Images

The team georeferenced the map images taken during the data collection process using clearly visible markers of latitude and longitude on the map image. Georeferencing uses known landmarks whose coordinates are known to align map images or paper maps to a specific coordinate reference system, a pre-requisite to digitizing (described below). It is required to overlay the map images and the catchment areas developed from them with other geographic data, including administrative boundaries, roads and rivers in the GIS. Tasks required to georeference the district maps included:

1. uploading the map image (i.e. digital photograph) into the GIS as a raster file[1];
2. aligning the georeferenced points which were added to the maps during development with their coordinates in the GIS; and
3. matching two or three other notable geographic landmarks from the map images, such as intersections, with corresponding locations in existing GIS data.

[1] Raster and vector are the two primary GIS data types. Raster data represents the world as a grid, where each pixel of the grid corresponds to a value (or color). Satellite imagery, land cover, and elevation are often stored in raster format. Vector data represents the world using 'shapes'. Health centers, schools, and town locations are often represented using points; roads and rivers using lines; and administrative areas and large water bodies using polygons.

Step 2: Digitizing

After lining up the photograph with the landmarks and georeference points in the GIS, the team digitized features from the georeferenced map images, creating new service-specific shapefiles[2] with points representing the communities from which clients come—the service reach (figure 5). Digitizing is the process for converting geographic features from georeferenced map images to vector format. In more detail, digitizing service reach involved the following:

1. The georeferenced map image was used to input the geographic location of each community/client location designated by the key informant. We call these locations "reach points".
2. Site locations were uploaded directly from the GPS devices.

With these data now in the GIS, the team created new shapefiles for each service to represent the geographic extent of service reach.

Catchment Area Analysis

After the data collected had been entered into the GIS by georeferencing the image and digitizing the reach, the each site/service's reach points were converted into a catchment polygon (area).

Step 1: Points to Polygons

To create the catchment polygon, the team first connected the outer-most "reach points" (figure 6). In some cases, key informants at the site stated that the majority of clients came solely from the village or town the site was located in. In these cases, that village itself was selected as the catchment area.

Step 2: Buffering to Generate Catchment Areas

After using the outer-most reach points to construct the polygons, each polygon was extended by one-half mile (figure 7) to ensure that villages identified as "reach points" were included in the

[2] A shapefile is a common vector data format readable by most GIS software.

catchment area. The resulting areas were given the standard code for the site and service with which they were associated.

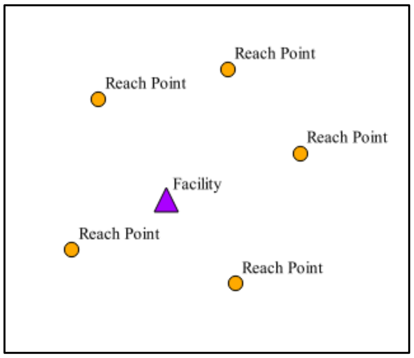


Figure 5: Map site location and digitize perceived reach points.

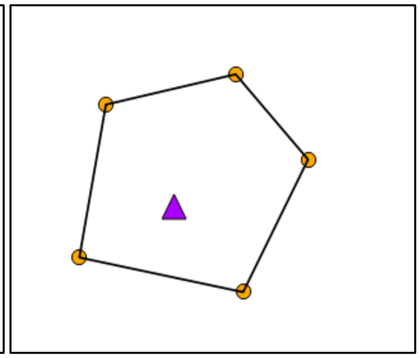


Figure 6: Create polygon by connecting reach points.

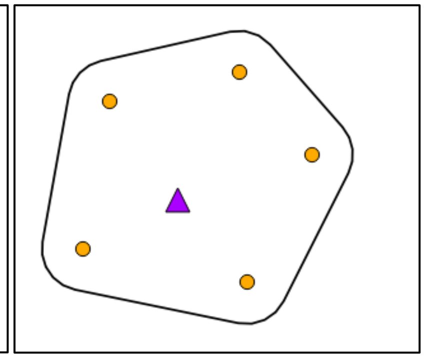


Figure 7: Buffer polygon to create final catchment area.

Coverage Estimation

Once the catchment areas for each service were identified, the team used population estimates and age/sex distribution data to estimate the target population coverage for each site/service's catchment area. By linking these population estimates with service statistics from the PEPFAR annual and semi-annual reports, the team was able to estimate the coverage for each service area.

Step 1: Determine reach population from the density grid

The team estimated the total catchment population based on an underlying, highly disaggregated population layer (Landscan 2010). LandScan divides the world into 1 x 1 km squares and models the resident population in each square based subnational census data, land cover, roads, and other ancillary geographic data. Using the zonal statistics feature in QGIS, the team overlaid the catchment polygons with the population data, and aggregated the total population within the catchment area for each site and service.

Step 2: Calculate estimate target population coverage

The estimated target population for each service was determined by multiplying the total population living within the catchment area for that service by the percentage of population eligible for that service. For example, the percentage of the population eligible for PMTCT services was estimated by multiplying age/sex distribution of the total population, HIV prevalence, and percentage of women who are pregnant. Figure 8 shows in detail the formulas used for estimating target populations for facility-based services. Similar formulas were used for CBO/NGO services. VCT target population was estimated by multiplying the total population by the percentage of the population that was sexually active—males and females ages 15-49 years old. The target population estimated for care and treatment services included individuals aged 15-49 years old with HIV and was calculated by multiplying the total population by the population percentage ages 15-49 years old and by the HIV prevalence rate.[3] The estimated PMTCT target population was HIV+ pregnant women ages 15-49 years old.

Age/sex distribution for these formulas was based on the U.S. Census Bureau's International Database (available at the district level). HIV prevalence and percentage of pregnant women were based on the most recent Demographic and Health Survey Program AIDS Indicator Survey. Age/sex distributions were available at the regional level.

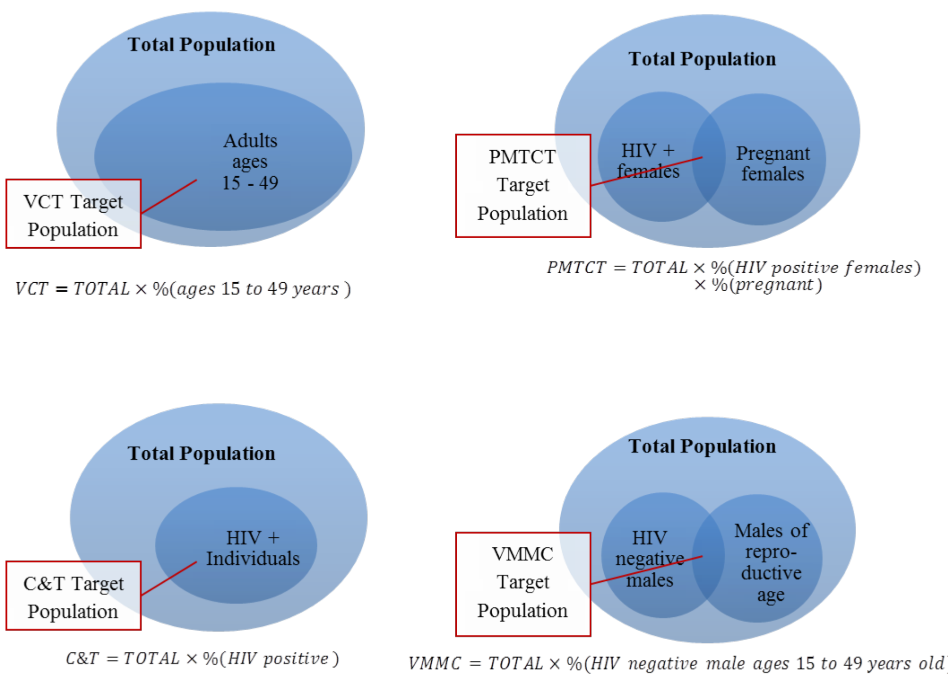


Figure 8. Target populations

[3] While we recognize that not all people living with HIV are necessarily eligible for antiretroviral treatment, the team lacked data on the proportion of people in Iringa whose CD4 counts would indicate need for treatment.

Step 3: Calculate coverage

Finally, after the estimated target populations—those eligible for services—were calculated for each service at each service delivery point, these populations were linked to the 2010 and 2011 PEPFAR semi-annual program results data and the PEPFAR 2010 annual program results data. These data included the number of people reached by the different services. The coverage for each service area was estimated by dividing the population receiving services by those eligible (figure 9 shows VCT coverage in Mufindi District). However, not all data could be linked due to discrepancies between the list of health facilities targeted for our survey and the list of health facilities reporting to PEPFAR.

Final maps were created using a GIS. Data shown on the maps included administrative boundaries and population, HIV service site locations, service catchment areas, estimated coverage percentage, and survey data including 'hotspots' from a recent Priority for Local AIDS Control Efforts (PLACE)-lite survey. The maps could be broadly divided into the following groups: service maps showing catchment and coverage for each service or for multiple services together; hotspot maps showing information on HIV transmission dynamics; and maps overlaying services with hotspots. Dropbox and ArcGIS Online were used to share maps, map layers, and data sets. Access was by invitation only.

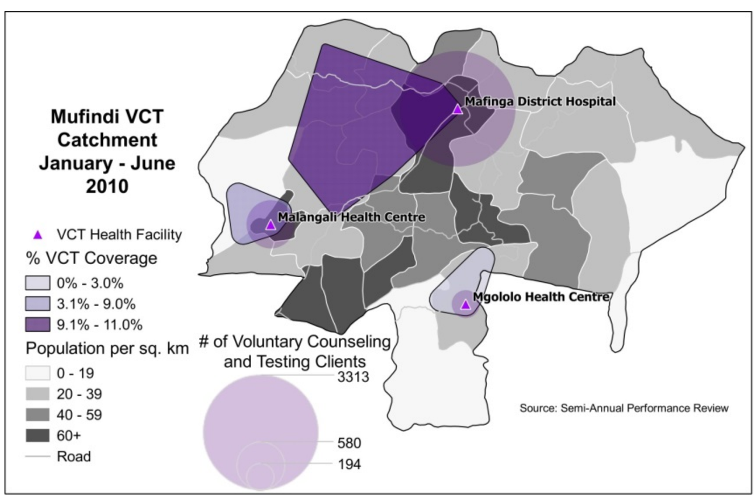


Figure 9: Mufindi VCT coverage estimates.

Limitations

There were several limitations to the methodology used for this study.

The estimation of service reach relied heavily on each key informant's knowledge of his/her client base by service. Informants were generally comfortable providing fine-scale geographic information identifying the locations of their client base for facility-based services. However, when asked about outreach activities—including condom distribution, home-based care, and orphan and vulnerable children services—CBO/NGO office managers provided less precise estimates of communities their outreach workers serve. In future application of this methodology, it may be helpful to include volunteers directly involved in the outreach visits. An additional complication for estimating catchment for outreach services is the temporal factor: while some areas routinely receive outreach services, others might only be visited once a year during major campaigns or other special events. Generating time-sensitive catchment areas capturing these nuances in service reach and linking them with corresponding reporting data is a challenge.

The Iringa participatory mapping exercise focused on U.S. government-supported sites, which provide the majority of the facility-based and outreach services in this region. This was identified as a limitation when findings were discussed with regional and district stakeholders, who noted that locations of other sites would have been helpful for evaluating overall service gaps.

Finally, while catchment maps can show clear gaps in service catchment areas, interpretation of the coverage maps should focus on general patterns. The population data, based on modeled Landscan estimates and dated census data, do not support precise assessments of the coverage of specific sites.

Conclusion

This document provides guidance detailing a straightforward, relatively inexpensive method for identifying patterns and examining program coverage based on key informant interviews at the service delivery level. The method merges low-tech printed maps and current GIS tools, blending the best of the analog and digital GIS worlds. The PVC maps were an easy-to-use data collection tool, which allow site managers to visualize and map their service reach. By using GIS, the team was able to convert the maps to a geo-located format and integrate them with other sources of data (e.g. other site catchment areas, high-resolution population estimates and disaggregated service statistics), and widely share them with decision makers.

Critical elements contributing to success in the implementation of this method in Iringa included:

- a standardized, easily understood code for linking the data together from the maps, survey forms, and master list;
- clear SOPs for generating this code, collecting site-specific data, and converting the raw data into GIS data; and
- high-detail maps made with durable materials (the PVC maps were reused repeatedly through field work, did not need to be replaced, and contained sufficient detail for site managers to identify service reach).

Key process details we learned that simplified (or would have simplified) implementation included the following:

- Hanging the district map on a well-lit wall allowed us to hold a camera parallel to the map while photographing it, prevented image warping and simplifying the georeferencing process.
- A commercial printing company with a solvent based printer is needed to print the PVC maps, as ink will typically smear if inkjet or typical laser jet printers are used. An alternative would be to print multiple paper district maps for each site/service.
- The site tracking list should be validated against the list of sites with reported service statistics prior to implementation, and differences between the lists resolved with

assistance from local authorities, to simplify linking the service data to the catchment areas.

Maps created through this method can be used to guide planning, monitoring, and evaluation efforts. In the case of Iringa, maps showing the catchment patterns and coverage estimates were used to inform discussions on service distribution and support the prioritization of resources for program improvement or expansion through a series of joint GIS and data use workshops and mentorship visits with district health authorities.

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