OVERVIEW OF TRIANGULATION METHODOLOGY:

Synthesis of multiple data sources for evaluation and decision-making in HIV epidemics, based on initial experiences

Contents

Throughout this overview we use the shaded gray boxes to outline an example of triangulation in a fictitious country called Bundo, experiencing a generalized HIV epidemic. These boxes will walk you through the twelve steps of triangulation.

LIST OF ACRONYMS USED

ACHAP	African Comprehensive HIV/AIDS Partnership
ART	Antiretroviral therapy
ANC	Antenatal clinic
AZT	Azidothymidine (Zidovudine), a reverse-transcriptase inhibitor used to treat HIV/AIDS. Used as part of a treatment regime for management, as a post-exposure prophylactic, and to prevent mother-to-child transmission.
BAIS	Botswana AIDS Impact Survey. BAIS-I was conducted in 2001 and BAIS-II was conducted in 2004.
BHP	Botswana–Harvard AIDS Institute Partnership
BOTUSA	A collaborative effort between the Botswana Ministry of Health, the U.S. Centers for Disease Control and Prevention\Division of Tuberculosis Elimination (CDC\DTBE), and the Global AIDS Program (GAP).
BSS	Behavioral Surveillance Survey
CDC	United States Centers for Disease Control and Prevention
CDC-GAP	Centers for Disease Control and Prevention's Global AIDS Program
CD4	A glycoprotein receptor found on the surface of T-cells in the human immune system. HIV infection reduces the number of CD4 cells in the human immune system. The CD4 count is one of the most useful indicators of the health of the immune system and a marker for the progression of HIV/AIDS.
CSO	Central Statistics Office
DHS	Demographic and Health Survey
DHS+	Demographic and Health Survey that includes HIV prevalence data
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HMIS	Health Management and Information System
HSU	Health Statistics Unit
IGH	Institute for Global Health, a part of the University of California, San Francisco
IRB	Institutional Review Board
IPMS	Integrated patient management systems

MACRO	See ORC-MACRO
MCH	Maternal-child health
MLG	Ministry of Local Government
MOH	Ministry of Health
MSF	Médecins Sans Frontières, also known as “Doctors without Borders”
NAC	National AIDS Commission
NACA	National AIDS Coordinating Agency
NGO	Non-governmental organization
ORC-MACRO	Opinion Research Company’s Macro International Inc.
PLWHA	Persons living with HIV/AIDS
PMTCT	Preventing mother-to-child transmission
PSI	Population Services International, a non-profit organization promoting social marketing of public health products, public health services and healthy behaviors
STI	Sexually transmitted infection
TB	Tubercle bacillus, also known as tuberculosis
UCSF	University of California, San Francisco
UCSF-IGH	See IGH
UNAIDS	The Joint United Nations Programme on HIV/AIDS
UNICEF	The United Nations Children’s Fund
VCT	Voluntary counseling and testing
WHO	World Health Organization

Introduction

The HIV/AIDS pandemic is one of the most complex public health crises in recent history. No single data source can fully explain the status and direction of the epidemic. However, research studies, surveillance projects, and prevention and care programs have accumulated a massive amount of data over the last decade. Synthesizing and interpreting these data can be a daunting task.

An analytical approach known as “triangulation” integrates multiple data sources to improve the understanding of a public health problem and to guide programmatic decision-making to address such problems. Triangulation can be used by public health officials to assess the impact of widely disseminated interventions at the population level. Whereas traditional intervention research seeks to definitively answer a pre-formed hypothesis, triangulation seeks to strengthen interpretations and improve decisions based on the available evidence. Triangulation does not infer causality, but offers a rational explanation or interpretation of the data at hand.

There are many advantages to triangulation. First, triangulation can make use of pre-existing data sources. This allows for rapid understanding of the situation and facilitates timely, appropriate decisions in health crises. Second, by examining information collected by different methods, by different persons, and in different populations, findings can corroborate each other and reduce the effect of both systematic bias and random error present in a single study. However, it is important to be aware that bias and error can also be increased in the final results if the analyst does not take care to fully understand each data source and what it represents.

Triangulation can also combine information from quantitative and qualitative studies, incorporate prevention and care program data, and make use of expert judgment. Triangulation provides a method to evaluate interventions and assess population-level outcomes. The use of many different data sources can raise ethical issues about their original collection. This overview also addresses those concerns.

How to use this overview

In this overview, we offer a 12-step systematic approach to conducting an analysis. To illustrate the nature of triangulation, we ask you to follow a triangulation exercise example in a fictional country called ‘Bundo.’ Use your imagination! Examples used are adapted from both real-life and hypothetical situations in countries affected by HIV/AIDS and are interspersed throughout this overview. Exercises and discussion boxes help clarify key points. Though the overview is organized in a step-by-step format, triangulation is best viewed as an iterative process. The results from a given step will help to formulate or improve upon results from previous steps. As new information arises, previous steps may need to be revisited. Flexibility and adaptability are crucial to the successful completion of the triangulation process. Our examples will help illustrate the iterative nature of triangulation.

In order to best use the overview, it is recommended that readers first review all the materials presented before setting out to do a triangulation. Every triangulation exercise will be different, so users should refer back to this overview to help them as they progress through the steps. Additionally, first-time users are advised to seek technical assistance from experts who have been trained in triangulation and have previously used this methodology.

One final note: local adaptation is essential to success. This overview serves as a template. It is up to the user to decide which components are relevant to their project and incorporate them as needed. Every triangulation analysis will vary based on the availability of resources. In addition, while reading the *Overview of Triangulation* it is important to keep in mind the varying scope of triangulation analysis. Triangulation analysis can be applied on the geographic level (national, regional, district or local) as well on specific population groups.

Included in the appendices are brief case studies of triangulation analyses conducted in real-life generalized epidemics. These examples outline how countries have used triangulation to answer important questions and are intended to provide the reader with an idea of some of the data sources used and conclusions that have been reached. As more triangulation exercises are completed, important lessons learned and other experiences will be incorporated and these case studies further refined.

Overview of triangulation

Learning objectives

After reading the triangulation overview, the reader shoulf have a thorough understanding of the following:

- How to organize the triangulation process
- How to identify and capture data
- How to synthesize multiple data sources
- How to develop and test hypotheses
- How to draw conclusions and make recommendations for next steps
- Country report of triangulation findings for key HIV/AIDS question of interest

What is triangulation?

The last few years have witnessed a dramatic increase in financial resources to combat the HIV/AIDS epidemic worldwide. Some of these funds have been used to collect data to track the epidemic, to monitor and evaluate prevention and care programs, and to conduct research. While data collection related to HIV/AIDS has both increased and improved in highly affected and resource-constrained countries in the last several years, a gap remains between the accumulation of data and their collective use for evaluation, policy implementation, and programmatic improvement.

This gap is not easily bridged. National health information systems tend to collect sub-national programmatic and surveillance data in separate databases that are housed in different locations from other relevant information, such as research data, national census data, and other special studies. National surveys, likewise, generally result in datasets that are analyzed independently, in isolation from other information. Integration of different datasets, in different data management or analytical formats, is difficult. In most instances, imperfect overlap in the wording of variables precludes direct comparison or combining of data and reduces the power of subsequent statistical analyses. At the other end of the spectrum, scientific research is often focused on specific questions, with slow turnaround time for the release of results, and has limited external validity.

Triangulation presents one strategy for using diverse datasets to develop timely recommendations for policy and program evaluation and decision-making. Triangulation is broadly defined as synthesis and integration of data from multiple sources through collection, examination, comparison,

and interpretation. By first gathering and then comparing multiple datasets to each other, triangulation helps to counteract threats to validity in each.

This approach has been applied in diverse fields of social science to strengthen conclusions about observations and to reduce the risk of false interpretations by drawing upon multiple independent sources of information. For example, in Zimbabwe, researchers used data from sentinel surveillance systems, population-based sero-surveys, local smaller research studies, and service statistics to provide evidence that national HIV prevalence was declining in the early 2000[1]. Triangulation has been used to answer questions in both generalized and concentrated HIV epidemics.

Triangulation includes not only the comparison of different data sources, but also the use of different data gathering techniques and methods to investigate the same phenomenon. Triangulation activities were recently conducted in Thailand to determine the effects of condom use policies in brothels and mass media campaigns addressing HIV. Through a variety of data collection methods, the Thai Government estimated that reported condom use in brothels increased from only 14% of sex acts in 1989 to over 90% by 1994. Over the same period, the number of new STI cases among men treated at government clinics plummeted by over 90%. Regular surveys among young male recruits in the Thai army revealed similar changes in sexual behavior and infection rates. HIV infection rates among 21-year-old military conscripts peaked at 4% in 1993 before falling steadily to below 1.5% in 1997. By 1995, fewer recruits were visiting sex workers (down from almost 60% of recruits in 1991 to about 25% by 1995) and condom use had increased. These changes in sexual behavior were paralleled by a decline in HIV infections and other STIs[2]. Using triangulation, the Thai government was able to synthesize different types of data indicating that the policies and programs resulted in both a reduction in risk behaviors and a decline in HIV and STIs.

It is important to distinguish between triangulation and meta-analysis. Meta-analysis combines rigorous scientific data of similar quality and design to conduct statistical analyses. In contrast, triangulation seeks to make use of data from diverse sources and study designs and incorporates judgments on each data source's limitations. It is intended to be used by researchers, policymakers, Ministries of Health, national AIDS coordinating bodies, and program managers, preferably with some knowledge of data analysis and basic epidemiology. This document is most useful as preparation for those who will take part in a data triangulation. It will help provide users with a solid background and

[1] A Mahomva, Greby S, Dube S *et al.*: HIV prevalence and trends from data in Zimbabwe 1997-2004. *Sex Transm Infect* 2006; 1:i42-7.
[2] http://www.who.int/inf-new/aids1.htm

understanding of the triangulation process. The users of the overview will work to describe trends in the HIV/AIDS epidemic and make programmatic, resource, and policy recommendations. Although the focus of the example used in this overview is on HIV/AIDS, and specifically the impact of antiretroviral therapy (ART) on mortality, it is possible to use triangulation for other diseases and interventions.

Discussion Question 1:
1. Define in your own words: a. *Triangulation*:

Shared ownership of the triangulation process

Because the success of triangulation depends upon access to and use of multiple data sources, a high level of cooperation and buy-in is required from multiple institutions and key persons or "stakeholders." A stakeholder is any person who has a vested interest in how the response to the HIV/AIDS epidemic is directed and how the data are used. Triangulation is most successful when stakeholders are involved in all phases, including deciding the priority questions to be answered, identifying and gathering data, guiding the analysis and interpretation, and using the results of the triangulation in their own policy and program decision-making.

Stakeholders can be included in the process through an initial consensus-building meeting to identify the priority questions to answer through triangulation, through the establishment of a regularly meeting taskforce, and through ad hoc consultation.

The composition of the body of stakeholders may change during the triangulation exercise, though many organizations will be represented throughout the process. The stakeholders can include a variety of policy- and decision-makers, as well as government, academic, and private organizations.

Box 1 describes the kinds of people who may be considered stakeholders.

Box 1. Stakeholders
• Policymakers and decision-makers (e.g. Ministry of Health officials) • Program sponsors and donors (e.g. the Global Fund, World Health Organization) • Program managers and staff (e.g. voluntary counseling and testing managers, hospital administrators) • Community members and organizations (e.g. NGOs, community leaders) • Research community (e.g. national and international university researchers) • Clients/users of services • Other countries, districts, and communities with similar research themes and objectives
List potential stakeholders in your area:

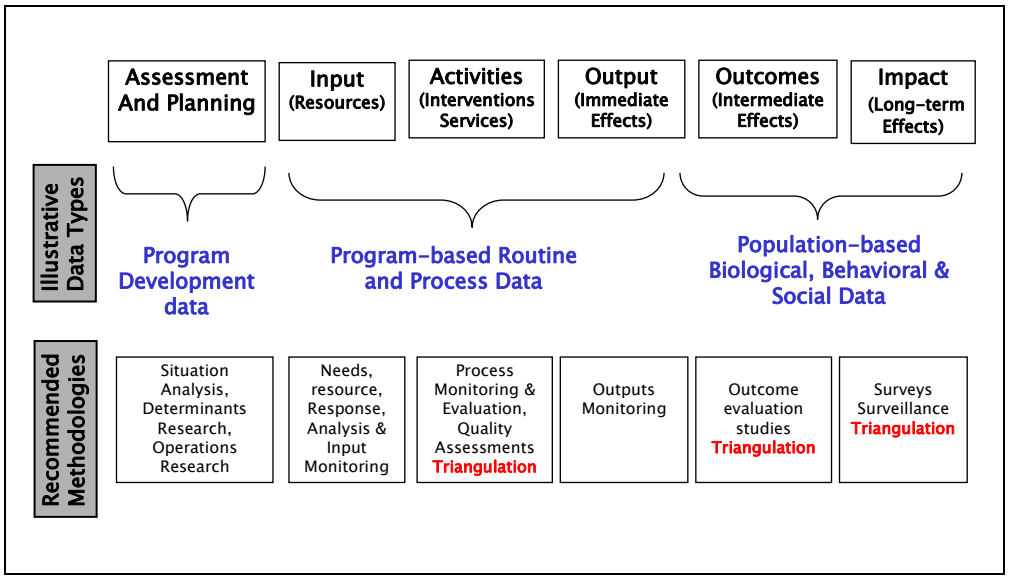
It is often useful to define a ‘taskforce,’ comprising a technically proficient subset of stakeholders, to guide the triangulation analysis after the questions have been chosen. This taskforce can serve as a conduit to the larger stakeholder group, and provide regular and active support and direction to the triangulation study. Ideally, taskforce members should be chosen to represent a range of expertise and have a recognized degree of involvement in the community. It is best to select persons for the taskforce who will be able to use the skills learned during the initial triangulation on an ongoing basis. Previous taskforces have included approximately 15 members who participated in regular meetings, but the stakeholders should decide how many taskforce members are needed.

The taskforce should have a chairperson whose main responsibility is to facilitate communication between all members of the taskforce and establish political support for the project. This person is ultimately responsible for ensuring that the triangulation goals are met. The group also requires one or more analysts with strong backgrounds in the subject area of focus. Analysts should have qualitative data skills, data management skills, and an understanding of public health statistics. They should be skilled in data collection and analysis and have experience working with various agencies and programs. Ideally, at least one analyst should be dedicated to the triangulation study, to collect data and maintain a good working relationship with the stakeholder group.

When to use triangulation

Triangulation can be used for virtually any phase of monitoring and evaluation. However, the methodology is most appropriate for evaluations that seek to answer complex questions concerning the quality, implementation, outcome, and impact of one or more programs, and to examine trends over person, place, and time.

Figure 1: Global AIDS Program evaluation framework and evaluation methodologies



Triangulation can be effective when there are multiple data sources (including both quantitative and qualitative data from various sources, such as research surveys, programs, employers, the military, etc.) that can be analyzed to inform policy or program decision-making.

Box 2: Comparison of conventional and triangulation analysis

Conventional Analysis	Triangulation Analysis
• Focus on statistical analysis • Designed to provide generalizable data • Variables from a single data set • Focus on internal validity: *"Did A cause B to change among group C?"* • Emphasis on generating the highest scientific rigor of data for interpretation • Long delay between data collection and presentation of results	• May or may not use statistics • Variables from multiple datasets • Focus on external validity: *"Can observed effects in group C be attributed to the larger population as well?"* • Emphasis on the 'best possible' interpretation of existing data for policy- and program decision-making • Quick turnaround between secondary data capture and presentation of results

Discussion Questions 2–5:

2. Which type of analysis seems more feasible for use in resource-constrained settings?

3. Which method promises the most rapid dissemination of its findings for public health action?

4. Which method is most likely to rely on measures of statistical significance for verification of findings?

5. What types of questions might be answered by each type of analysis?

By allowing for the use of a wide range of sources of information, the process of triangulation can identify more data sources than researchers may initially anticipate. For example, during a triangulation exercise in one sub-Saharan country with very limited resources, over one hundred sources of data were identified. Triangulation often presents the first opportunity to compare a wide range of data side by side, providing new insights and generating new hypotheses.

There are several circumstances where triangulation may be particularly useful, including the following:

- When data are scant
- When data are plentiful but dissimilar
- When the “best” single data source is not available
- When a rapid response is needed
- When impact must be determined at the population level

Triangulation can be effective when a rigorous, specifically designed research study is not available, when such a study is infeasible, or when action urgently needs to be taken. Rather than generating new data to answer a specific research hypothesis, triangulation seeks to make the best possible public health decisions based on the available evidence.

Box 3 shows some ways in which triangulation can be applied to answer questions quickly and inexpensively.

Box 3. Uses of triangulation in the response to the HIV/AIDS epidemic

- Tracking trends in HIV/AIDS prevalence
- Evaluating and planning prevention and care programs
- Allocating resources
- Monitoring and evaluating prevention and care programs
- Mobilizing political commitment (advocacy)
- Informing and educating the public
- Guiding research

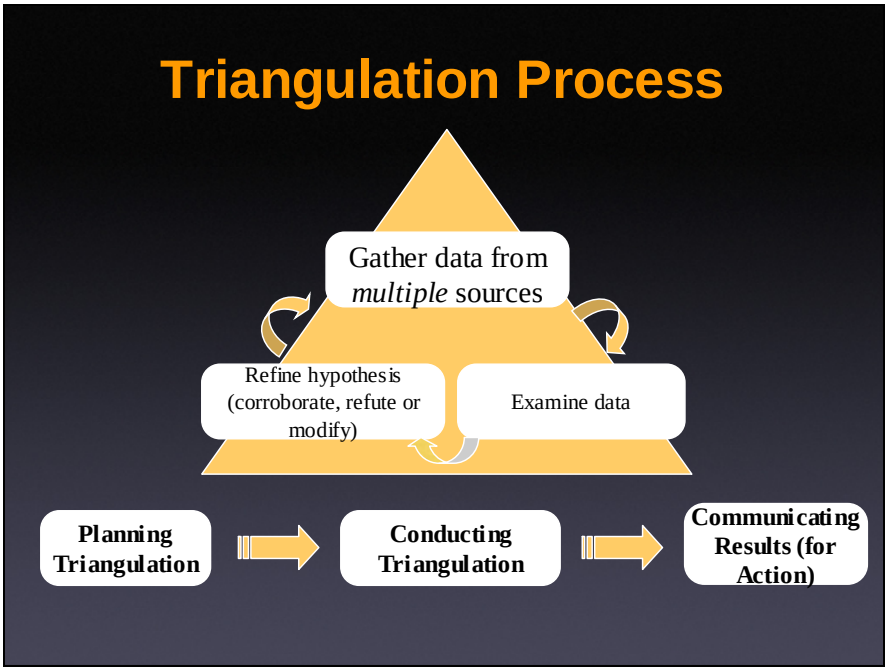
Discussion Question 6-7:

6. Which of these uses is most time-sensitive?

7. Which uses are applicable to your country?

For structure and simplicity, we present the triangulation process as a 12-step sequential procedure in the following section. However, a key point to note is that triangulation is practiced as an iterative process in which returning to previous steps is common as new information or interpretations come to light. The following diagram illustrates the triangulation process and demonstrates its iterative nature.

Figure 2: A visual representation of the triangulation process



Because triangulation uses existing data sources, it is usually cheaper than conducting a single large survey, and it can be completed in a short period of time. The entire process has been completed in 5-6 months.

The time and resources needed to complete the triangulation process depend on several factors, including the complexity of the question being examined; the availability, quality, and cleanliness of the data; the use of external consultants to assist in the process; and the skill level and experience of the analysts and others conducting the exercise. An approximate timeline is provided on the next page. It includes a capacity-building workshop that focuses on transferring the necessary skills and methodologies to in-country participants.

1. **Initial Stakeholder Meeting** (1 week)—Stakeholders meet to identify key question, develop triangulation taskforce, and begin collecting data sources to be collated.

2. **Data Capture** (3-4 months)—Collect and collate existing data and conducting data cleaning and initial analysis.

3. **Data Analysis** (Simultaneous with data capture)—Analyze data and develop hypotheses.

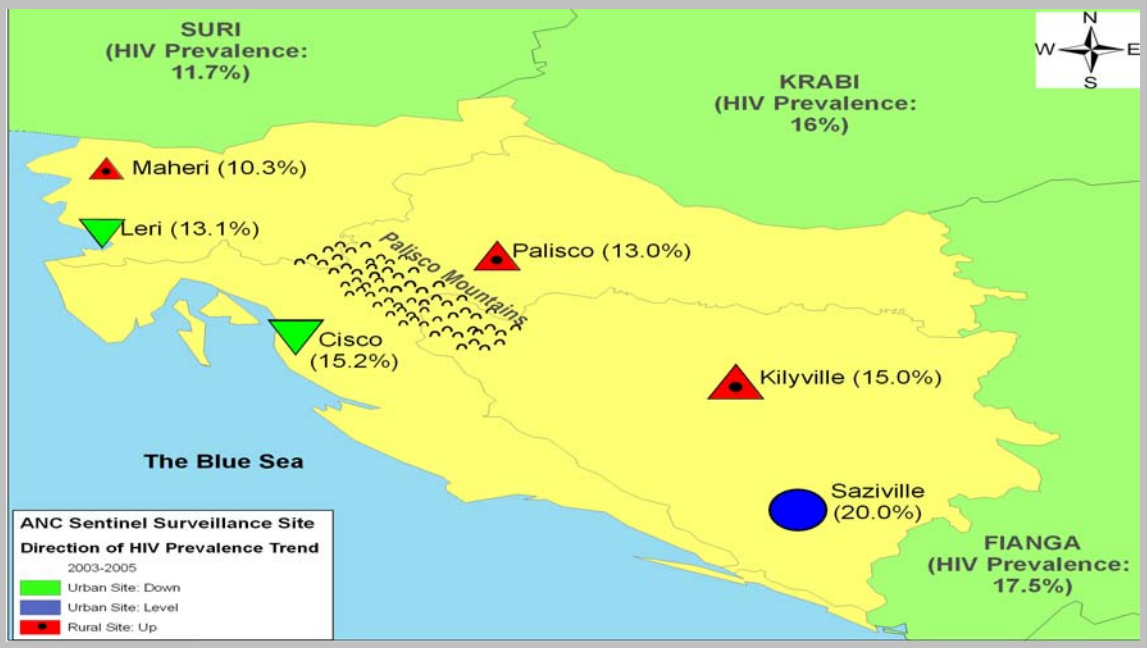
4. **Training Workshop** (1 week)—Using data captured in-country, a triangulation training workshop is conducted for epidemiologists and data analysts. Training workshop includes instruction in triangulation methods, refining and finalizing analyses to answer questions, and development of findings and next steps.

5. **Final Stakeholder Meeting** (1-2 days)—Immediately following the training workshop, a meeting with stakeholders is held to present key findings of triangulation analysis and discuss next steps.

6. **Final Country Triangulation Analysis Report** (1 month)—Produce country analysis report to be delivered to key stakeholders.

   It is important to identify a person who is available to dedicate a majority of his/her time to the project. His/her tasks would include organizing stakeholders and ongoing taskforce meetings and assisting with any problems in capturing and cleaning the data.

BACKGROUND: Fictional country of Bundo



Bundo is a sub-Saharan African country with a population of 2,044,147, according to the 2000 census. Major urban areas include Cisco, the capital city located in the central region; Leri, the university center in the north; and the commercial capital of Saziville in the southern region. HIV/AIDS experts consider Bundo to have a generalized HIV epidemic. In 2005 there were an estimated 300,000 people living with HIV/AIDS and 16,000 deaths due to AIDS. National sentinel surveillance surveys of antenatal clinic (ANC) attendees have been conducted since 1997 in all three major urban areas, as well as three rural sites: the northern border town of Maheri; the isolated town of Palisco in the central region; and the mining town of Kilyville in the south. At the national level, surveillance data show an increase in HIV prevalence in pregnant women from 1997-1999, followed by a continual decrease through 2005, with ANC prevalence ranging from 10.3% in Maheri to 20% in Saziville.

In early 2007, the Ministry of Health in Bundo opted to use triangulation to make better use of the data collected over the past 10 years. The triangulation exercise was conducted with technical assistance from international NGOs and universities that had previous experience working with the triangulation process. HIV prevalence data over time, documented changes in prevention efforts, and antiretroviral therapy (ART) rollout records provided the data required to look at several topic areas of interest.

REGIONAL DESCRIPTIONS:

CISCO (Central Urban)

- Cisco is the capital city of Bundo and has the largest population. The government is based in Cisco and all official government business is conducted there. Many residents cultivate maize in this area and, as in most regions of the country, there is ample subsistence farming.
- Historically, there has been a large Christian missionary influence in Cisco. As a result, most residents are devout Christians. Church values are strong, with key beliefs including monogamy and abstinence.
- An ART program was rolled out in Cisco by the Ministry of Health in 2004. Since then, an increasing number of HIV-infected residents have initiated treatment.

KILYVILLE (Southern Rural)

- Kilyville is a rural area located in the heart of the South. Large sapphire deposits can be found here and consequently there has been a large influx of miners coming from surrounding areas, creating a “boom town” climate with the expansion of the mining industry.
- Although it is rural and has a small population, due to the presence of sapphires discovered in the late 1990s and a newly constructed airport, Kilyville receives international traffic from potential sapphire consumers.
- Due to extreme loss in the workforce from AIDS, in February 2005 the mine owners initiated a partnership with an international HIV non-governmental organization to provide prevention services, such as counseling and testing services, condom distribution, and ART to employees.

SAZIVILLE (Southern Urban)

- Saziville is located in the southern region. Historically, it thrived economically due to prosperous tobacco plantations. There are many wealthy owners of these plantations, as well as migrant workers who are brought in to farm.
- Saziville is the closest city to the neighboring nation of Fianga, which is currently engaged in a civil war. Many refugees cross the border from Fianga to Bundo and travel to Saziville. The outskirts of Saziville have seen an explosion in refugee camps. In order to maintain border security, there is a surplus of military troops on border patrol in Bundo.
- Bundo border patrol guards and tobacco plantation laborers are men away from their families with disposable incomes. As a result, Saziville has a large commercial sex industry.
- The influx of refugees has led to increased crime and scarcity of water and food.
- Due to the high HIV prevalence in Saziville, Medicine Sans Frontieres (MSF) and the Ministry of Health have worked collaboratively to roll out ART to HIV-infected patients since 2003.

Proposed 12-step process for triangulation

This overview has structured the process of triangulation into twelve steps. Although these steps illustrate the triangulation process in a linear fashion, triangulation is actually an iterative process. The identification of new data, new findings, or new interpretations often requires that the process cycle back through some of the steps. The 12 steps are shown here:

Box 4: A 12-Step Approach to Triangulation	
Which part of the process?	**What steps are involved?**
Planning for Triangulation	1. Identify key questions 2. Ensure that question(s) are important, actionable, answerable, and appropriate for triangulation
	3. Identify data sources and gather background information 4. Refine research question
Conducting Triangulation	5. Gather data/reports 6. Make observations from each data set 7. Note trends across datasets and hypothesize
	8. Check (corroborate, refute, modify) hypotheses 9. If necessary, identify additional data and return to step 5 10. Summarize findings and draw conclusions
Communicating Triangulation	11. Communicate results and recommendations 12. Outline next steps based on findings

Step 1: Identify key questions

In the first step of triangulation, the key questions of interest and importance are identified. In some situations, the questions may already be decided. However, we recommend that the triangulation questions be decided upon by the consensus of the key stakeholders. Without buy-in, the triangulation process may miss priority topics and may not garner sufficient support to access key data and information successfully. Of course, time and resources may not permit taking on all questions or more than one key question if the stakeholders do not settle on a single priority question. Nonetheless, by agreeing upon priorities with the stakeholders, a future agenda of triangulation questions can be set. The efficiency of future triangulation analyses is improved as the available data are collected and catalogued.

Thus, the first step is to hold a meeting of stakeholders. The stakeholders meet to brainstorm what key HIV/AIDS-related questions need to be answered. The meeting should be led by national AIDS organizations or other decision-making bodies in consultation with triangulation experts. The meeting leaders will present an overview of triangulation and will guide the stakeholders though examples of triangulation and an explanation of the triangulation methodology.

The first round of generating key questions of interest should be as inclusive as possible. Allow sufficient time—possibly more than one or two separate meetings—for the stakeholders to complete their brainstorming. At this first stage, do not pass judgment on the feasibility or importance of any suggestions.

Some examples of questions generated in previous triangulation exercises are in Box 5 below.

Box 5: Sample Brainstorming of Potential Triangulation Questions

1. What is the overall trend in HIV prevalence nationally? Why?
2. Is there a difference in epidemic trends regionally? If so, why?
3. What is the trend in STI prevalence? Why?
4. Is there an association between HIV prevalence and natural disasters (hunger, drought, flood, etc.)?
5. What are the reach, intensity, and impact of HIV prevention in youth?
6. What are the reach, intensity, and impact of HIV prevention in high-risk groups?
7. Are prevention resources being allocated appropriately?
8. What have been the changes in behavior, or why isn't behavior changing?
9. Are behavior-change communication materials effective?
10. Are community-based organizations effective in their work?
11. Are HIV policies enforced?
12. What is the relation between drug use and risk behavior?
13. What is the impact of "opt-out" testing on ANC, PMTCT, TB, STI, other clinical services? How do we move toward provider-driven HIV testing?
14. Has VCT resulted in behavior change?
15. Are there socioeconomic status disparities in access to testing?
16. Do HIV-infected parents have their children tested?
17. What is the impact of ART on mortality?
18. What is the impact of prophylaxis on mortality?
19. What is the impact of ART on HIV transmission?
20. Are there disparities in the reach of and access to ART?
21. Is ART related to early death (Why? Who? How? Relation to TB?)
22. What is the impact of PMTCT on infant and child mortality (including children of HIV-infected mothers, nutrition, pediatric ART, other causes of death?)
23. How do side effects of ART affect adherence?
24. What are the reach, interpretation, and effect of CD4 counts and clinical staging in pregnant women?
25. Has antiretroviral treatment (ART) increased productivity, employment, and human resource capacity?
26. What are family-planning choices among people living with HIV/AIDS (PLWHA)?
27. What is the biological effect of HIV/AIDS on fertility?
28. What is the impact of ART on fertility among people living with HIV/AIDS?
29. What is the current status of prevention for positives?

Stakeholders are encouraged to develop many questions. This will allow for a comprehensive evaluation of the questions, which occurs in Step 2. The questions should be documented and shown to the stakeholders during and after the process. Some questions that are similar may be combined or changed during the brainstorming. For example, in Box 5 above, questions 5 and 6, about the reach, intensity and impact of prevention efforts in youth and high-risk groups could easily be combined.

Bundo Step 1: Identify Key Questions

To begin the triangulation process, the AIDS Office in the Ministry of Health convened a two-day stakeholder meeting in Cisco. Representatives from the following organizations were present at this stakeholders' meeting:

Ministry of Health-HIV/AIDS Office	Association of People Living with HIV/AIDS (PLWHA)	UNAIDS
National AIDS coordinating body (NAC)	Kilyville Mining Company	WHO
National Statistics Bureau	Ministry of Labor	UNICEF
Bundo AIDS Counseling and Resource Organization	University of Bundo	MSF
Saziville Regional Hospital	CDC	

On the first day, MOH officials presented the theoretical background of the triangulation methodology and provided real-life examples from other triangulation case studies. The meeting participants then brainstormed a list of questions that might be addressed by triangulation in Bundo. The group came up with an initial list of thirty-one questions of public health importance to the HIV/AIDS epidemic in Bundo.

The questions were categorized into five main categories:

1. Epidemiology
2. Prevention
3. Testing
4. Treatment
5. Living with HIV/AIDS

Step 2. Ensure that the questions are important, actionable, answerable, and appropriate for triangulation

The following criteria help guide the selection of the triangulation question(s):

Importance: Could the answer to the question have a large effect on HIV/AIDS in your area? The question should address a current and pertinent issue.

Actionability: Can the results of the process be used to make improvements in HIV prevention or AIDS care activities?

Data availability: Are there at least three data sources that can help answer the question? Are the data accessible to the triangulation project staff? Whose permission is needed to access the data? Can the data be accessed in a reasonable time period?

Appropriateness: Is triangulation the appropriate method to use to answer the question? Could the question be better answered by traditional research methods, an expert panel, or another type of study? Bear in mind that more specific questions may better lend themselves to traditional analyses. Additionally, the question may already be undertaken in a specific research study.

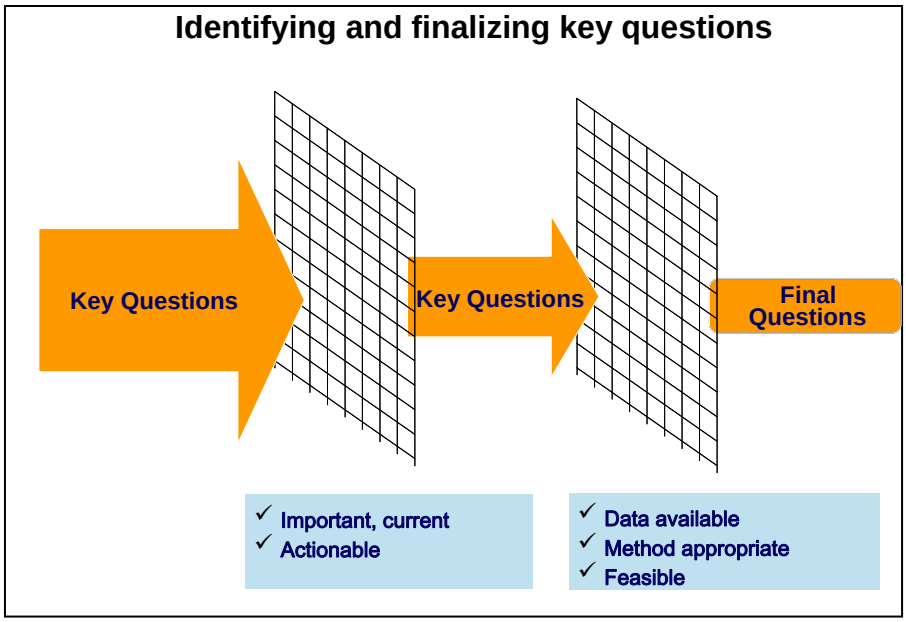
Feasibility: Can the project be completed in a reasonable amount of time? Are there enough resources available to complete the analysis? A successful triangulation requires funding, human resources, and data.

Conceptually, we divide the process of question selection into a two-step screening process (See Figure 2). We focus first on whether the question is important and actionable (broad policy considerations), and second on the logistical considerations. In practice, the logistical questions can often be addressed with more detailed field work, whereas if the broad policy considerations are not met, the field effort will not be worthwhile.

In Box 5, Step 1, for example, some of the 29 potential questions may be eliminated because they do not meet the above criteria for selection:

- Often, stakeholders find that virtually all questions meet the criteria of importance. But some questions are more relevant to program planning than others. For example, the relationship between drug use and risk behavior in Question 12 is important, but if drug-use rates are very low in a country, the answer may have less relevance than the answer to a question that addresses a more prevalent risk factor.
- Question 4 focuses on the association between HIV prevalence and natural disasters. While triangulation could be used to determine the association, little can be done to prevent the disasters from happening, so actionability may be limited and a more practical question might be preferable.
- Question 23 asks if the side effects of antiretrovirals affect adherence. If there were no studies or monitoring and evaluation reports that could address this specific question, it would be impossible to answer the question due to lack of available data.
- Some questions could be eliminated because triangulation is not the most appropriate method to answer them. Question 27, about the biological effect of HIV/AIDS on fertility, would be best answered by a review of the literature or a clinical study.
- Determining the answer to Question 25 might not meet the criteria of feasibility in some places, since any country will have many employers, and employers may be reluctant to give information about productivity among their employees.

Figure 3: Identifying and refining key questions



Ideally, the stakeholders should try to arrive at a consensus on the ranking of the potential triangulation questions. One method to help select questions would be to assign numeric scores to each question for each selection criterion. For example, a question may score highest (5) on importance, but low (1) on the appropriateness of triangulation as a method. In the exercise below, discuss how you would rank each question in terms of the appropriateness of triangulation to answer it.

Exercise 1. Appropriate use of triangulation		
Question	**Triangulation or Other Method?**	**Why?**
Does a two-session intervention reduce unprotected intercourse between young men and women in high school settings?		
Have increased prevention activities in a country with a concentrated epidemic resulted in a reduction of new HIV infections among injection drug users?		
Is the HIV epidemic slowing in Luap?		
Does the length of time breastfeeding babies by HIV-infected mothers increase or decrease infant mortality?		
Are HIV-infected patients satisfied with the level of care and treatment they are receiving at a hospital?		

Bundo Step 2: Ensure that the question is important, actionable, answerable, and appropriate for triangulation

The following day, participants at the stakeholders' meeting began to refine the questions and narrowed the initial list based on two criteria:

1) **Importance** - *how much of the epidemic does the question potentially address?*
2) **Actionability** - *would the answer lead to clear program or policy action?*

The stakeholders' group next generated an extensive inventory of data sources available in Bundo that could be used to answer the potential triangulation questions. After this inventory, their list of questions were further refined based on four additional criteria:

1) **Data availability** - *do data exist to answer the question?*
2) **Appropriateness of the method** - *is the triangulation methodology the most appropriate one to answer the question, or is another method more appropriate (e.g., trial, cohort study, expert panel)?*
3) **Feasibility** - *can the question be answered in the five- to six-month timeframe?*
4) **Duplication** - *is the question already being addressed by another group?*

The results from an ART impact triangulation were determined to have powerful funding implications, and if the rollout was seen to be effective, then national expansion of the program would be implemented beyond the three current sites in Saziville, Kilyville, and Cisco. Based on this factor and the above criteria, the stakeholders identified one key question:

What is the impact of ART on mortality, morbidity, and productivity?

Step 3: Identify data sources and gather background information

Step 3 is used to determine what data may be available and relevant to your area of focus. It includes finding and collecting appropriate data to answer selected questions generated in step 2. If, during this step, you find that data are not available, you will need to go back to step 2 and consider other questions.

Data sources:
The table below displays some types of data that may be used in the triangulation. Each source contains different measures. For example: survey data such as DHS and BSS would have risk behaviors and possibly HIV prevalence; hospital records might have the number of STI and AIDS cases; VCT data would have the number of tests performed and HIV prevalence; and qualitative studies would have additional information on knowledge, attitudes and behavior. These types of data sources can be found in several places, including the following: websites (www.measuredhs.com, www.pubmed.org, www.unaids.org), the national bureau of statistics, national AIDS coordinating body, and collaborating partners such as universities, as well as other donors and agencies working in-country.

Sources	**Examples**
Research	institutional (NGO / University) studies; behavioral surveillance surveys (BSS); demographic and health surveys (DHS)
Surveillance	sentinel sites; ANCs
Programmatic	ART registries; VCT, hospital / clinic records; STI treatment; condom distribution; Institutional (NGO / University) programs; other prevention and treatment activities
Census	national census

Qualitative and quantitative data:
Data collected for research or program monitoring and evaluation can be either qualitative or quantitative.

Qualitative data include open-ended textual data found in the words and phrases of the study population. They are used to produce information on the language, behaviors, and belief systems of the study population from an insider's point-of-view, in an attempt to describe, characterize, analyze, and synthesize information. Qualitative methods are used to gather information by asking, observing, and interpreting.

These methods are used to produce information on how and why:

- People feel about situations
- Things are done
- People behave

It is important to note the limitations of qualitative data. Due to small sample sizes and the dynamics of qualitative data gathering, it is often difficult to generalize results. However, these data can be used in the beginning of the process to help develop hypotheses, and later to strengthen or refute findings from other data sources.

Quantitative data, on the other hand, represent measurable actions, services, conditions, objects, or other things that can be tallied. Research strategies that produce and analyze numeric data are called quantitative methods. These methods are restricted to questions that provide answers that can be easily translated into numbers. This limits their ability to provide insight on human behavior, as it is difficult to capture using simple numeric scales. However, quantitative methods often produce results that can be generalized across larger populations, as they have the ability to incorporate probability sampling when selecting a sample size.

The strengths and limitations of qualitative and quantitative data are summed up in the following table:

Comparison of different methods*:	
Qualitative	**Quantitative**
▪ Use observation and words as data ▪ Have a goal of exploration and discovery ▪ Ask "how" and "why?" ▪ Use data collected through interviews and observation ▪ Are case-oriented ▪ Do not have generalizability as a goal ▪ Use sampling that is purposive, convenience, snowball, or quota ▪ Use small sample size	▪ Use numerical data ▪ Have a goal of verification or proof ▪ Ask "how many?" ▪ Use data collected through surveys ▪ Are population-oriented ▪ Have generalizability is a goal ▪ Use probability sampling ▪ Use large sample size

*Unpublished: Global AIDS Program. (2006). *Qualitative Methods for Monitoring and Evaluation of HIV/AIDS Programs.* U.S. Centers for Disease Control and Prevention, Atlanta, GA.

Sources of both qualitative and quantitative data will depend on the study question and available resources in your country. A list of possible data sources for both types of data is provided below:

Potential data sources for both qualitative and quantitative data:	
Qualitative	**Quantitative**
▪ Peer-reviewed literature (anthropology, sociology, public health) ▪ Program documents, reviews, and reports ▪ Meeting and consultation proceedings ▪ Mapping ▪ Recorded observations ▪ Expert panels, focus groups, working groups ▪ Patient interviews	▪ Peer-reviewed literature (anthropology, sociology, public health) ▪ Program documents, reviews, and reports ▪ Mortality data (if available) ▪ Program monitoring data ▪ Demographic data ▪ Population-based surveys (BSS, DHS) ▪ Census data

Exercise 2.
List available data that you could use for triangulation in your own country. Note which data are qualitative and which are quantitative or both.

Determining the quality of data

Some data sources will be more useful than others. Data issues encompass many different considerations, such as the overall quality of the data and the types and sources of biases. It is important to realize that all sources of data potentially have biases. However, triangulation helps interpret data in the face of possible biases. That is, if several different sources agree, then the conclusion is strengthened. These data quality issues are outlined in the following table and some issues (e.g., quality and ethics) are explained in more detail in the text.

Box 7: Criteria for data issues	
Criteria	**Key Points**
1. Access	Can permission be obtained to use data? What format are the data in (line listed or aggregate)?
2. Description of the data	What are the sources of the data? Qualitative or quantitative? What years were the data collected? Are the data relevant to the question(s) being asked?
3. Quality	What is the quality of the data? Are there any gaps in data? How complete are the responses to the questions?
4. Ethics [defined below]	Have data used in the triangulation been obtained according to ethical standards? Was the study protocol approved by an institutional review board (IRB)?

1. Access: Can permission to use data be obtained? Are the data in a useful format?
This criterion is important for several reasons. Some data holders do not readily share their data. For example, many militaries around the world test their new recruits for HIV, which would provide an excellent means of assessing HIV prevalence in young men. However, those militaries may refuse to give their data even to public institutions in their own countries for reasons of national security. This is why it can be useful to include stakeholders who have access and are willing to share data.

Suppose the question deals with the effect of HIV on the workforce. While this may be an excellent and relevant question, accessing work records such as sick leave, absences, and productivity reports from businesses can be enormously time-consuming and will rely on the willingness of employers to give these data.

Also, the data must be in a format that can be used and analyzed. Some data are only available through reports, and cannot be broken down to line-listed format. For example, some data will often only be available in the form of a report or peer-reviewed publication, not in their “raw” form. Other data may need cleaning or may have missing or corrupted elements. Also, some questions require that data be analyzed at sublevels (e.g., by gender or location), but the data may not have the necessary variables or may not be designed to be analyzed at that level. If data owners cannot provide line-listed data, analysts can arrange for the data-owners to perform the analysis themselves.

2. Description of data: What are the sources of the data? Is the data qualitative or quantitative? In what years were the data collected?
One benefit of triangulation is that it can make use of a wide variety of datasets, both qualitative and quantitative. It is important for the analyst to understand the sampling methodology and data collection techniques used for each dataset. Different methods will determine the value, reliability, and limitations of each dataset. National census, mortality statistics, focus groups, voluntary counseling and testing (VCT), and national reporting systems on prevention efforts have all been used in triangulation. VCT data, for example, can tell you much about the changes in testing coverage. But reasons for testing change over time and the characteristics of clientele who seek testing may change over time. Thus, a sentinel surveillance source may prove to be more useful than VCT data as an indicator of HIV prevalence.

Triangulation is usually used to track trends over time, not measure absolute levels of a variable. Different data sources may have different levels of accuracy, and cannot be combined to provide a single estimate. Combining ANC HIV prevalence data with VCT HIV prevalence data would not accurately reflect the actual prevalence, as the sample populations of each dataset are too different to allow direct comparison.

Useful datasets with only one data point in time should not be discarded. Rather, the tracking of trends across time can be combined with single data points to better answer the key questions. Without looking at trends over time, analysts may miss the effects of certain interventions on the population of interest. Data collected for a single variable, at a single point in time, can also be used to make comparisons across different locations or populations.

It is also important for the analyst to understand what questions the datasets can answer. Surveillance data are a good example of this. If a research question is: “What is the recent trend in HIV prevalence?” the number of AIDS cases will only give information on HIV infections that occurred several years ago and may not represent the effect of recent interventions or prevention programs. The data may simply be too old and therefore not relevant, or the data may not have been collected for long enough. It will be difficult to determine trends from information if the data have only been collected for two years.

Here are some typical sources of data:

Disease case reporting
- AIDS
- HIV
- STI
- TB

Epidemiological
- Sero-prevalence surveys (sentinel, population-based)
- Behavioral surveillance

Programmatic
- VCT
- Outreach education
- HIV, STI, TB care and treatment

Research
- Cohorts measuring changes in mortality
- Intervention studies
  - Prevention, treatment, care, adherence
  - Qualitative studies

3. Quality: What is the quality of the data? Are there any gaps in data?

Data quality can first be assessed by looking at the data collection methods and determining gaps and limitations.

Some important questions the analyst should consider when looking at a new data set for the first time include the following:

- Was there a clear statement of the aims of the research?
- Was the methodology appropriate to answer the research question?
- Was the research reviewed by an Institutional Review Board (IRB)?
- How was the research explained to participants? Was there a process of informed consent?

Examining the sample and determining the representativeness of the data is critical. Check to make sure that the sites and the population that they serve have not changed over time, and that they are representative of the population of interest. It is important to consider what sampling strategies are used to obtain data sources—is it cluster sampling and random sampling, is it convenience sampling, or are the data simply taken from all clients who visit a healthcare provider? For example, the Demographic and Health Survey (DHS) is a rigorous population-based survey representing the overall population of a specific country. The sampling methodology allows for stratification of different subpopulations within the overall sample. Thus, DHS findings can be generalized to the population. In comparison, ANC sentinel surveillance often uses consecutive sampling consisting only of pregnant females seeking antenatal care. The results are harder to generalize to the overall population.

Here are general questions to help evaluate a data set's sampling strategy:

- From where was the sample selected and why?
- Who was selected and why?
- How were they selected and why?
- Was the sample size justified?
- Is it clear why some participants chose not to take part?

Bias is another issue that should be examined when looking at the data collection methods. There are several different types of bias, but two of the more important ones are confounding and selection bias. Confounding occurs when two or more independent variables are associated both with each other and with the dependent variable of interest. An example of this would be people associating the transmission of malaria with eating mangos, as mangos are often present during the rainy season, when malaria is more prevalent. Selection bias occurs when people selected for

a survey do not reflect the overall population—for instance, using VCT or prevalence among blood donors to directly estimate overall HIV prevalence in a country.

When looking at trends over time, it is important to know if all data were collected in a consistent manner. For example, if a new organization or program manager took over data collection responsibilities, their methods must be identical to the previous manager's methods. Analysts will need to determine if data collection methods have changed or if there were gaps in data collection.

When using finalized reports or studies, it is also important to understand how the data analysis was conducted. The methods of analysis can have profound effects on validity of the results.

Data are often incomplete. This causes problems in analysis, and can be dealt with in several different ways. Some possible solutions include imputation, re-extracting the data from the original source, sub-sampling similar populations or groups, or triangulating with other data sources (see Box 8).

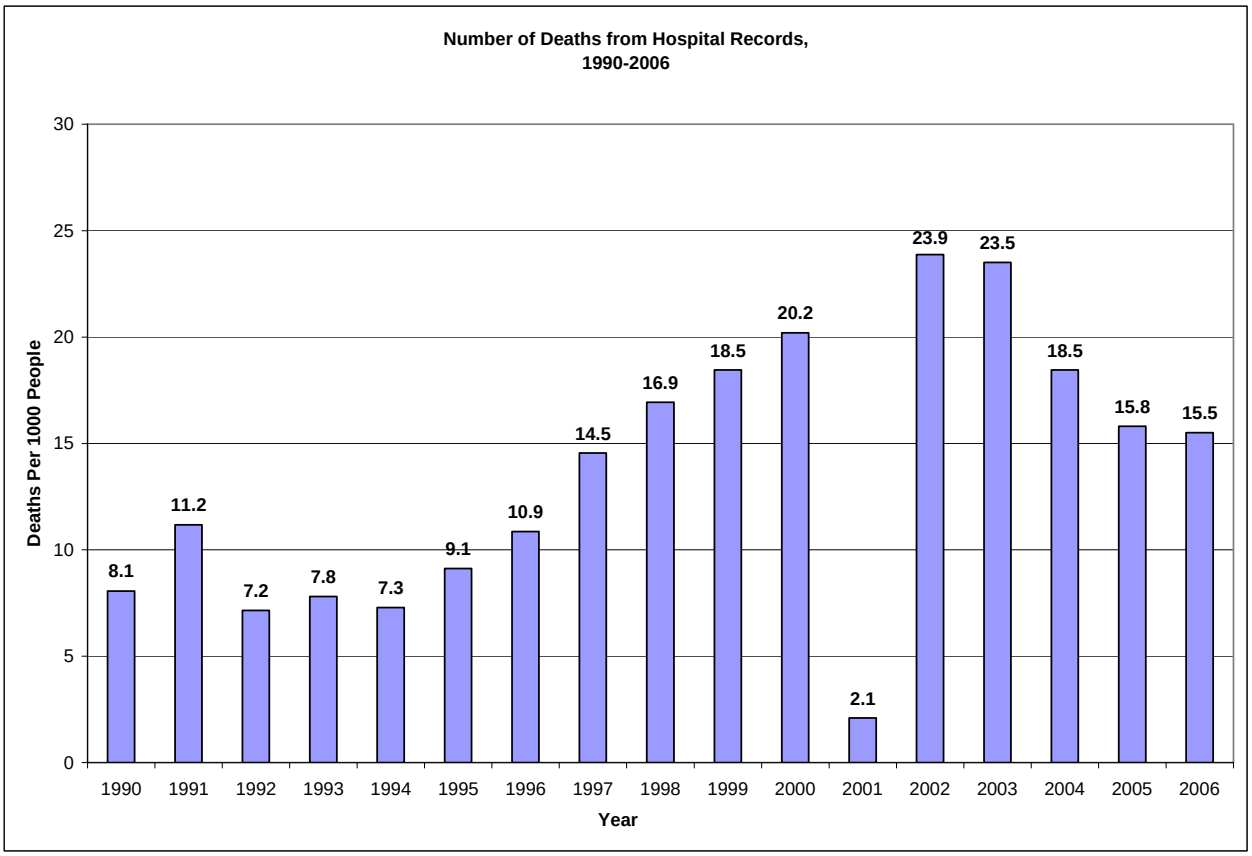
The analysts will need to decide if these issues make the data unusable, if the problem can be remedied, or if the data are usable as they are. If data quality is an issue, make sure to exhaust all resources for available data (both qualitative and quantitative).

Box 8: Examples of problems with completeness of reporting

Quantitative data:

Mortality data were collected from a major hospital.

- What do you see as potential issues with completeness of reporting in this data source?
- Brainstorm what the causes may be and how to remedy them.



Solution: Try re-abstracting the data to determine if there are missing records from the year in question (2001). If there are too many records, consider using a 10% sub-sample. If other data sources are available, check to see if findings corroborate results.

Qualitative data:

Researchers conducted two focus groups with hospital nurses about the impact of anti-retroviral treatment (ART) among HIV-infected patients. When analysts listened to the tape recordings, they learned that little about ART use was actually discussed.

- What should the triangulation researchers do with this information?

- Solution: This data may **not** be useful in providing information about the impact of ART on mortality. However, it may be useful for other topics, depending on what the participants talked about.

4. Ethics: Have data used in the triangulation been obtained according to ethical standards?

Ethics are a set of principles of right conduct. Ethical principles used in public health settings are described in the Belmont Report (found at http://www.hhs.gov/ohrp/humansubjects/guidance/belmont.htm), the Helsinki Agreement (found at http://www.wma.net/e/policy/b3.htm) and the Council for International Organizations of Medical Sciences (http://www.cioms.ch/frame_guidelines_nov_2002.htm).

Ethical principles of data collection include:

- **Respect for persons**—Study subjects are persons whose rights and welfare must be protected, not just passive sources of data.
- **Beneficence**—Researchers should balance benefits and risks (physical and psychological harm) to individuals.
- **Justice**—Risks and benefits from studies should be distributed fairly and evenly in populations.

The ethical standards considered should include the applicable national, state, and local laws. If international organizations are involved, their ethical standards should also be considered. The standards of professional conduct and practice of studies should be considered when evaluating data sources used in triangulation.

Major considerations requiring ethical data collection:

- Elevated risk of harm for people in high-risk populations, especially if their behavior is illegal
- Potential risk of stigma for HIV-infected individuals
- Confidentiality
- Informed consent
- Access to prevention and care services

The rigorous application of ethical principles when conducting data collection for use in triangulation is paramount. Data must be ethically collected and, depending on the funding source, it may have to be approved by an IRB, local institution, or other ethical committee that reviews data collection protocols for compliance with ethical principles.

The following situations may provide indication that data were ethically collected or can be used in triangulation:

- Data were collected anonymously
- All identifying information was removed from data before the triangulation analysts received them
- Information was obtained from published reports and/or papers
- Owners (source) will do the analysis and provide aggregate anonymous output to the triangulation team

Bundo Step 3: Identify data sources and gather background information

Following the meeting at which the key question '***What is the impact of ART on mortality, morbidity, and productivity?***' was selected, a taskforce was created to guide and see the analysis through to completion. Participation on the taskforce was voluntary. Recruiting both influential members with access to the identified data sources and analysts with an interest in ART impact was pivotal to the success of the project.

The taskforce recruited a representative from each of the following organizations: MOH, CDC, Global Fund, WHO, UNAIDS, University of Bundo, National AIDS Coordinating Body, Saziville Regional Hospital, and Kilyville Mining Company.

Due to the taskforce's involvement in the data collection and analysis, members helped gather background information and specified what they could offer in terms of identifying additional data sources.

Members of the taskforce also shed light on more specific issues about each data source, such as ethical issues and institutional review board (IRB) approvals, biases, limitations, study population, time frame, methodology, and inclusion/exclusion criteria.

Bundo Step 3: Identify data sources/gather background information (continued)

The taskforce initially identified the following three data sources:

Data Source	Type of data; measures	Area or site	Years	Access
Health Management Information Systems (HMIS)	Surveillance; Adult mortality	Cisco Central Hospital; Saziville Regional Hospital	1997-2007	Yes
National AIDS Commission	Surveillance; Cumulative number of patients on ART	Three sites; Cisco, Kilyville, and Saziville	Cisco 2004-2006; Kilyville 2005-2006; Saziville 2003-2006 ;	Yes
MSF Programmatic Data	Programmatic data; Cumulative number of patients on ART	Saziville	2003 - 2006	No

Exercise 3.

List data and sources in your area and assess their quality.

1.

2.

3.

4.

5.

Step 4: Refine the research question

In the first three steps, the questions were intentionally left broad. As the triangulation analysts look at their data, they will gain a better understanding of what they can and cannot interpret from the data. As the triangulation stakeholders discuss the question in the context of the data sources, they will gain a better understanding of the issue they are studying. This new understanding should lead to a refinement of the research question(s). Refining the research question(s) is the last step in determining the final question(s) you will address in your triangulation exercise. In this step, the remaining questions are organized into topic areas and, if possible, combined so that more than one question can be answered at once.

The questions can be refined by the attendees of the stakeholders' meeting where the questions were initially developed, or by a taskforce charged with seeing the analysis through to its end. In one sub-Saharan African country, for example, triangulation analysts sought to determine the reach and intensity of prevention efforts in high-risk groups. They realized over time that there were gaps in the information on prevention in most high-risk groups, such as sex workers and truck drivers; however, they did find information on prevention efforts in the general public and in one high-risk group—youth. The question then had to be refined in order to make use of the data that they were able to utilize, and was adjusted to focus on prevention in the general public and in youth.

A round of refining the questions is helpful in ensuring that you have selected the final question(s) and that it meets all the criteria mentioned in Step 2. However, this step is one that tends to be repeated during the triangulation. As more data come in, or as analysts find that the data are incomplete or flawed, it may become apparent that the data will determine how much of the original question can be answered, and in what depth.

Bundo Step 4: Refine the research question

As the analysts became more familiar with the data, the research question "***What is the impact of ART on mortality, morbidity, and productivity?"*** evolved. This was a cyclical process between steps 2, 3 and 4. The taskforce refined the research question to focus on the three cities that had received ART rollout: Cisco, Kilyville and Saziville.

Additionally, the definition of 'impact' was more narrowly defined as the effect on overall mortality rather than including morbidity and productivity. The population of interest was defined as the overall adult population, which includes more than just those adults on ART.

Triangulation Question Selected for the Bundo Triangulation Project:

What is the impact of ART on overall adult mortality in Cisco, Kilyville, and Saziville?

Step 5: Gather data/reports

Gathering data and reports is a labor-intensive step in the triangulation. Make sure adequate time is allowed for this activity and that there is at least one dedicated person assigned to the task. The overall success of the triangulation exercise depends on the thoroughness of the work done in obtaining, cleaning, and preliminary synthesis of the data.

In this step, regular taskforce meetings to monitor the progress of data collection are particularly beneficial. The taskforce should be a diverse group of individuals representing different organizations. It is best to include people who have access to some or most of the data sources. The taskforce will guide the analysis of data, but can also help access the data, explain its strengths and weaknesses, and analyze data itself. Quite often, officials at various levels spend a great deal of time getting authorization for and access to data. Having key organizations represented in the taskforce can reduce that time.

The individual assigned to data collection may need to work on an individual basis within each organization that maintains identified datasets. In some cases, the individual will have to physically go to these organizations to collect the data, and may even have to enter data that have not yet been collated in a usable format. This may be time-intensive and include travel and many hours of planning and coordination.

After data are gathered, they may need to be cleaned, as it is likely that many different data sources will exist in various formats in terms of both software (Excel, Access, SAS, STATA, SPSS, Epi-Info) and data structure (line-listed, relational). Depending on the expertise of the analyst, data can be analyzed in its original format, or it can be transferred into a common format using a software program like DBMS Copy or Stat/Transfer. Each dataset will need to be cleaned individually prior to making observations.

Using qualitative data in analysis:
The taskforce should include not only quantitative and qualitative data experts, but also researchers, monitoring and evaluation specialists, and others who are familiar with the specific data sources being used. In past triangulations, qualitative data have proven beneficial, not only in explaining the “why” of analysis findings, but also in identifying new HIV risk behaviors and other factors that were not measured in quantitative data.

One way to use qualitative data is by summarizing qualitative reports and articles. Some triangulation exercises have used summary tables in which the key findings of qualitative research were organized by theme, region, or subpopulation.

As you analyze and interpret the data, triangulate the analysis whenever possible by incorporating multiple data sources addressing a specific topic. Options include:

- Assessing the consistency of findings generated by different data collection methods (i.e., methods triangulation).
- Assessing the consistency of different data sources within the same method (i.e., triangulation of sources).
- Using multiple analysts to review findings (i.e., analyst triangulation). Qualitative data can be useful to triangulation even when they do not share the same methods. Conclusions are strengthened when the same interpretations arise from data collected by different methods, by different persons, and in different populations.

When summarizing findings, be careful to report findings in the context of guiding research questions, themes that emerge from the data, and the particular cases that were examined. Look for alternative explanations to the answers and highlight exceptions to the patterns. Be cognizant of both the shared and divergent views and perspectives. By studying various qualitative research projects, analysts should be able to summarize themes. Try to avoid quantifying results. Remember, qualitative research isn't about counting the number of people who give the same response. It is oriented toward exploration and discovery, and can provide a better understanding of social and material context. It includes searching for and incorporating research results related to the research question and arraying published findings. In one African country, qualitative research found that some HIV prevention strategies developed by married women did not follow the traditional categories of abstinence, being faithful, and use of condoms. These findings were then taken into account to corroborate quantitative evidence.

Bundo Step 5: Gather data/reports

The taskforce agreed to meet once a month. Between meetings, members attempted to gather data and reports that were accessible to them and might be relevant to the research question. At this stage, the process was systematic and inclusive in terms of collecting all potentially applicable data sources without pre-judging the quality and relevance. However, since resources were limited, the taskforce focused on first gathering the data sources that were believed to be instrumental in the analysis; mortality figures and data on ART rollout.

The National AIDS Commission provided an anonymized line-listed dataset with information on ART patients, including when they began therapy and their current health status. Mortality data were obtained from hospital records at the national hospital in Cisco, the Saziville regional hospital, and through Kilyville Mining Company employee records. Due to IRB issues, the analysts were not allowed to access employee records, so a Kilyville Mining Company representative on the triangulation taskforce arranged for analysis. Additionally, the University of Bundo (UB) conducted a nationally representative survey every four years starting in 1997 that included measures of adult mortality. Their published report was available to the taskforce in electronic format.

Ultimately, an inventory of all datasets identified was compiled by the taskforce for use in the triangulation. The inventory included a list of all the datasets with the name of the study/program, type of data, measures of interest, population, sites, years, data format and IRB approval status.

Bundo Step 5: Gather data/reports (continued)

Name of study/program	Type of data; measures	Population	Area or site	Years	Format	IRB Status
Health Management Information Systems (HMIS)	Surveillance; Adult mortality	Adults	Cisco Central Hospital; Saziville Regional Hospital	1985-2006	Annual results	Approved
National AIDS Commission	Surveillance; Cumulative number of patients on ART	HIV-infected patients accessing ART	Three sites; Cisco, Kilyville and Saziville	Cisco 2004-2006; Kilyville 2005-2006; Saziville 2003-2006	Line-listed	Approved
University of Bundo	Survey; Adult mortality	Adults	National	1997, 2001, and 2005	Results from published report	Approved
Kilyville Mining Company	Programmatic; Non-accident mortality	Kilyville employees	Kilyville	2000-2006	Annual results	No direct access

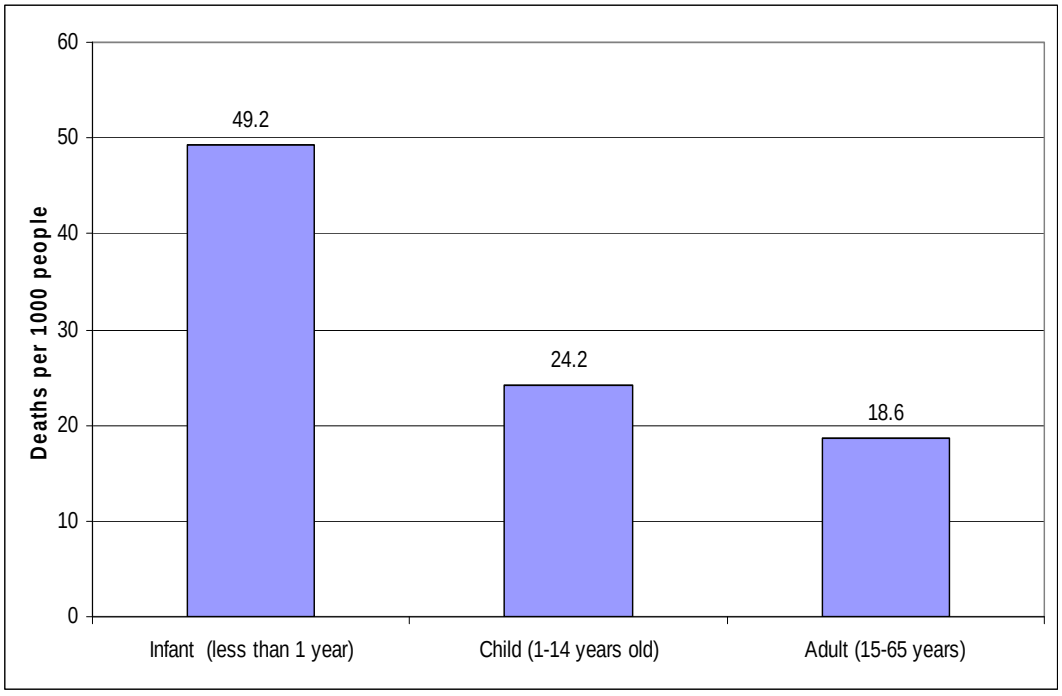
Step 6: Make observations from each data set

In a triangulation exercise, much of the analysis is descriptive in nature. As mentioned earlier, the software used in the analysis may vary depending on the format of the dataset. Data are typically used to make graphs or tables that can be compared side by side; or sometimes two different types of data are placed together in a single graph or table.

Person, place and time

The first and perhaps simplest way to look at data is in terms of people. The following figure (4) illustrates mortality, from one source of data or dataset, stratified by age group. In this illustration, it is clear that mortality is greatest among infants.

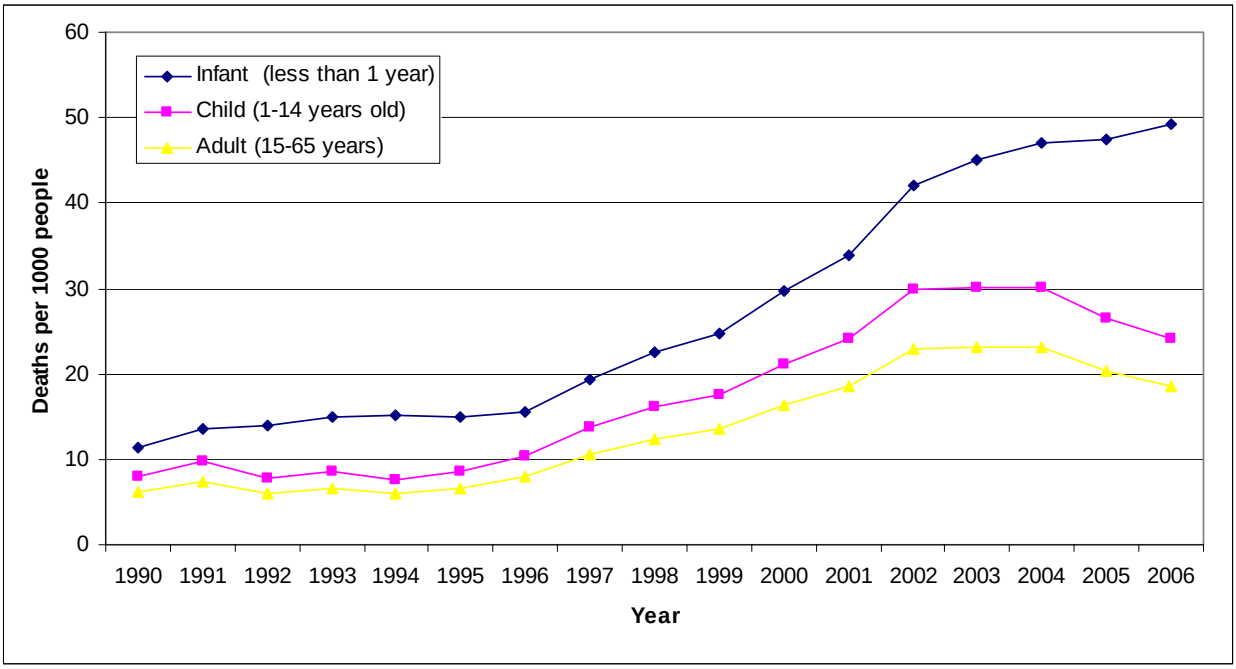
Figure 4: Bar graph of mortality by age group, 2006



For data that have been collected at different points in time (such as HIV infections among ANC attendees and reported mortality by age), combining these data on a single graph demonstrates the trend over time. Adding this element adds further detail to the analysis and may allow for more meaningful observations.

Figure 5 shows mortality by age group over time. When looking at data over time it is important that data are collected in a consistent manner; from the same population and measuring the same variable. For example, if testing practices for ANC attendees change one year, it may not make sense to compare data from previous years to the current year.

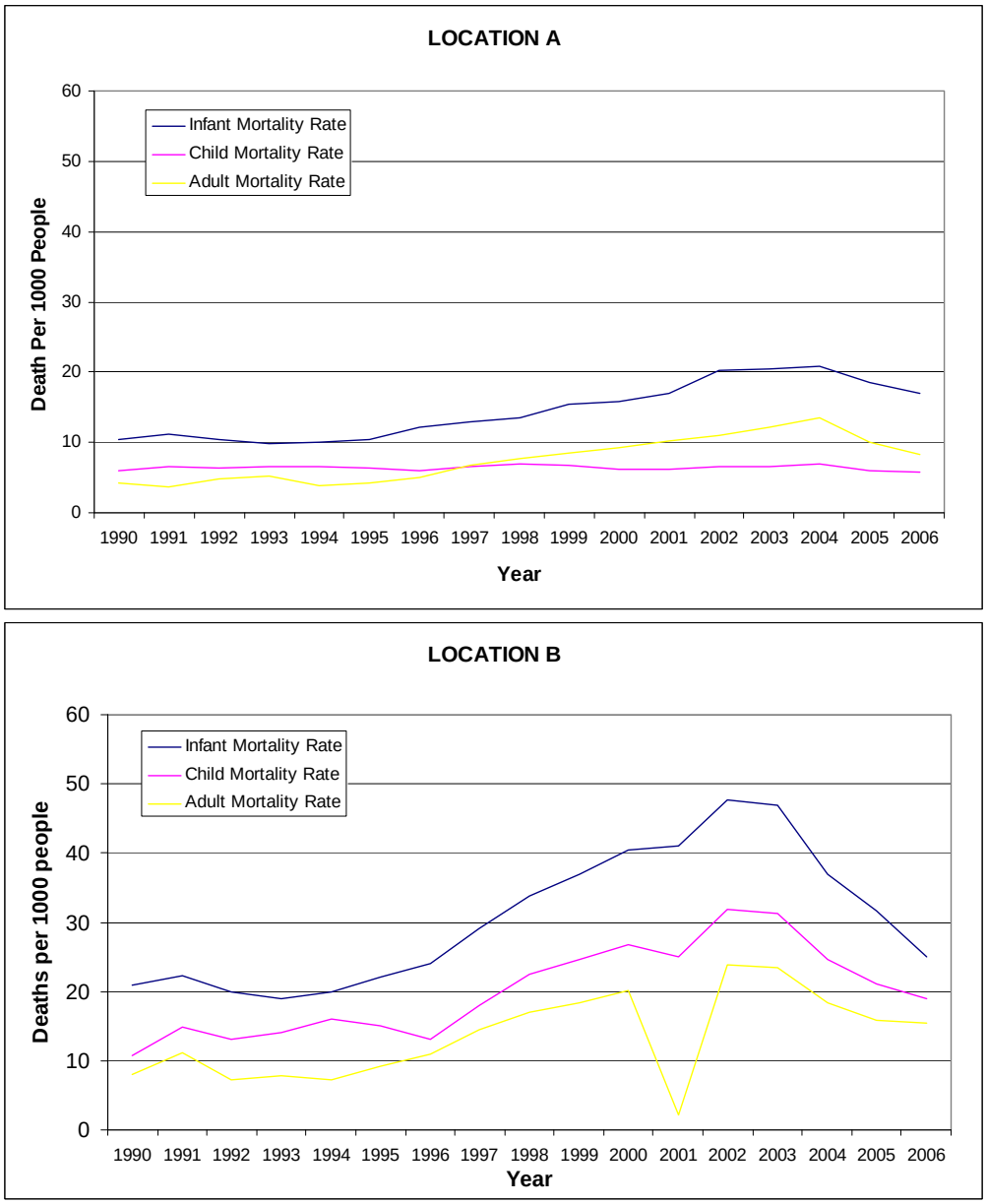
Figure 5: Line graph of mortality by age group, 1990-2006



When time is added, it becomes clearly evident that mortality is highest among infants and has been higher than in older age groups over a long period of time. Furthermore, the addition of time to the graph allows for inferences of trends in mortality to be made.

Finally, adding a third dimension—place—further refines interpretation of the data. In Figure 6, mortality is further stratified by place.

Figure 6: Mortality (deaths per 1000 people) by location, 1990-2006



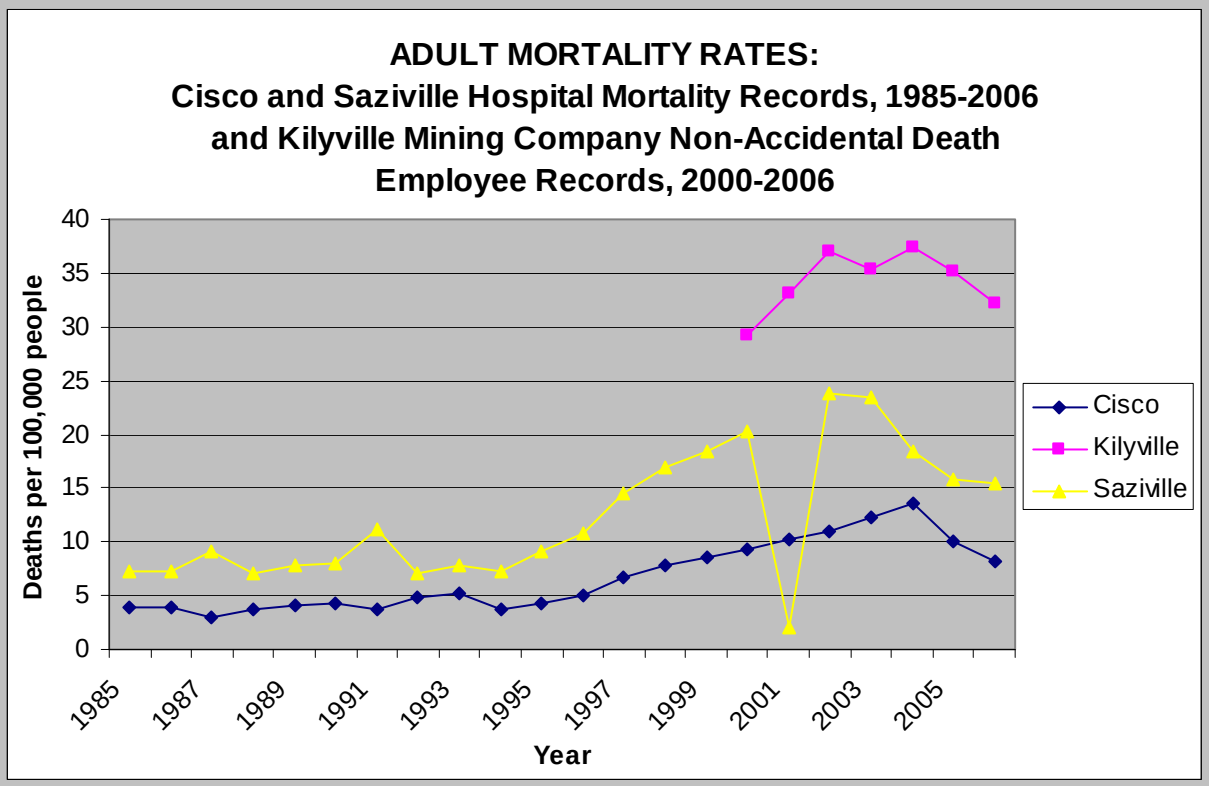
This last stratification allows the investigator to form a better understanding of the geographic differences in mortality. These differences are crucial to formulating the best interpretations of the data.

It is also important to consider all of the possible explanations for each finding. For example, changes in HIV prevalence in the national blood supply may reflect changes in donor recruitment towards low-risk donors, as opposed to a decrease in overall HIV prevalence. Likewise, HIV testing of pregnant women may change over time from voluntary to routine, causing the HIV prevalence among pregnant women to change.

Bundo Step 6: Make observations from each data set

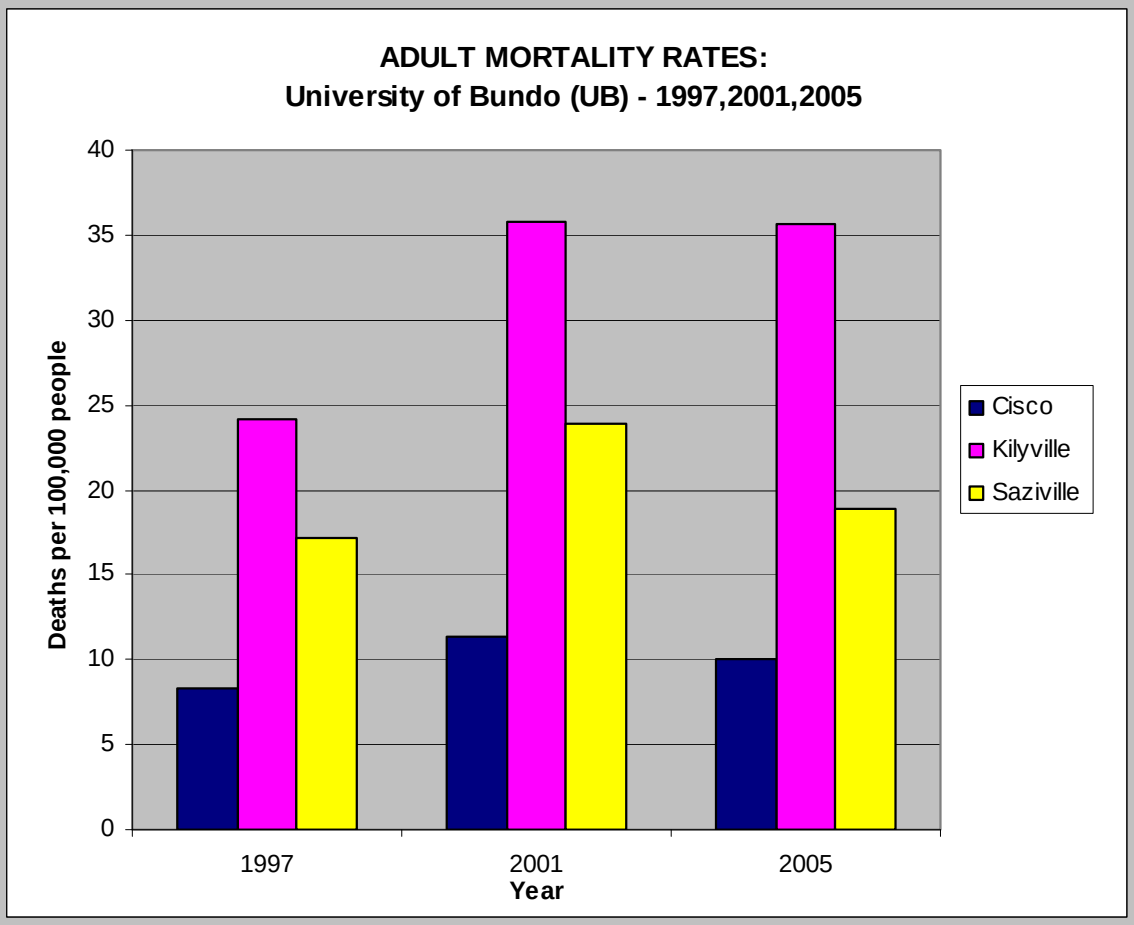
Under the direction of the triangulation taskforce, the analysts conducted preliminary analyses of key data sets. These preliminary analyses helped to assess the quality and interpretability of the diverse sources of data and to guide the search for further information. To begin investigating the key research question, '***What is the impact of ART on overall adult mortality in Cisco, Kilyville, and Saziville?***' the analysts made observations from each of the primary data sources: HMIS, Kilyville Mining Company Employee Records, the University of Bundo study, and the National AIDS Commission ART Rollout Records.

Based on mortality data from hospitals in Cisco and Saziville, as well as mortality from the Kilyville Mining Company, mortality rates appeared highest in Kilyville, with Saziville reporting significantly lower mortality rates, and the lowest rates of adult mortality reported in Cisco. Additionally, mortality rates among adults have begun to decline in each of the three areas in recent years. The dip in mortality observed in Saziville in 2001 is likely due to missing/erroneous data, and not representative of an actual change in mortality for that year.



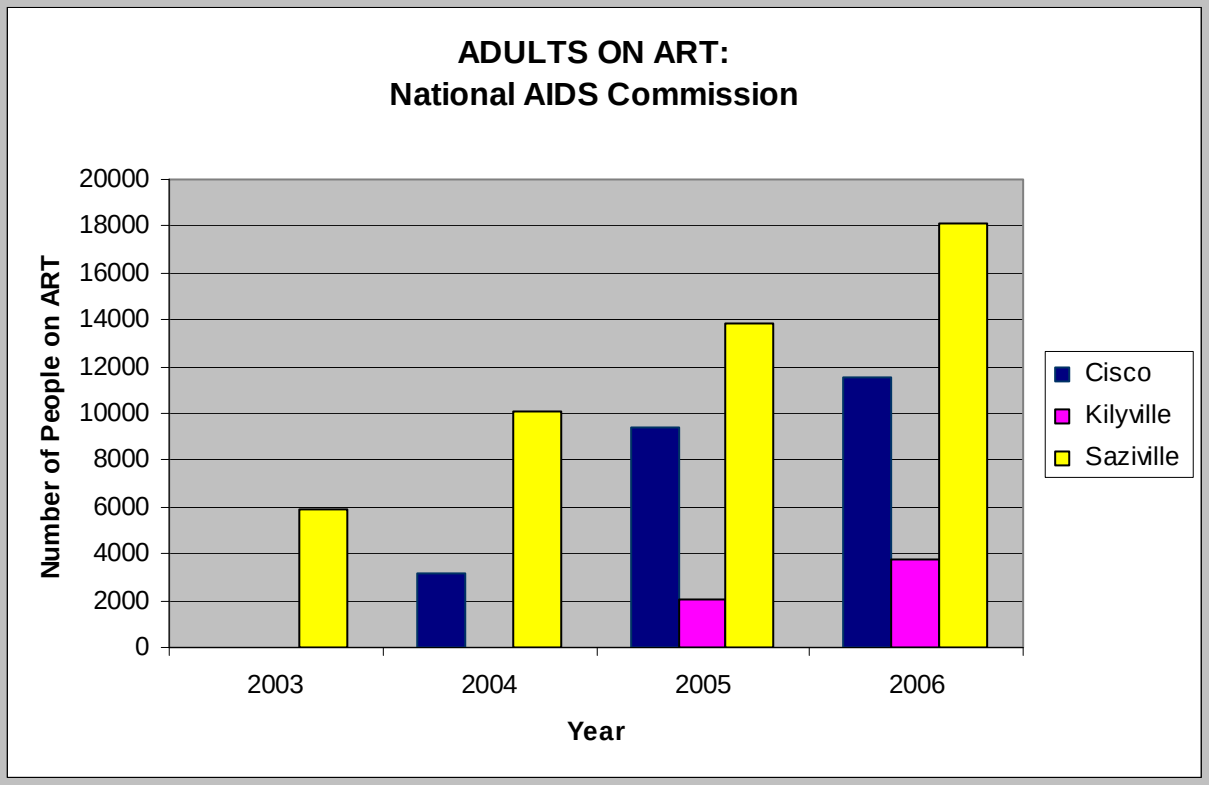
Bundo Step 6: Make observations from each data set (continued)

Mortality rates from the University of Bundo study in 1997, 2001, and 2005 were next investigated. Saziville experienced the most noticeable decline between 2001 and 2005, with Cisco having a slight decline and mortality rates in Kilyville appearing stagnant for the same period.



Bundo Step 6: Make observations from each data set (continued)

Lastly, the analysts were interested in the number of adults currently on ART. Saziville was the first site to rollout ART in 2003, and had the greatest number of people currently enrolled at the time of data collection. Saziville is followed by Cisco, then Kilyville, which made ART available in 2004 and 2005, respectively.



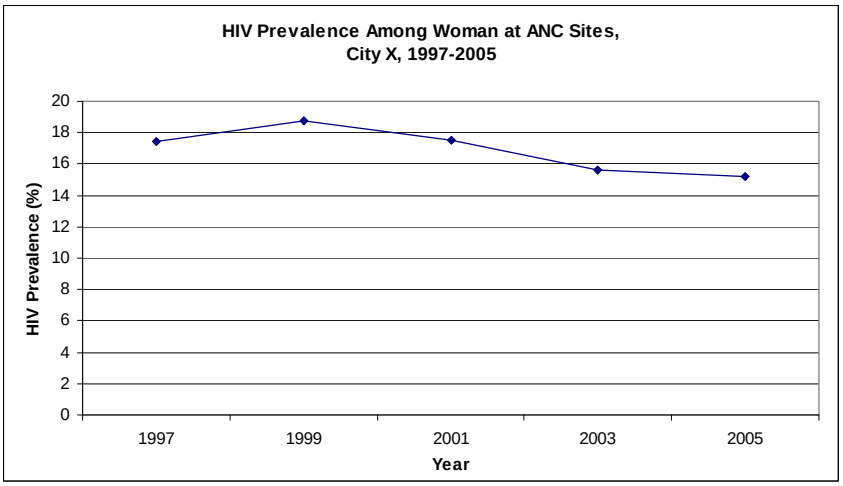
Step 7: Note trends across datasets and hypothesize

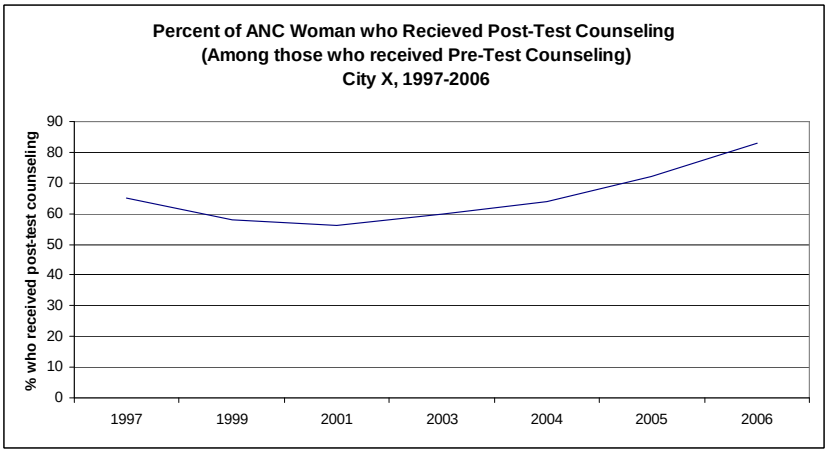
The next step in analysis is to compare different datasets arrayed side by side. The datasets can measure the same indicators, such as HIV prevalence based on ANC sentinel surveillance data and DHS estimates of behavior. Alternatively, datasets can use different indicators to draw out specific themes, such as hospital data, ART programmatic data, and qualitative research on migration. This is where the term “triangulation” actually gets its name.

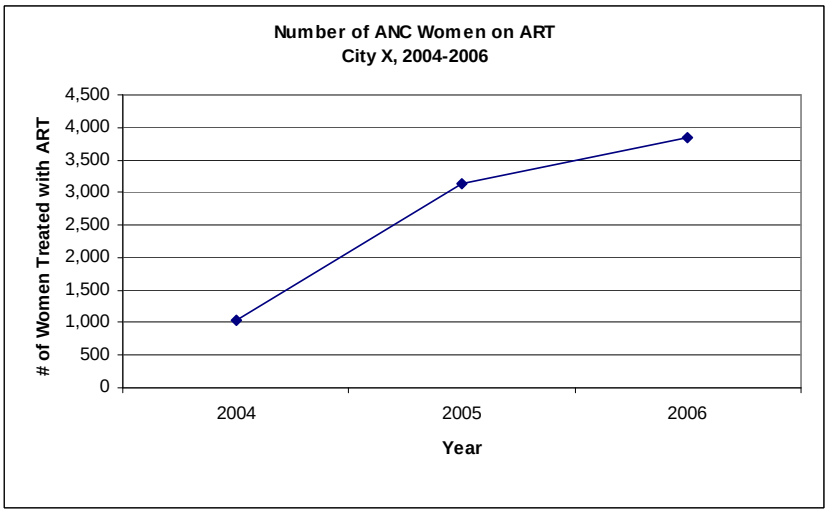
For example, one might look at hospital discharge data from a district hospital and note that fewer people are being admitted to the hospital. At the same time, program data from an ART clinic affiliated with the hospital may suggest the number of patients on ART is increasing. These are empirical observations. We might interpret these observations to mean that increasing ART coverage is leading to a decrease in HIV/AIDS morbidity (and corresponding hospital stays). Next, we could obtain qualitative data indicating that there is a large degree of movement among the population in the district during the same time period because of a drought and migration to other areas for employment. This information may lead us to modify the initial interpretation of the data—the decrease in hospital stays could be due to a simple decline in the population, and not to the impact of ART, as initially hypothesized.

Step 7 builds directly on Step 6, in that the same techniques are now applied to multiple datasets looking at different trends across person, place, and time.

Exercise 4.1. Observations from three datasets from "City X" are shown below. After looking at these three datasets together and describing what they show, what hypothesis (interpretation) might you want to make about this situation?







Observations: **Hypothesis:**

If your hypothesis involves trends over time and the factors that affect those trends, you will have to consider causality. Causality is crucial to verifying a hypothesis. Box 10 discusses the major criteria for causality.

Bradford Hill was a statistician who, in 1965, established a set of widely used criteria for demonstrating causal relationships. These are also important to keep in mind when developing hypotheses. Below is a description of four of the most relevant criteria for triangulation.

Box 9: Bradford Hill Criteria of Causality in Observational Studies Relevant to Triangulation

1. **Causality**
   If the intervention causes the change, then it must be initiated before the outcome occurs. For example, if a prevention program causes fewer HIV transmissions, then its initiation should precede a drop in HIV incidence.

2. **Strength of association**
   The larger the relative effect, the more likely the causal role of the factor. For example, the more highly correlated side effects are with treatment non-compliance, the stronger the relation between side effects and non-compliance is.

3. **Consistency**
   Multiple studies should consistently confirm the hypothesis. For example, numerous studies of the difference in HIV infection risk between circumcised and uncircumcised males, by a number of different researchers and under a variety of different circumstances, are required before a conclusion can be made regarding whether an HIV protective effect exists in circumcised males.

4. **Plausibility**
   The link between a cause and an effect should be plausible and logical. For example, researchers may discover a correlation between the price of bananas and VCT uptake, but there is not likely to be any logical connection between the two phenomena. On the other hand, the discovery of a correlation between treatment availability and VCT uptake would fit well with social theories of hope affecting the decision to pursue awareness of infection.

5. **Consideration of alternate explanations**
   It is important to consider alternate explanations, and they must be ruled out before the hypothesis can be confirmed.

Note: Two factors may co-exist. Alternate explanations are not always mutually exclusive.

The work you already did in noting data limitations and potential biases, as described in Step 3, will also be helpful when you have discrepancies between various datasets.

For example, you may look at trends in prevalence in two populations and find that HIV prevalence is going down among VCT clients and up in the sentinel surveillance population.

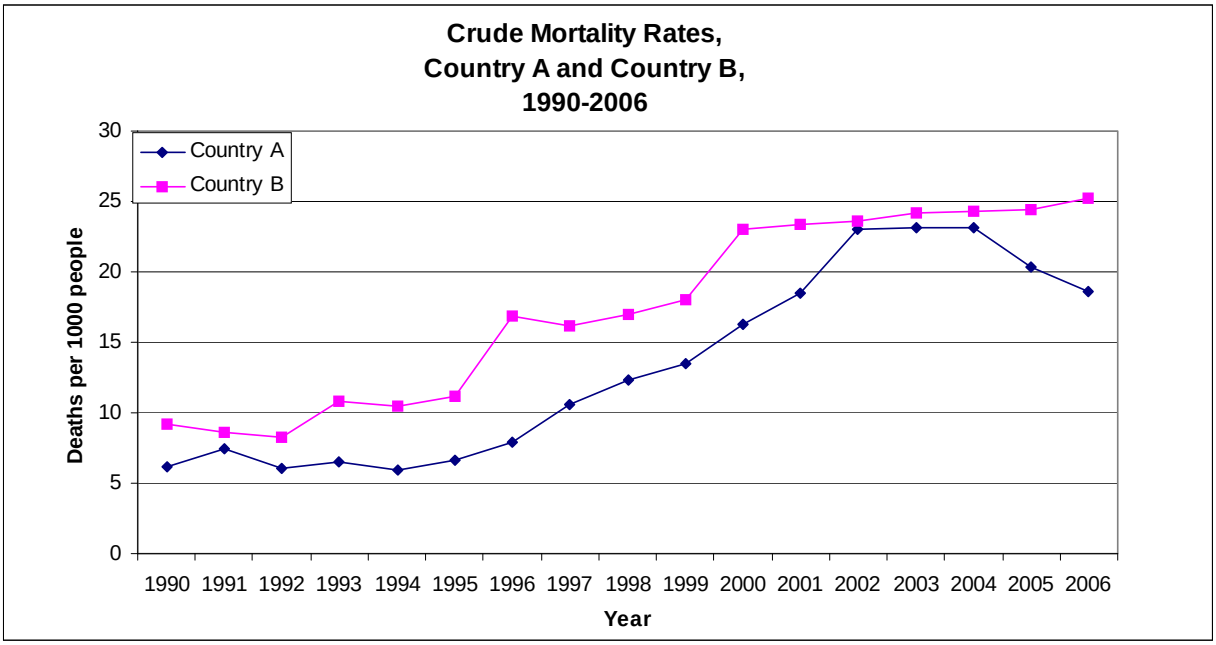
If you have noted that the sentinel sites randomly and routinely sample a population whose risk has not changed as far as you know, you can be reasonably confident that the increase in the HIV prevalence in that population is real. However, if you find that the number of VCT clients has gone up because of improved outreach, you can reasonably assume that the number of low-risk people attending VCT sites is causing the apparent HIV prevalence to go down.

Stratifying among first-time HIV testers may give you a clearer impression of the HIV prevalence in the community, or you may need to use other indicators to verify the trends. An example of this is given in Box 10 on the next page.

Box 10: Examples of comparing data

Quantitative data:

- Compare mortality data from two fictitious neighboring countries.



- Solution: Examine the differences in the mortality rates between countries. The number of deaths per 1000 people appears to have been slightly elevated in Country B compared to Country A from 1990 through 2002, when the rates became similar for a few years before again diverging, as Country B's rate continuing to climb and Country A's rate began to decrease.

Qualitative data:

- Focus groups conducted among married women in Country A indicated that most women felt confident asking their partners to use condoms. Yet a similar study in Country B found that most women felt that they had no control over condom use.

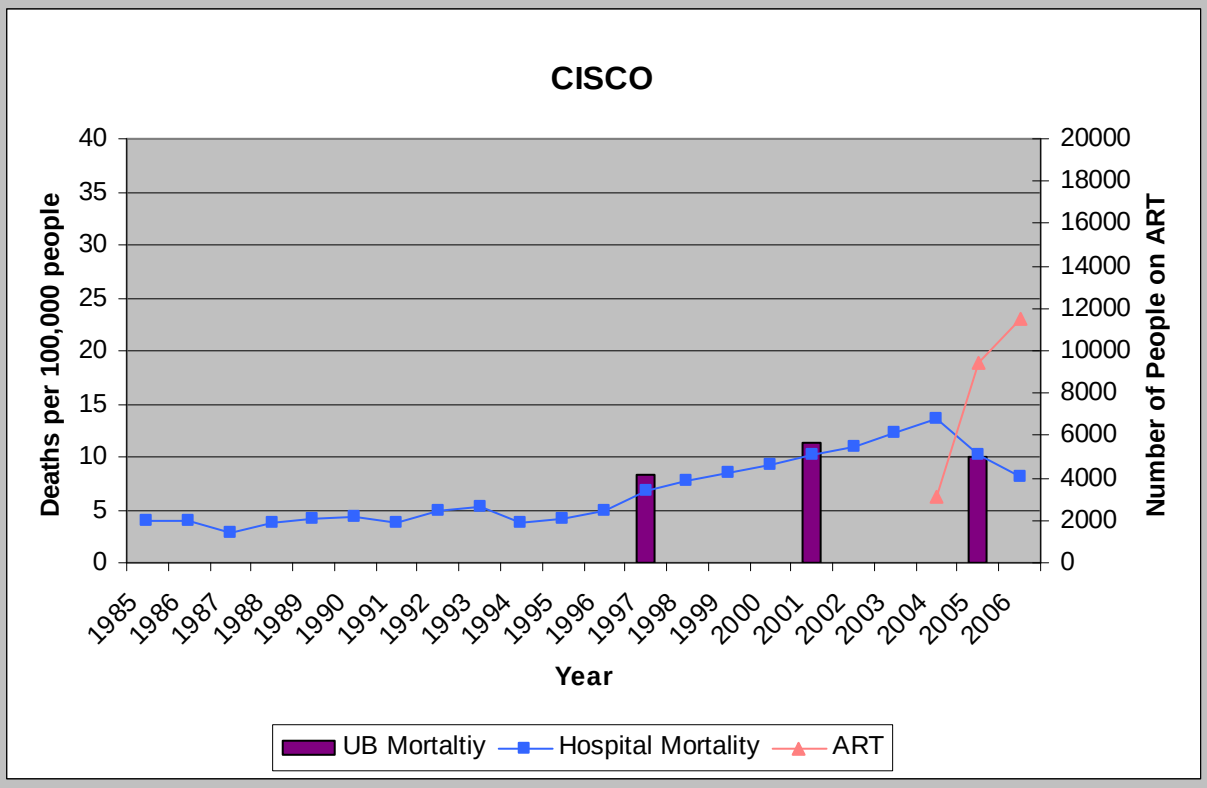
- Solution: Examine the differences in the populations studied. Determine if these differences (socioeconomic status, education, urban/rural, cultural differences) explain the different results. [This is part of the "refining" step, not the quality of data step (i.e., corroborating, refuting, modifying)].

Based on the information you have, you can be reasonably confident that the increase in the HIV prevalence in that population is real. However, if you find that the number of VCT clients has gone up because of improved

outreach, you can reasonably assume that the number of low-risk people attending VCT sites is causing the apparent HIV prevalence to go down. Stratifying among first-time HIV testers may give you a clearer impression of the HIV prevalence in the community, or you may need to use other indicators to verify the trends.

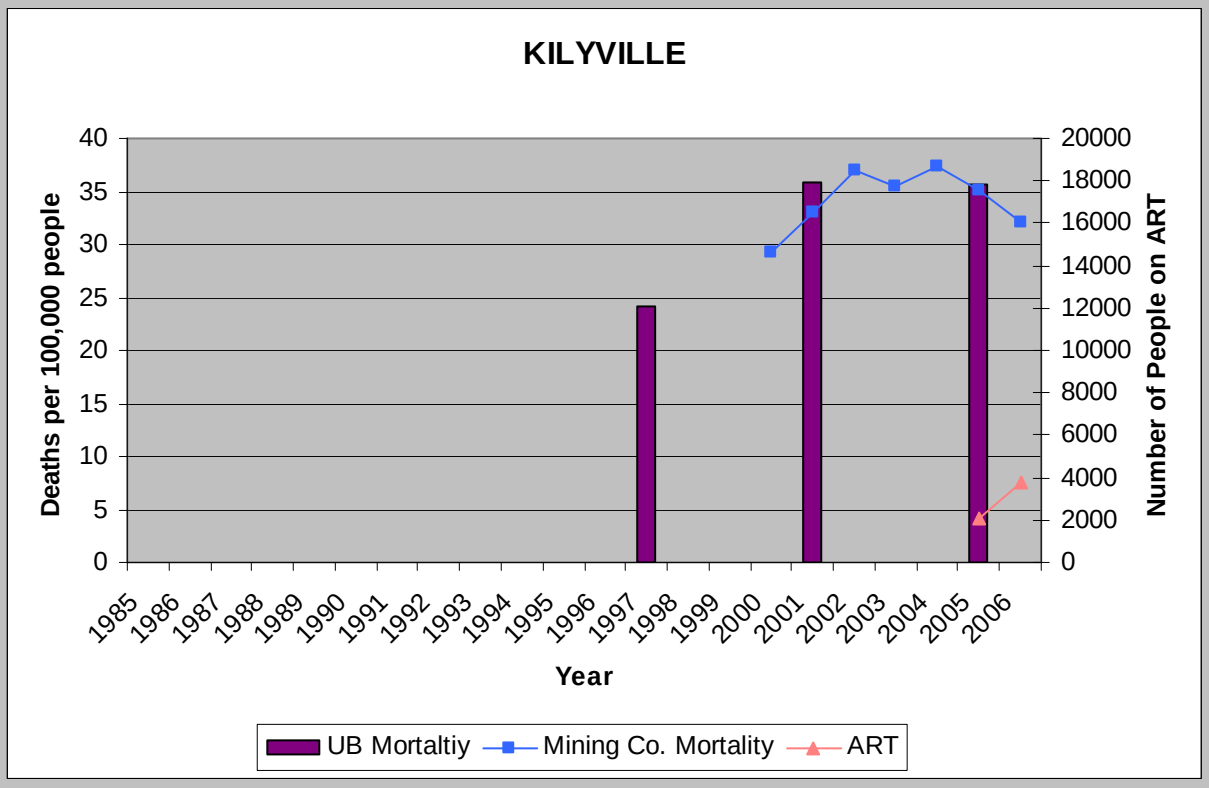
Bundo Step 7: Note trends across datasets and hypothesize

The next step for the analysts was to put all of the data together by location, and form hypotheses. In Cisco, mortality rates from the hospital had been increasing since the early 1990's; however, a sharp decline began in 2005. Mortality rose in the UB study between 1997 and 2001, but declined between 2001 and 2005. ART rollout started in 2004 and the number of people treated increased every year thereafter.



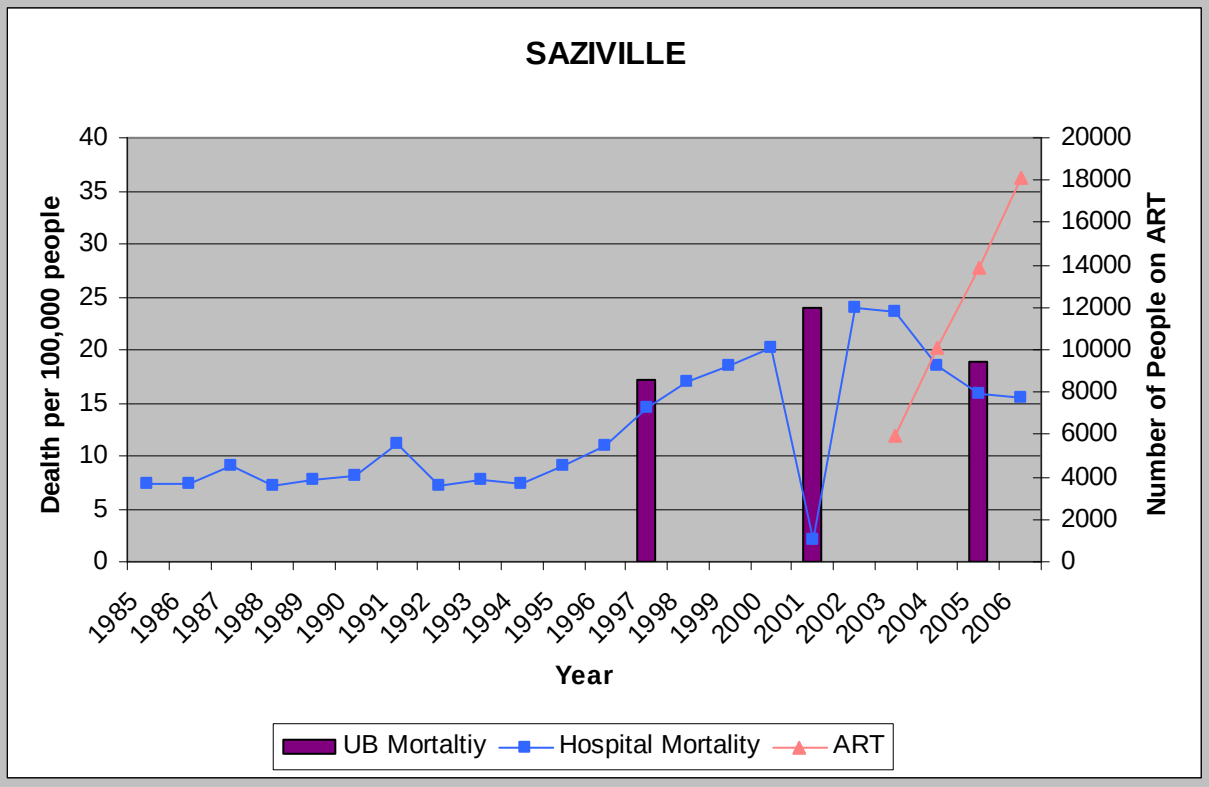
Bundo Step 7: Note trends across datasets and hypothesize (continued)

In Kilyville, non-accidental mortality at the mining company rose from 2000 to 2004 with a dip in 2003, and declined each year thereafter. The UB mortality rate rose between 1997 and 2001, and remained stagnant between 2001 and 2005. ART rollout began in 2005 and the number of people treated increased in the next year; however, the cumulative number of adults on ART remained relatively low.



Bundo Step 7: Note trends across datasets and hypothesize (continued)

In Saziville, hospital mortality rose from the early 1990s until it began to decline sharply in 2004. Data also included an inconsistent dip in 2001 that may indicate an error in the data. The mortality rate in the UB study was also much lower in 2005 compared to 2001. Saziville currently has the greatest number of adult patients on ART in the country, and between 2003 and 2006 the number of adults on ART tripled.



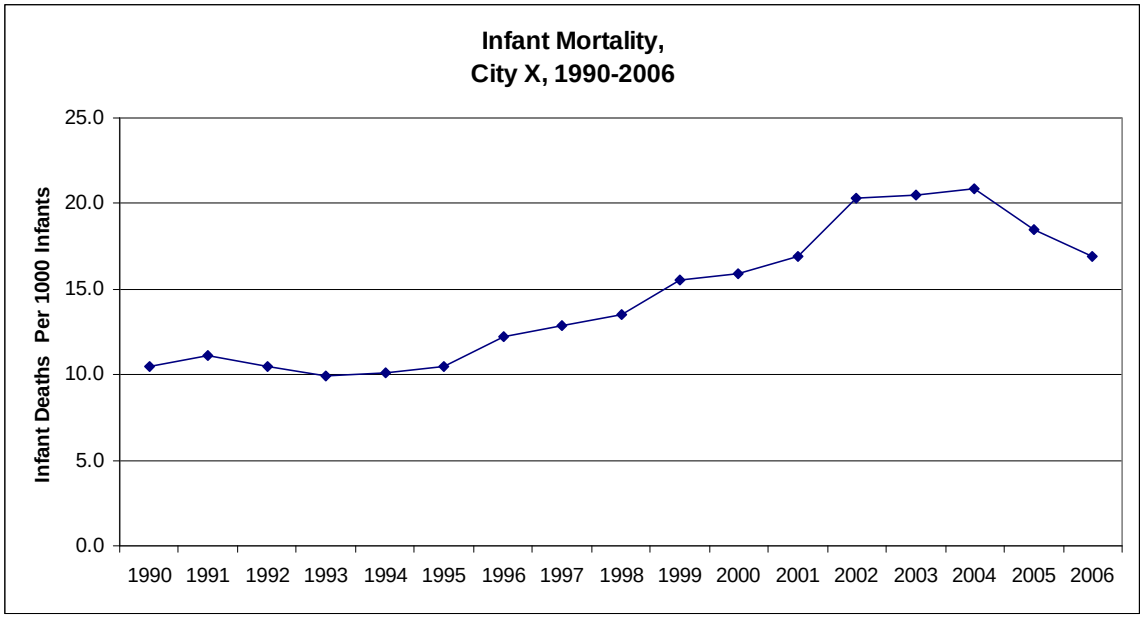
In all three of the cities, the analysts observed that an increase in the number of people receiving ART coincided with the onset of a decline in mortality.

Step 8: Check hypotheses

Checking hypotheses is crucial to refining and strengthening your interpretation. In triangulation, we are searching for the hypothesis or explanation that is consistent with most of the data and has face validity. If the evidence refutes the hypothesis, the hypothesis should be rejected. Hypotheses are assumed true until proven otherwise. By comparing our hypotheses to the data, we can draw conclusions.

Think back to the hypothesis you generated in Exercise 4.1. If now you are presented with a new piece of data, what will happen to your hypothesis?

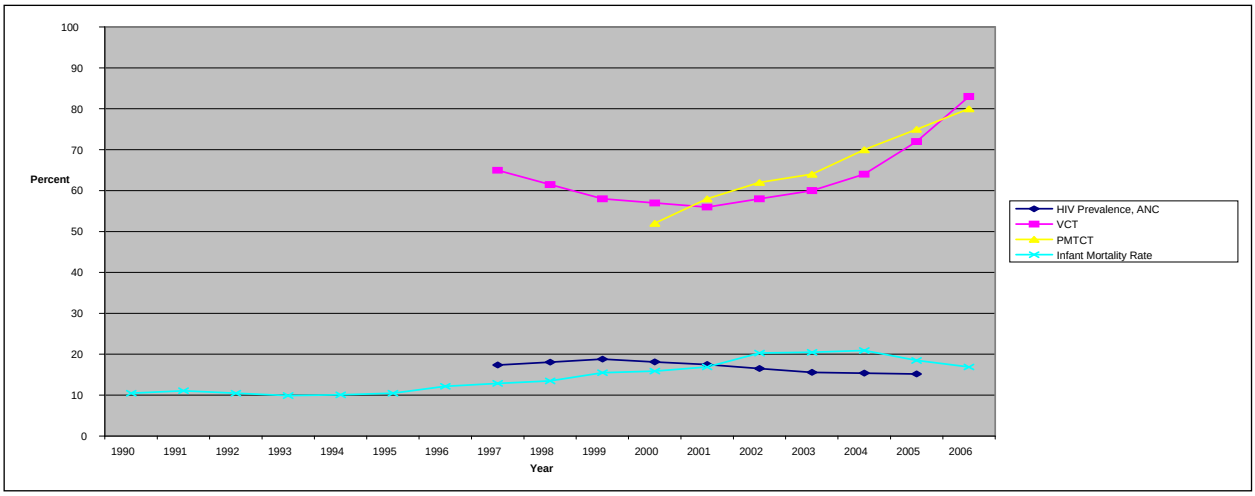
Exercise 4.2 Additional data



Hypothesis 1: Increased VCT among ANC attendees should result in increased PMTCT and decreased infant mortality.

Data observations below show:

- HIV prevalence has decreased among ANC attendees.
- VCT among ANC attendees has increased.
- PMTCT among ANC attendees has increased.
- Infant mortality has decreased in recent years.



Result: Hypothesis is supported by data.

Does this change your observations and hypothesis? If so, revise them below.

Observation:

Hypothesis:

Bundo Step 8: Check hypotheses

The triangulation analysts wanted to ensure that the observed changes in mortality were due to HIV and not to other causes. The analysts investigated an alternative hypothesis and other data sources to corroborate or refute this hypothesis:

Alternative hypothesis: *Changes in mortality are due to causes of death other than HIV/AIDS.*

- A brief look at the other major causes of death (interpersonal violence, tuberculosis, road traffic injuries, maternal hemorrhage, cerebrovascular disease, malaria, and ischemic heart disease) found no major changes during the period of ART rollout in Cisco, Kilyville, and Saziville. Therefore, it was concluded that these other causes did not explain the changes observed in mortality during the time period.

- Comparison of different indicators from the University of Bundo (UB) study corroborated a potential decrease in AIDS mortality. The percentage of people who knew someone who had AIDS increased between 2001 and 2005 in the UB dataset, but the number of people who knew someone who had *died* of AIDS either declined or increased less, indicating that while the number of people with AIDS has increased, the number of people with AIDS who have died is not increasing accordingly.

Step 9: If necessary, identify additional data and return to Step 5

As mentioned earlier, triangulation is an iterative process. Throughout the process, analysts should continually review existing data and identify gaps. If needed, other data should be obtained or further analysis done on existing data. As trends in the data become clear, new datasets may be useful that may not have been previously recognized as relevant. Additional data helps test hypotheses (Step 8) and helps verify the validity of the observations already made. Additional data can also help rule out confounders.

Use Exercise 4 as an example. As more information is gathered, more hypotheses may be generated.

Exercise 4.3
New Data: Informal interviews with nursing staff at ANC sites indicate that ANC attendees have been weaning their infants early and giving them formula. **Hypothesis 2:**

You may not have thought of this hypothesis until hearing input from nurses at the ANC. Now you may want to gather data relating to specific behavior changes among ANC attendees.

Qualitative data can also help support or refute a hypothesis. Such data may fill in a gap in knowledge when quantitative data cannot explain an issue.

Continue back through Steps 5-9. When your interpretation is supported by your data, the process is complete.

Bundo Step 9: If necessary, identify additional data and return to step 6

Since the analysis greatly depended on the accuracy of the mortality data, the taskforce decided it would be beneficial to validate the mortality data.

After some investigation, it was determined that a midnight census was collected independently at the Saziville hospital. The midnight census internal hospital estimate collected at the Saziville hospital validated the institutional mortality data collected by MOH.

In addition, while looking at cemetery data in Kilyville, it was uncovered that village elders maintained informal records of the number of deaths. These individuals were contacted and they agreed to share their records. The village elders indicated that fewer adults in the 25 to 50-year-old age group were dying of diseases in the past 2-3 years, whereas the number of deaths due to causes such as accidents and violence had remained stable. Members of the community also provided qualitative data, summarizing recent trends in causes of death in their community.

Since 1999, HIV prevalence, as indicated by ANC sentinel surveillance, has been going down slightly in Cisco, increasing in Kilyville, and has been stable in Saziville. Taking into account the likelihood that HIV-infected ANC attendees are not likely to develop AIDS for at least several years on average, it seems unlikely that a decline in HIV-infected patients can account for the decline in mortality rates.

Step 10: Summarize findings and draw conclusions

In previous steps, analysts did their best to confirm that the hypotheses met the criteria for causality. In this step, they must decide which hypotheses are supported by the most (and most robust) data sources, and which are supported by both quantitative and qualitative data.

At this point, the analysis may be complete, but interpretation needs to be done. Analysts can determine if there are gaps where data are lacking, and areas where future research could help answer the question. It may be helpful to hold another workshop where stakeholders from various disciplines and from different locations can look at the data and provide insight. They can draw conclusions by interpreting and extrapolating the data.

Make your strongest case on the preponderance of evidence:

- Which hypotheses are supported by the most independent sources of data and the most rigorous data?
- Which hypotheses hold up to the most criteria for causality and the most important criteria for causality?
- Which hypotheses are supported by both the ‘numbers’ and the ‘stories?’ (qualitative and quantitative)
- Would the likely biases, limitations, and potential confounders change your conclusions?
- Have you considered all the alternative explanations?

Additional considerations:

- Favor hypotheses that can be proven true or proven false.
- Favor hypotheses that you can do something about (actionable).

Box 13. Examples of conclusions

Important trends noted:
Example—'PMTCT among ANC attendees is increasing.'

Your conclusions:
Example—'The decline in infant mortality is being driven by PMTCT.'

This is not only the place to draw conclusions about what you did find, but to record what would make the analysis stronger. Were there relevant existing data that you were unable to access? What, if any, were the quality issues in the data you used? Is there anything else you would like to be able to do to complete this analysis? Throughout the process, and especially in this step, the analysts should take note of what studies need to be done to strengthen the hypotheses, and what studies could answer questions that are currently unaddressed.

Box 14. Examples of conclusions about what information is needed

Express limitations:
Example—'This analysis was limited by the lack of data on cause-specific mortality data.'

Discuss which data could be useful in the future:
Example—A new system of village-level death registries should include priority causes of mortality.

Bundo Step 10: Summarize findings and draw conclusions

Next, all observations from the triangulation exercise related to the key question, '***What is the impact of ART on overall adult mortality in Cisco, Kilyville, and Saziville?***' were compiled and the taskforce began drawing conclusions based on their findings.

To recap, some of the key observations made were:

In Cisco:

- Mortality rates in adults at Cisco Hospital, which had been rising since the early 1990's, began to decline in 2005.
- UB mortality rates decreased between 2001 and 2005.
- Overall, *low* rates of adult mortality compared to other areas of interest.
- ART rollout began in 2004 and the number of people treated increased each year thereafter.

In Kilyville:

- Non-accidental mortality at the mining company rose from 2000 to 2004 and declined each year thereafter.
- UB mortality rates remained stagnant between 2001 and 2005.
- Overall, *high* rates of adult mortality compared to other areas of interest.
- ART rollout began in 2005 and the number of people treated increased in the next year; however, the overall number of people on ART remained low.

In Saziville:

- Mortality rates rose in the late 1990s, but began to decrease sharply in 2004.
- UB mortality rates were also much lower in 2005 compared to 2001.
- ART rollout began in 2003, and the number of ART patients tripled between 2003 and 2006.

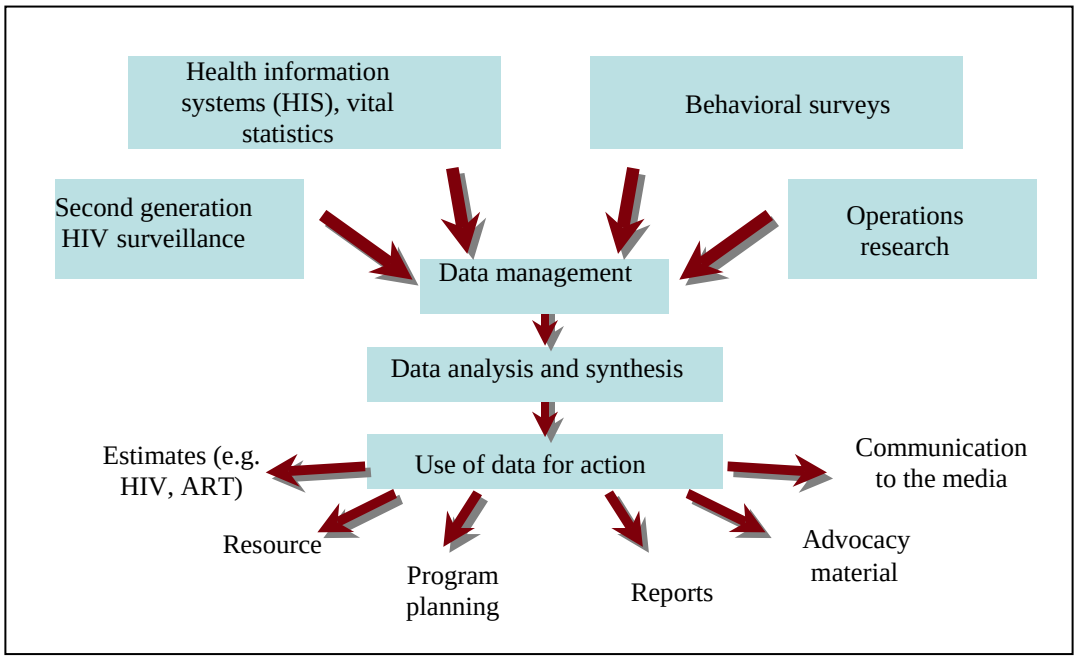
Based on the observations listed above, the workshop participants interpreted the data and concluded that the decline in mortality among adults in the three sites was associated with the rollout of ART. The following hypothesis was formed:

In Cisco, Kilyville, and Saziville, the rollout of ART and the increase in the number of people receiving ART led to the onset of a decline in adult mortality.

Step 11: Communicate results and recommendations

The ultimate goal of triangulation is to facilitate better policymaking and program planning. Triangulation is also an opportunity for capacity building. The process and findings should be shown to policymakers, program decision-makers, and others who were involved in the triangulation exercise. The triangulation process needs to be explained to those who are unfamiliar with it. The presentation frequently takes the shape of a slide presentation, making use of chart, figures, graphs, and maps.

Figure 7: Information flow in the monitoring and evaluation system within the context of strategic information: an overview



Here is an outline for presenting the triangulation process and findings (an example of how to communicate results from a triangulation is available on the internet at: http://www.who.int/hiv/pub/casestudies/Botswana2006.pdf).

1. Describe key questions and how they were selected
2. Describe data sources and methods used
3. State hypothesis and primary findings
    i. Present key question in the format of the hypothesis generated prior to analyzing across data sources
    ii. Briefly state why the hypothesis is viable
    iii. Briefly state what data supports the hypothesis
    iv. After stating the hypothesis, affirm whether it was proved or disproved based on the triangulation analysis. Formulate new hypotheses if necessary.
    Hint: Use charts, figures, graphs, and maps to visually display your results
4. Discuss data interpretation findings (secondary findings)
    i. Summarize secondary results identified through the triangulation analysis. Although these results were not your main hypothesis, they may provide further explanation on the issue.
5. Note limitations (be honest)
6. Summarize findings
7. Translate findings into:
    i. Need for additional data
    ii. Programmatic recommendations
    iii. Policy recommendations

Box 15. Example of an observation matrix

Observations on HIV indicators North

	Urban	Rural
P	HIV Prevalence decreasing (Syphilis level down)	HIV prevalence level/up (lowest DHS prevalence; Syphilis up/level:
B	Generally, risk behavior indicators improving; abstinence, multiple partners	Risk behavior indicators worst/ worsening; abstinence men, NCP men cbndom NCP men, CSW men, worsening female testing
T	Testing going up. Testing high in men and women	Testing lowest among women Program coverage improving
K	Some knowledge/attitudes poor (esp. speaking to spouse about AIDS)	Lowest knowledge
O	Program intensity and quality high	

Prevalence | Behavior | Testing | Knowledge | Other

Hypothesis: **Rising HIV prevalence in rural area is driven by power imbalances between men and women.**

- Polygamy, interspousal age gaps, living with husband's family, low negotiation skills
- Low rate of testing among women, low HIV/AIDS knowledge
- Consider how far this hypothesis may extend

Recommendation: **To address the "rural increase" hypothesis.**

- Target women with micro-enterprise building programs
- Integrate such programs with HIV prevention education, reproductive health, social support, and empowerment

Bundo Step 11: Communicate results and recommendations
Finally, the taskforce concluded the triangulation exercise by conducting a workshop and inviting policymakers, analysts, and program managers involved in ART delivery. The taskforce communicated all results and recommendations from the triangulation exercise to the workshop attendees. The taskforce recommended that ART rollout efforts be ramped up in Kilyville, given its high adult mortality and low cumulative number of patients on ART. They also recommended that the ART program be expanded to at least three more areas of the country in the next year, and that national agenda setting prioritize doubling the number of people receiving ART in the next year. The taskforce also noted that more research was needed to determine whether the rollout of ART had affected all populations equally (e.g., stratification by gender, urban/rural, income, and education). They recommended that future analysis also examine whether ART rollout improved mortality rates among children, since the survival of parents should improve the survival of their children. Following the workshop, the taskforce and the analyst from the Ministry of Health wrote up the results and recommendations in a report intended for the stakeholders, and published their findings in a peer-reviewed journal.

Step 12: Outline next steps based on findings

Work with a coordinating body to apply findings and consider future triangulation activities. In previous triangulation exercises, coordinating bodies have chosen to continue the triangulation taskforce in order to address other questions that had been prioritized below the initial questions. Triangulation findings were used to inform HIV planning at national and subnational levels.

Box 16. Some potential next steps and examples

If findings are strong, advocate for action.

Example: MOH should continue to fund HIV prevention activities in communities where reductions in risk are shown.

If findings are weak, advocate for further investigation.

Example: Prevention activities in communities examined showed no apparent reductions or increases in risk. Inform the prevention activity funders and discuss next steps.

Bundo Step 12: Outline next steps

Possible next steps include validating the mortality data with cause-specific sources. Since this is presently not available in Bundo, one next step might be to initiate research on this subject. If additional relevant data are identified, it may be beneficial to include them in the analysis and reinstate the iterative process to further confirm or refute previous findings.

In addition, the presenters requested that another triangulation exercise be started immediately to look at the impact of PMTCT on infant and child mortality.

Conclusions

These steps for implementing a triangulation project are based on experiences conducting triangulation exercises in generalized epidemics in sub-Saharan Africa, and concentrated epidemics in the United States. The findings provide a good basis of understanding for using triangulation analysis to rapidly provide information for program planning and policymaking.

All epidemics are local and no two HIV epidemics have exactly the same characteristics. Thus, the triangulation methodology must be adapted to different situations and different questions.

Triangulation has proven to be a valuable tool for making use of data from multiple sources for program decision-making. To date, triangulation has been used to answer questions primarily related to the HIV epidemic. In the future, triangulation can be used to answer questions related to both chronic and other infectious disease epidemics.

Appendix A: Exercise and discussion answers

Box 1 discussion

1. Which type of analysis seems more feasible in resource-poor settings?

Triangulation seems more feasible because it does not require special studies or costly studies like randomized control trials. Triangulation relies on existing data to answer key questions.

2. Which method promises the most rapid dissemination of its findings for public health action?

Triangulation promises the most rapid dissemination of its findings for public health action.

3. Which method is most likely to rely on measures of statistical significance for verification of findings?

Conventional analysis.

Box 2 discussion

1. Which of these uses is most time-sensitive?

Essentially, all of these uses can be considered "time-sensitive," as all can help advance public health in a timely manner.

2. Which of these applies to your country?

This depends on the situation of the epidemic in your specific country.

Exercise 4.1

Observations:

- HIV prevalence decreased among ANC attendees between 2002 and 2005.
- Post-test counseling initially declined between 2002 and 2003 and then increased again in 2004-2005.
- The number of HIV-infected women receiving treatment increased between 2002 and 2005, except for a steep dip in 2004.
- Fertility rates have not declined.

Taken together, these observations lend themselves to the following **hypothesis:**

- VCT among ANC attendees should result in increased PMTCT and decreased infant mortality.

Exercise 4.3

New data:
Informal interviews with nursing staff at ANC sites indicate that ANC attendees have been weaning their children early and giving their babies formula.

Hypothesis 2: Infant mortality decreases due to PMTCT have been offset by behavior change.

Appendix B: Case Report: Summary of Botswana Triangulation

Case Report: Assessing the impact of ART and PMTCT on mortality in Botswana: A review of the 12-step triangulation methodology using country data

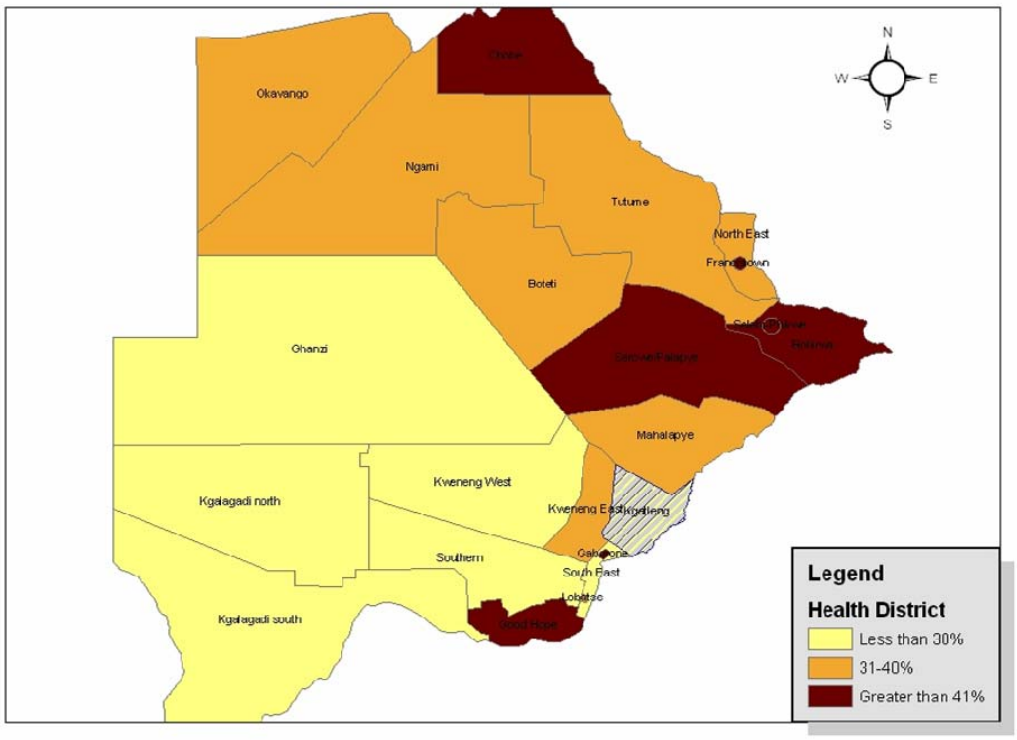
In 2002, the government of Botswana rolled out a national program for the treatment of AIDS with antiretroviral therapy (ART). In 2005, the impact of this ART scale-up program was assessed by the National AIDS Committee of the Botswana Ministry of Health (MOH), together with the World Health Organization (WHO), the Joint United Nations Program on HIV/AIDS (UNAIDS), and the University of California, San Francisco's (UCSF) Institute for Global Health, using country-enhanced monitoring and evaluation methodology tailored specifically to the situation in Botswana.

The following case report summarizes the methodological process that was used in Botswana in 2005 to determine the impact of antiretroviral therapy (ART) and prevention of mother-to-child transmission (PMTCT) scale-up programs. Using triangulation, the researchers were able to develop a model to assess the impact of ART and PMTCT in Botswana. Preliminary results indicated that, during the three years since its inception, the ART program in Botswana has reduced mortality in adults aged 25-54 years. We also found that early initiation of district ART programs and the overall rate of ART uptake in the district were associated with reduced mortality.

The benefits of the triangulation methodology as applied in Botswana were twofold. First, the use of pre-existing data sources allowed the study to be executed and concluded relatively rapidly. This is of particular importance for studies with significant policy or programmatic implications. Second, the systematic collection and examination of data from multiple sources revealed new questions to be studied, permitted verification, and reduced the likelihood of data and researcher bias. The limitations imposed by the quality of the existing data remained, but were mitigated by this methodology.

The Botswana experience also identified some of the prerequisites for the effective application of triangulation. It is necessary to be flexible during analysis, and to consider complementing triangulation studies with additional qualitative and quantitative research if existing data are not sufficient to answer some questions. The application of triangulation in Botswana has demonstrated that the engagement of high-level policymakers and administrators throughout the early part of the triangulation process is critical to the success of data identification and collation, and remains important through the analysis phase. A week-long training course for representatives from a range of institutions was initiated to build capacity in Botswana for future application of triangulation methods.

Figure 1: Age-adjusted HIV prevalence rates by district, Botswana, 2003



Step 1: Identify key questions

In 2005, the Botswana National AIDS Coordinating Agency (NACA) and Botswana Ministry of Health (MOH) cooperated to evaluate the effectiveness of national ART and PMTCT programs by enhancing the analysis of existing data. A project was developed with the financial support of the World Health Organization (WHO), and collaborative in-country participation by WHO and the United National AIDS organization (UNAIDS). UNAIDS and NACA provided international and in-country coordination of triangulation planning and data collation, while the overall technical leadership came from the Institute for Global Health at University of California-San Francisco (UCSF-IGH).

In July 2005, stakeholders from Botswana national and district bureaus and the international partners held a series of half-day meetings to agree on priority goals for the triangulation analysis. Stakeholders included MOH, NACA, the Ministry of Local Government (MLG),UNAIDS, WHO, BOTUSA (a collaboration between the Botswana government and U.S. Centers for Disease Control) and UCSF-IGH. The group listed and discussed various issues of current importance related to both behavioral and clinical inputs.

The stakeholder group produced a hierarchy of critical themes for the triangulation analysis based upon the likely availability of data and the importance of setting new policies and programs or revising the existing ones. Some of the most important issues that were eliminated from our list due to lack of existing data were the effect of religion,

of single mothers, and of changes in risk behavior after HIV testing. The key themes that remained included the importance of behavioral issues related to condom use, alcohol intake and multiple partners, treatment effects stemming from PMTCT rollout, the shift from routine to opt-out HIV testing, prophylaxis with isoniazid for tuberculosis in HIV-infected patients, the direction of increased susceptibility to infection between HIV and tuberculosis, ART effectiveness, and the incidence of opportunistic infections among adults receiving ART.

Of these broad themes, isoniazid effectiveness was eliminated, as this was the subject of a large ongoing BOTUSA-led clinical trial. Lack of available data eliminated HIV-tuberculosis linkages and post-ART infection, while uncertainties about the data that would be available from the Botswana AIDS Impact Survey of 2004 (BAIS II) led to the decision to set aside the three behavioral questions regarding alcohol intake, condom use and multiple partners, and the influence of these on HIV dynamics.

The stakeholders reached a consensus that, of the issues for which sufficient data existed to allow study with triangulation methods, the effectiveness of ART and PMTCT programs was of the highest priority for policymakers.

Step 2: Ensure question is answerable/actionable
Although it is extensively documented in small populations, clinical trials, and in developed countries and Brazil, the effectiveness of ART in reducing population mortality from AIDS in sub-Saharan Africa had never been established. The priority among stakeholders was to use triangulation methods to ascertain the applicability of ART to Botswana's specific epidemic. The high rates of HIV prevalence in Botswana and the widespread and growing coverage of ART programs offered the opportunity for obtaining unambiguous results regarding impact on mortality. Botswana, more than many other African countries, has large amounts of well-collected, consolidated data with sufficient overlap to allow for verification of critical topics.

There was consensus that the most significant measure of programmatic effectiveness would be decreased mortality, both among adult recipients of ART and among neonates and infants through PMTCT programs. The availability of well-documented ART programmatic data, combined with credible vital registration statistics on mortality in an institutional setting (such as a hospital or a healthcare clinic) for more than 90% of births and deaths, made it likely that if a relationship between declining mortality and ART program rollout existed, it could be shown. The results could then be used in determining program planning for enhanced ART rollout. Therefore, it was agreed that this question was both answerable and actionable.

Step 3: Identify sources and gather background information
Identification of potential data sources, database managers, and actual data was an iterative process that began with the first stakeholders' meeting in July 2005 and continued until January 2006.

Many types of data are collected in Botswana. The Central Statistics Office (CSO)—a department of the Ministry of Finance and Development Planning—sets norms, consolidates data, and directly manages the Health Statistics Unit (HSU), which is located within the MOH. CSO collects census data and—through HSU—inpatient and outpatient statistics on morbidity and mortality, as well as statistics on modifiable diseases, hospital bed occupancy rates, and number of deaths. In coordination with CSO and HSU, the MOH manages hospital data through Integrated Patient Management Systems (IPMS), as well as data related to HIV testing, PMTCT, tuberculosis, ANC, ART and other vertical programs. BOTUSA has supported the MOH in its development of an electronic registry for tuberculosis. The electronic registry and other program databases include district-level data, which are consolidated at the Ministry level. These are not linked with each other or with identification records from the Department of Home Affairs.

Data specific to the treatment of tuberculosis among HIV-infected patients exist both in the electronic registry for the tuberculosis program and in treatment and research programs jointly undertaken by the government of Botswana and CDC via BOTUSA. A number of additional clinical studies are underway, with laboratory data consolidated at the Botswana-Harvard AIDS Institute Partnership BHP.

Population survey data are principally collected and managed by CSO. The most relevant data for HIV/AIDS research were the Botswana AIDS Impact Survey of 2001 (BAIS I) and 2004 (BAIS II). Compilation of data from BAIS II was not yet available in the summer of 2005. Additional qualitative and quantitative data from small studies exist, but are often not centralized. The plethora of data sources and array of background information collected in this step enabled the triangulation researchers to move on to the next step in refining the research question more thoroughly.

Step 4: Refine research question

Specific study questions were revised based on the availability or quality of specific data sources. The agreed-upon goals were to measure the population-level effect of the rollout of ART and PMTCT in Botswana. Morbidity and rates of incidence for HIV and HIV-related opportunistic infections and clinical presentation were all considered for study and discarded. There was consensus that the most significant measure of programmatic effectiveness would be decreased mortality, both among adult recipients of ART and among neonates and infants through PMTCT programs, while additional measures of program effectiveness were examined as potential effect modifiers and/or confounders. The availability of well-documented ART programmatic data, combined with credible vital registration statistics on mortality in an institutional setting for more than 90% of births and deaths, made it likely that if a relationship between declining mortality and ART program rollout existed, the relationship could be documented.

The research question was therefore refined, and it was decided that, based on the agreement among stakeholders and researchers, analysis of programmatic strengths and weaknesses was important, but secondary to the broader policy questions of ART impact on mortality.

Step 5: Gather data and reports
While the initial identification of data sources was efficient, large investments in time and effort by both researchers and officials at differing levels of authority were required to gain authorization for, and access to, the data themselves. This process was a significant challenge for colleagues within Botswana due to ongoing demands upon their time and the political considerations implicit in requesting data belonging to other branches of government. To access the most recently collected and unreported data required making special arrangements for CSO staff to work outside of normal hours and manually duplicate datasets. Difficulties in clarifying who had ultimate responsibility for differing datasets also led to delays in obtaining data.

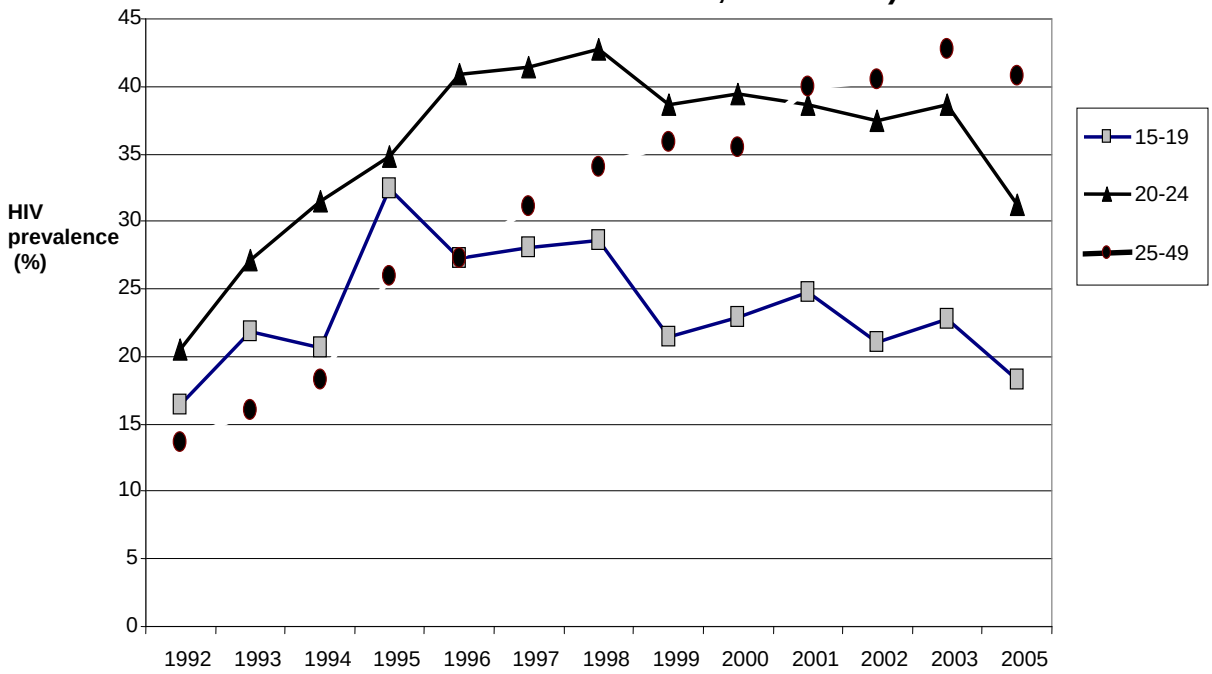
Once accessed, difficulties remained both in standardizing the data format, and in identifying and understanding problems with the data themselves. Discrepancies between, for example, national mortality figures (which dipped in 2002) and hospital mortality figures (which did not) were difficult to reconcile. Many discrepancies remained unresolved for some time because of the need for leadership by accountable officials in order to have open discussions about the possible reasons for conflicting data.

Cleaning data—identifying gaps in data or erroneous entries—took place in Botswana and at UCSF beginning in October 2005, when the first data were transmitted to the researchers. Leadership by high-level administrators from NACA, CSO, and MOH was of paramount importance throughout this period of data collection, collation, and cleaning. The presence of the research team on-site and intervention by policy-level personnel were critical to assure the validity of the analysis outcomes.

Step 6: Make observations from each data set
The basic analytical approach to measuring the impacts of ART and PMTCT programs on adult and child mortality involved four stages. The analysts first used Botswana mortality statistics from the HSU to verify evidence for the effect of HIV on adult and child mortality over time by district in institutional settings. Second, they analyzed data from the MOH ART program, measuring cumulative numbers of persons currently receiving ART by district since 2003 and PMTCT program indicator data from the MOH MCH unit, measuring the numbers of women receiving ART during postpartum care and infants receiving postpartum ART and formula-feeding. Data were analyzed both overall and by district over time. The fourth analytical stage involved the comparative analysis of ART uptake in adult patients and trends in adult mortality over time and by district. To assess the impact of PMTCT programs on infant and child mortality, they compared the numbers of HIV-infected women and their offspring who received ART pre- and postpartum, and trends in infant and child mortality both overall and by district over time.

Sentinel surveillance showed a declining trend in HIV prevalence among pregnant women between 2001 and 2005, with especially large declines in the 15-19 and 20-24 age groups. Mortality rates stabilized in the early 2000s. Mortality decreased by 8% between 2003 and 2004, and 20% between 2004 and 2005.

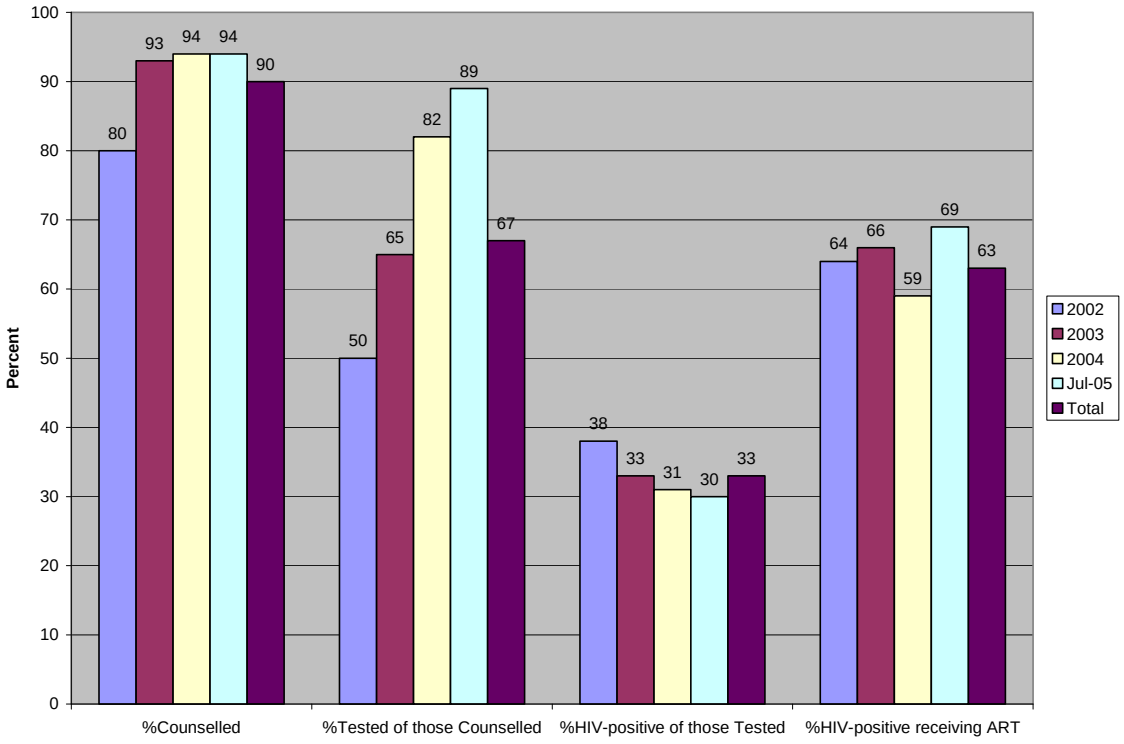
Figure 2: Trends in HIV prevalence among pregnant women in Botswana, ANC Sentinel Surveillance Data, 1992-2005)



The rates of ART uptake (cumulative number of persons aged 20-49 years currently receiving ART per population) by district, from date of program initiation until July 2005, indicate that ART sites in Francistown and Gaborone districts had the highest rates of ART uptake throughout the period.

With regard to PMTCT, 63% of pregnant women from 2002–2005 who tested positive for HIV were provided with preventive ART. The annual proportions of pregnant women counseled and tested have shown a steady increase between 2002 and 2005. However, the proportion of HIV-infected clients receiving ART has remained relatively stable, ranging between 59% and 69%. During the same period, maternity-related indicators for PMTCT interventions also show substantial increases in programmatic coverage: the number of deliveries of patients with unknown HIV status decreased and the number of newborns treated with ART increased.

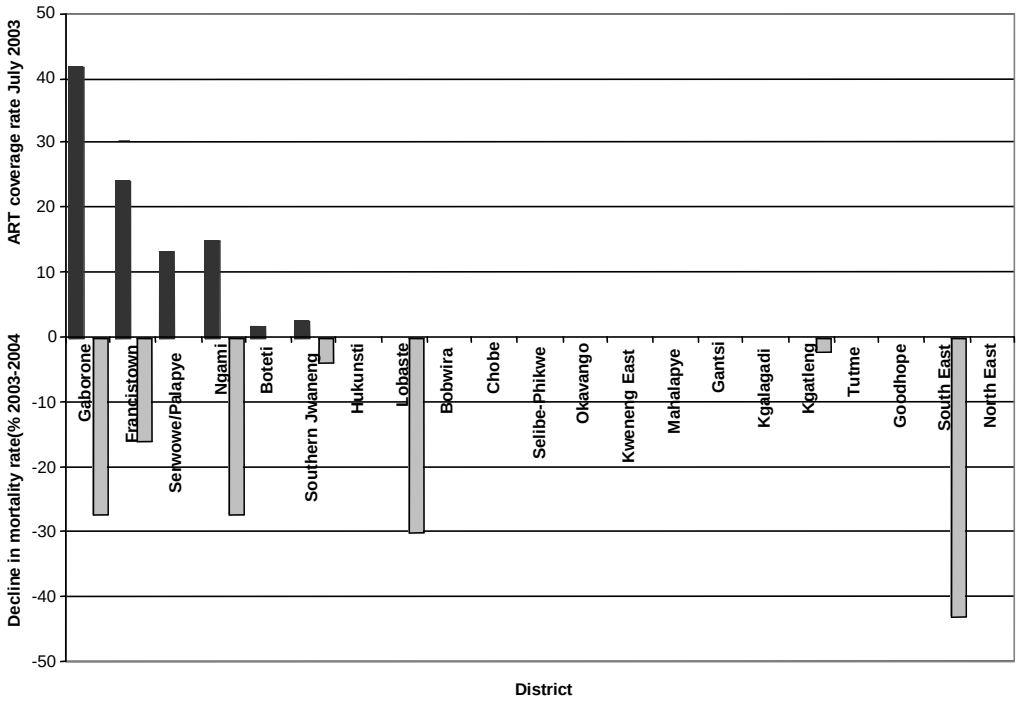
Figure 3: Counseling, HIV testing and ART among ANC attendees, Botswana 2002-2005



Step 7: Note trends across datasets and hypothesize

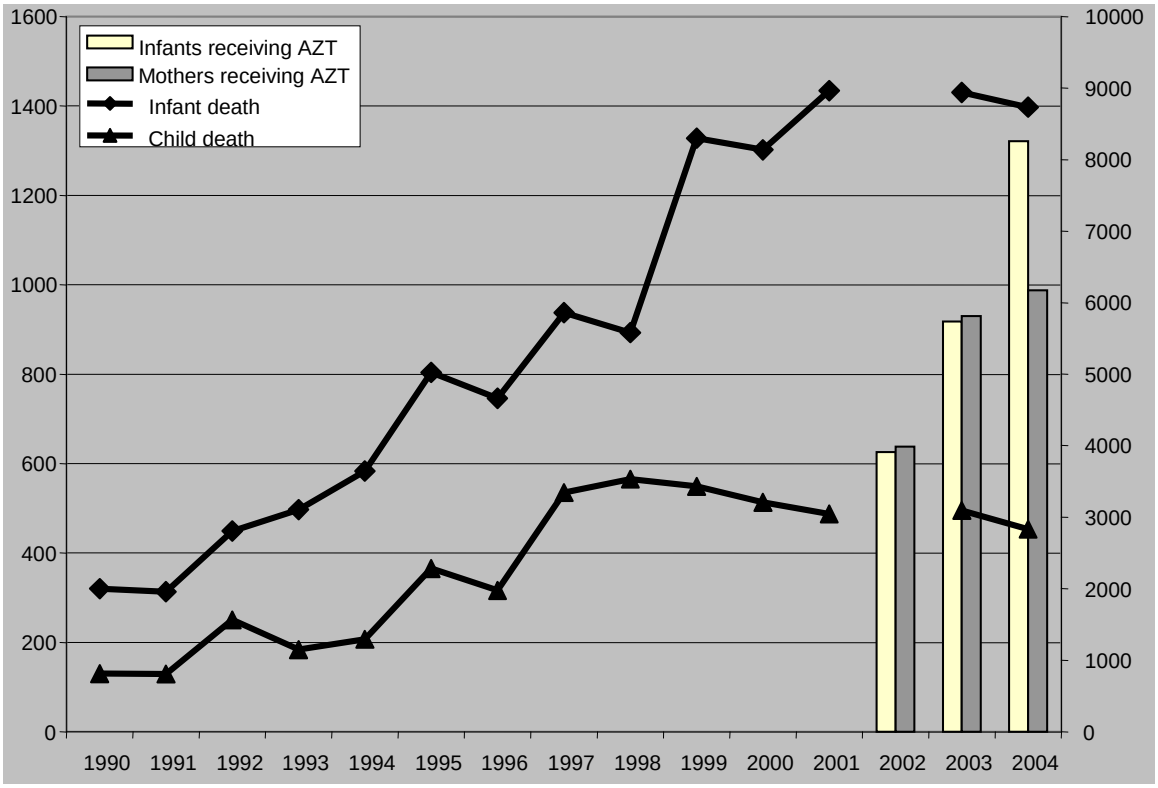
The decrease in mortality was coincident with increasing numbers of patients receiving ART, beginning in 2002. A comparison of declines in mortality rates among those aged 20-49 years between 2003 and 2004 (the early stage of ART rollout is most likely to capture the effect of ART) and ART coverage rates reported by July 2003 by district, reveal that mortality declines were evident in 29% (7 out of 24) of the districts. Gabarone and Francistown had early site opening dates and the highest rates of people receiving ART, and those locations experienced 27% and 17% mortality declines, respectively. Other districts that were located near Gabarone also experienced mortality declines (see map of districts in Figure 1). Mortality rates continued to increase in districts that did not have early rollout of ART.

Figure 4: Declines in mortality rates for people aged 20–49 years between 2003 and 2004, and 2003 ART coverage rates by district



Trends in infant and child mortality showed linear increases, followed by stabilization in 1998 and 2000, respectively, and a modest decline of 2% in 2003-2004. Coincidentally, the numbers of pregnant women reportedly treated with AZT pre-partum and infants similarly treated at birth increased between 2002 and 2003. However, the rate of increase in numbers of mothers treated pre-partum with AZT declined sharply relative to the similar treatment of infants between 2003 and 2004.

Figure 5: Trends in institutional mortality in infants and children compared with PMTCT indicators for AZT use in mother and infants, 1990–2004



Based on preliminary mortality data reported through June 2005, there was a continued decline in the numbers of deaths of children less than five years of age. Furthermore, there is evidence of a decline in the rate of institutional infant deaths (excluding neonates) between 2003 and 2004, by district. Nevertheless, high variability in reported deaths, particularly in districts with lower populations, coupled with concerns of reporting completeness, makes it difficult to draw strong conclusions from declining trends in infant mortality as one could in adult mortality.

Step 8: Refine hypotheses

The analysis provides reasonable evidence for an early association between ART uptake and declines in adult mortality from 2003 to 2004. Alternative hypotheses, including the effect of other HIV interventions, population out-migration, natural dynamics of HIV, other competing causes of mortality, or artefacts of biases in mortality reporting are less plausible. Preliminary vital registration data from 2005 provide further empirical support for the continuation of these mortality declines. Before considering these conclusions as definitive, updating of the vital registration data to complement existing data on preliminary reported deaths until 2005 and into 2006 is necessary, as are studies to validate the accuracy of mortality reporting at key hospitals. A cross-validation study of data from the vital registration database in the Botswana Department of Home Affairs would also be important. District mortality trends should be further investigated in “outlier districts” such as Serowe and Palapye, where ART uptake

appears quite high, but mortality continues to increase. The strength of the geographical association between ART site opening dates, uptake rates, and declines in mortality is probably diluted by district cross-migration to access ART drugs.

However, investigators were not able to draw conclusions regarding the effect of PMTCT on infant mortality. Preliminary analysis of mortality data for 2005 suggests that infant and child mortality have declined in some districts. However, under-reporting of deaths in 2004–2005 is a concern that may confound trend interpretation. A further validation of mortality data for 2005 and 2006, as well as audits of PMTCT indicator data, should provide insight into evidence for potential PMTCT or ART programmatic impacts, or reasons for their absence. In addition, the relative stagnation of ART preventive interventions at around 60-70% is of particular concern and requires further investigation. Finally, assuming that mortality and PMTCT indicator data are reasonably accurate, it is unclear why the impact of PMTCT interventions among nearly 10,000 HIV-infected women in 2002–2003 would not have reduced infant mortality by a measurable degree by 2004. This phenomenon is worthy of further investigation.

Step 9: If necessary, identify additional data and return to step 5
Analysts further examined the association between district-level mortality changes between 2003 and 2004 and ART initiation date and coverage rates. After weighting for population size, the decline in district-level mortality is significantly correlated with the date of initiation of district ART programs ($p<0.05$) and with the district-level ART coverage rate in July 2004 ($p<.05$), although co-linearity between these two factors prevents their integration in a single analysis.

Analysts were also able to identify an additional data source—consolidated data on hospital mortality from the MOH midnight census—that allowed them to verify the census mortality statistics.

Step 10: Summarize findings and draw conclusions
The data used in this triangulation provided the researchers with support for their hypothesis that the decline in death rates in adults from 2003 to 2004 was coincident with an increase in patients' use of ART. Country-enhanced monitoring and evaluation provided reasonable evidence of an association between ART scale-up and declines in adult mortality from 2003 to 2004. Preliminary vital registration data from 2005 provided further empirical support. However, updating the vital registration data to include reported deaths through 2005 to date, validation of mortality reporting at key hospitals, and perhaps using the vital registration database in the Botswana Department of Home Affairs will help to confirm findings. The investigation indicated that vital registration data, if analyzed in a timely manner, can provide a reasonable HIV morbidity and mortality surveillance system at the national and district level. In addition, the triangulation could be modified to monitor the effectiveness of ART programs and HIV dynamics both nationwide and by district. The researchers concluded that ART is an effective way to reduce excess mortality attributed to AIDS in Botswana, and that expansion of ART coverage will continue to reduce the number of deaths.

Assessing the impact of PMTCT on child deaths may be more complex for a variety of reasons. This analysis provides little evidence of any substantial decline in infant or child deaths until 2004, and issues concerning data quality would be unlikely to produce biases that would mask true declines in the numbers of deaths. The researchers noted that district-level analysis and qualitative data would allow for further conclusions.

Step 11: Communicate results and recommendations

The analyses reported above were conducted collaboratively with partners from a number of agencies in Botswana. Reports based on the analysis were created and disseminated to stakeholders in Botswana. In the Country Report, the analysts made the following recommendation:

> "Botswana policy and program managers should note the potential benefits to public-health program management of applying triangulation, or simply rigorous epidemiological analytical methods to multiple datasets, which are usually readily available. This study demonstrates the utility of demographic analyses of vital registration data, and the benefit of linking vital registration data to program data in order to evaluate programmatic effectiveness." (http://www.who.int/hiv/pub/casestudies/Botswana2006.pdf)

The methodology used to identify, collect, organize, analyze, and interpret data formed the basis of a week-long training course in Botswana for researchers, program managers, and policymakers from district and national stakeholder institutions, conducted jointly by researchers from UCSF and CDC in January 2006. This training was practicum-based, using data from Botswana as the basis for analyses conducted by participants. For many participants, this was the first opportunity they had to view data from other agencies, and their interpretation and insights added greatly to the researchers' understandings of what programmatic and individual behavior lay behind the shifting numbers of testing, treatment and deaths.

As one example, participants' insights regarding migration or "commuting" for ART treatment during the early months of program rollout helped to explain some variability in hospital-reported ART uptake and mortality during this period.

Step 12: Outline next steps

Continued capacity-building is necessary before triangulation methodologies are integrated into use at the national level in Botswana. The principal challenges to future efforts have more to do with institutional comfort with data sharing than with the individual capacity of technical staff in Botswana. Data sharing is still uncommon and considerable time and energy by upper-level administrators is required to assure access to data from other departments. Once data have been accessed, the variability of triangulation methods, dependent as they are upon the kinds of data available to respond to each specific question, require flexibility in the processes used to clean individual datasets, verify specific sources through comparative indices, and methodically go through the steps of population, geographic, and temporal analysis set out in the simplified standards developed by UCSF. This flexibility is likely to come primarily from experience, rather than simply from training.

Building upon the concepts transferred in the January 2006 training course, the partners involved are planning future collaborative triangulation exercises, with the lead in data identification and analysis to be taken progressively by the Botswana partners. It is expected that a small number of such collaborative studies will be sufficient to ensure capacity for triangulation studies among the technical analysts involved, and an appreciation of the value of these studies among administrators and policymakers in the respective institutions. Together, this is expected to be sufficient to ensure data availability and appropriate use at the national level. Of particular interest is the potential use of IPMS data for ongoing systematic analysis. IPMS data are being used to plan a cohort analysis to study survival of patients receiving ART, as a complement to this triangulation analysis.

The constraints of technical capacity and access to multiple data sources in useable formats are such that application of triangulation at the district level is unlikely to be developed in the near future. Notwithstanding this limitation, training of district staff in triangulation methodologies has been very useful in ensuring their ability to understand the value and limitations of this analysis and to properly interpret and communicate the results of analysis studies to their local constituents.

Appendix C: Summary of Malawi Triangulation for HIV prevalence

Case Report: Assessing trends in HIV prevalence in Malawi
A review of the 12-step triangulation methodology using country data

The following case report summarizes the methodological process that was used in Malawi from April to September 2006 to determine the trends in HIV prevalence. Using data from multiple existing sources, the researchers were able to develop a model to assess recent changes in HIV prevalence nationally and by geographic sub-region. Triangulation was applied to data from Malawi to answer the overarching question: Has HIV prevalence (incidence) increased, decreased, or remained the same in Malawi from 2000 to 2005?

National data indicated a decline in the HIV epidemic in Malawi and an increase in the reach and intensity of prevention efforts from 2000 to 2005. This assessment was based on an overall decline in HIV prevalence, syphilis prevalence, and sexual risk behavior (abstinence, risky behavior, and condom use), and a scale-up of prevention programs. However, HIV prevalence appeared to be decreasing in urban and semi-urban areas with no concomitant decrease in rural areas. Given that the majority of Malawians reside in rural areas, a relative shift in the epidemic from urban to rural may ultimately demonstrate an overall increase in HIV infections. Of equal importance is the fact that the decline in HIV prevalence appeared to be slowing.

The findings are based on the use of triangulation as an iterative analysis process. During this process, the following steps were revisited and repeated as researchers gained a better understanding of both the data sources and their findings. The triangulation methodology used by the University of California San Francisco's Institute for Global Health (IGH) in Malawi can be encapsulated in the following 12 steps.

Step 1. Identify key questions
Malawi has produced a large and varied amount of data on its ongoing HIV epidemic. The country's National AIDS Commission (NAC) and the U.S. Centers for Disease Control and Prevention's Global AIDS Program (CDC-GAP) office in Malawi decided to use those existing data sources to inform its programs and policies and requested the assistance of the IGH to provide technical assistance in the triangulation exercise.

NAC convened a two-day meeting of stakeholders at the Lilongwe Hotel, Lilongwe, Malawi 18-19 April, 2006. Thirty-six representatives from Malawi governmental agencies, universities, Malawi-based non-government programs, and international organizations attended the meeting. The CDC-GAP and IGH triangulation team presented a background of the triangulation methodology and examples of how triangulation has been successfully used in the past. Meeting participants then brainstormed a list of key questions that might be addressed during the Malawi triangulation exercise. An initial list of 33 questions was generated. Those questions

were divided into the following categories: epidemiology, prevention, testing, treatment, and living with HIV/AIDS.

Participants refined the questions and then narrowed the initial list of 33 questions to 11, based on two criteria: 1) **Importance**: *How much of the epidemic does the question potentially address?* and 2) **Actionability**: *Would the answer lead to clear program or policy action?* During this process, some of the questions were combined where subject areas were related.

At this point, the stakeholders went through an extensive inventory of the data sources available in Malawi that could be used to answer the key questions. After this inventory, the eleven questions were further narrowed to six based, on three additional criteria: 1) **Data availability**: *Do the data exist and are they accessible enough to allow us to answer the question?;* 2) **Appropriateness of the method**: *Is the triangulation methodology the most appropriate one to answer the question, or is another method more appropriate (e.g. cohort study, expert panel, etc.)?;* and 3) **Feasibility**: *Can the question be answered in the 5-6 month timeframe of this project?*

The six triangulation questions developed by the team were:

1. Has HIV prevalence increased, decreased, or remained the same in Malawi from 2000 to 2005?
2. What is the reach and intensity of HIV prevention programs in Malawi from 2000 to 2005?
3. Are there disparities in the use of ART in Malawi?
4. What is the impact of services on the well-being of orphans in Malawi?
5. What is the impact of provider-driven testing on HIV care and other clinical services in Malawi?
6. Has ART increased productivity among PLWHA in Malawi?

Participants decided to set up a triangulation taskforce that would remain active for the duration of the triangulation exercise. Taskforce members volunteered themselves at the end of the April meeting. The taskforce was made up of a group of representatives from a diverse set of organizations: Malawi National AIDS Commission (NAC); Malawi Ministry of Health (MOH); Malawi National Statistics Office; U.S. Centers for Disease Control and Prevention Global AIDS Program (CDC-GAP); World Health Organization (WHO); UNAIDS; Médecins Sans Frontières; Malawi Ministry of Gender; Lighthouse Trust (a center providing care and treatment services to HIV/AIDS patients in Malawi); Baylor University; MACRO, a voluntary counseling and testing program; and Malawi College of Medicine.

The main activities of the taskforce during this period were to identify all possible relevant data sources in Malawi, assist with data gathering (Step 5), guide preliminary analyses, and identify participants for the final triangulation training and analysis workshop. CDC-GAP provided a public health prevention specialist to assist in acquiring and analyzing data and coordinating the taskforce for three months. The IGH team in San Francisco provided continued analysis of the datasets.

Step 2. Ensure question is answerable and actionable
The goal of the triangulation was to produce recommendations that could be used by the MOH and NAC at their annual HIV planning meeting in October. Thus, the triangulation exercise would need to be completed by the end of September.

The Malawi Triangulation taskforce met four times between May and July 2006. The taskforce first met on May 5 to prioritize the six final questions for the triangulation exercise. Questions not considered a high priority for this triangulation exercise would be answered at a later time, either through triangulation or another method, as deemed appropriate. Although all six questions were recognized as critical to Malawi, a prioritization exercise was needed to allow for the first triangulation exercise to be completed in five months.

The taskforce discussed each question and gave a score to each question based on a series of criteria (1=lowest, 3=highest). The results of the discussion and ranking follow:

	Q1. Prevalence trends	**Q2. Reach/intensity of prevention programs**	**Q3. Disparities in access to ART**	**Q4. Impact of services on orphans**	**Q5. Impact of provider-driven testing on HIV care/other services**	**Q6. Has ART increased productivity among PLWHA**
Actionability	3	3	3	2	3	2
Importance	3	3	3	3	3	2
Appropriate use of triangulation methodology	3	3	2	1	3	3
Data availability	3	2	3	2	2	2
Feasibility (project must be completed by mid-August)	3	2	2	1	1	1
Total	15	13	13	9	12	10

The group decided it would only have enough time prior to October to use the triangulation methodology to address one question. The rankings were not meant as the final decision on which questions to include in this triangulation exercise, but as a means to compare the questions. The group then came to a consensus on which

questions to study. The taskforce all agreed that the first question (prevalence trends) should be a priority. Preliminary data had already suggested that HIV prevalence had declined in several areas of Malawi while remaining stable or increasing in other areas. The taskforce chose to use triangulation to verify the current trends in the HIV epidemic, but also to delve deeper into differences in HIV prevalence and risk behavior between different geographic areas and populations and to establish trends in prevalence and risk factors in those geographic areas and populations.

The second and third questions were considered equally important, actionable and probably feasible within the four-month time frame. The third question also had readily available sources of data, while the taskforce had some concerns about whether they would be able to access all the data on prevention efforts needed to answer the second question. The other three questions (4, 5, and 6) were considered to be of high importance, but the taskforce did not feel they could be answered by the end of September. For example, data on people living with HIV/AIDS and productivity, such as sick records from employers, would be difficult to capture from sources in the five-month time frame. Ultimately, the third question was selected for the focus of the analysis.

Step 3. Identify data sources and gather background information
Identifying data sources and gathering background information was an iterative process that began with the first triangulation meeting in April. By the end of the triangulation exercise, more than 100 data sources had been identified, though many of them were available only in report form (i.e., not line-listed data). Data sources included published scientific papers, unpublished reports, and in some cases, the line-listed data themselves. All data used either had national and international IRB approval or exemption or were available in publications or online.

Participants in the April meeting listed a large number of data sources that could be used to answer various HIV questions. Most of the organizations represented at the meeting possessed data that would be relevant to the triangulation questions and/or knew of data sources owned by other organizations in Malawi. In May, the possible key questions were narrowed to one question and the taskforce developed a matrix that listed data sources relevant to HIV prevalence, the contacts at the organizations holding the data, and information describing those data sources (time period, type of data, population, and key measures).

The triangulation exercise primarily used quantitative data, partly because quantitative data are easy to array and compare. However, this triangulation also used qualitative data, which provided context, a greater depth of understanding of the reasons behind behavior change, and insight into behavior change that was not measured in quantitative indicators. A separate data matrix was made for qualitative data. Due to time constraints, triangulation analysts did not directly access the raw data from qualitative studies, but instead used the reports describing the analysis of this data. Most reports came in the form of peer-reviewed and published articles based on studies conducted in Malawi or reports from academic institutions working in Malawi. The qualitative data matrix included much of the same information as the quantitative matrix,

but, additionally, contained main findings from the studies. Qualitative data experts from CDC-GAP's main office in Atlanta also helped develop the matrix of relevant qualitative data and organize it by theme, as many of the articles addressed themes like "influences for behavior change," "fatalism and hope," and "condom acceptance."

Step 4. Refine research question

The research question was refined throughout the triangulation process in response to the evolving nature of the data that became available. The taskforce developed an analysis plan with a timeline for the process and the variables to be analyzed. However, as the taskforce and IGH analysts studied the data, it became apparent that HIV prevalence data by geographic area were more extensive than HIV prevalence data by population. That is, more conclusions could be drawn about people in specific geographic locations (e.g. the North, the South, and the Central regions, or urban and rural residents) than on people who shared similar demographic qualities, such as age groups, job types, and religious or cultural groups. Some individual studies and some national-level studies like PSI's Knowledge, Attitudes and Practices of Secondary School Youth Related to Sexual and Reproductive Health in Malawi, and the National Survey of Adolescents, provided some insight as to the risk factors for HIV in certain populations. However, these data were predominantly collected at one point in time, and thus, could not provide time trend information. The taskforce decided that it was primarily interested in recent trends and, thus, focused mostly on prevalence trends since 2000. The taskforce was originally interested in studying HIV incidence, but they could not find any incidence data.

After refinement, the question became: Has HIV prevalence increased, decreased, or remained the same in Malawi from 2000 to 2005?

Step 5. Gather data/reports

Gathering data and reports was the most time-consuming part of the triangulation exercise. Stakeholders from the April 2006 meeting and triangulation taskforce members provided most of the relevant data. Nearly all relevant data sources were identified early in the process.

Analysts gathered information from other data owners as needed. NAC taskforce members were particularly crucial in this step, as virtually all HIV/AIDS organizations working in Malawi are connected to NAC, due to the agency's role as the coordinating AIDS body in the country. Many of those organizations are required to report to NAC. NAC and the MOH provided much of the crucial data, including the antenatal clinic (ANC) sentinel surveillance system data and information from government hospitals, such as reported STI and AIDS cases. In many instances, the process of extracting and using data provided by the taskforce was not simple. The Demographic and Health Survey (DHS), for example, was owned by the National Statistics Office; however, the U.S.–based company that managed the DHS was the only agency with the most recent dataset. The dataset was not ready for use until late in the triangulation process, and analyzing the dataset required continued coordination with ORC-MACRO staff.

Other datasets were similarly difficult to procure, particularly when the data holders were not members of the triangulation taskforce. It was important to have members of the taskforce help coordinate with those organizations. In some cases, only one individual from the organization was authorized to disseminate data. In other cases, staff members were reluctant to release data. One strategy to avoid confidentiality conflicts was to arrange for staff members from the organization holding the data to perform the analysis and to give the aggregate results to the taskforce analysts. In one case, an organization only had annual reports of their data, but the information in the annual reports was sufficient to allow the taskforce analysts to draw some conclusions about trends in prevalence over time in that location.

Ethical issues about data collection also needed to be addressed. Since the analysis was done mostly by CDC-GAP staff, the CDC Institutional Review Board (IRB) needed to approve the use of all datasets. One dataset was not approved by the CDC IRB. Therefore, some of the raw data from that source could not be used in the triangulation. Instead, the taskforce analysts were able to use data from a published report that had most of the relevant information.

Types of data gathered for the triangulation included the following:

- Surveillance case reporting data (e.g., AIDS cases, STI cases, TB cases)
- Sentinel surveillance data (e.g., HIV and syphilis prevalence among women at ANC sites)
- Population-based surveys (e.g., the Demographic and Health Survey (DHS) in 2000 and 2004)
- Surveys in high-risk populations (e.g., behavioral surveillance)
- Data from scientific research projects (e.g., cohort studies, surveys, qualitative studies)
- Data from the national census and National Statistics Office
- Data from other health programs (e.g., sites delivering ART, patients on ART, blood transfusion services, voluntary counseling and testing, clinical records)

Step 6. Make observations from each dataset

Under the direction of the triangulation taskforce, the analysts conducted preliminary analyses of key datasets. These preliminary analyses helped to assess the quality and interpretability of the diverse sources of data and to guide the search for further information.

Early in the triangulation process, it became clear that the foundation of the analysis would come from ANC sentinel surveillance data and the DHS data, by virtue of their national coverage, representative sampling methodology, and consistency of methods from year to year. The ANC data complemented the DHS data by providing trends in HIV prevalence in selected locations, including 19 sites in urban, semi-urban, and rural areas. Together, the ANC sentinel surveillance data and the DHS data served as the primary indicators for trends in the HIV epidemic. The DHS was particularly useful in determining trends in risk behaviors and the reach of prevention efforts because of its large sample size and representative sampling design. The 2004 DHS also included

HIV prevalence (also known as “DHS+”). When the DHS sample size was greater than 200 men and women in a district, the data were examined for that particular district. However, DHS district-level data were not interpreted in isolation. When possible, a minimum of three independent data sources were used to corroborate any district-level findings.

Additional data assessments and preliminary analyses were conducted at UCSF by IGH faculty in consultation with CDC-GAP and the taskforce through regular conference calls. However, the bulk of the interpretation of the data was reserved for the Triangulation Workshop in Lilongwe from 25 to 29 September, 2006.

Step 7. Note trends across datasets and hypothesize

This step also occurred over several months. Analysis of ANC data found that, while HIV prevalence had been declining nationally since 1999, there were some locations that seemed to have an increase in HIV prevalence, particularly in the rural areas throughout the country. Trends in risk behaviors in DHS respondents over that time period also showed that the prevalence of some risk behaviors in the rural North, rural Center, and rural South were either not declining or were increasing. But like ANC HIV prevalence, most behavioral indicators in the DHS were declining at the national level. The increase of HIV prevalence in four of eight rural ANC sites was of particular concern, because the national census in Malawi showed that 85% of the population lives in a rural area.

The DHS data on risk/protective factors also served as a starting point to generate hypotheses on the reasons behind the HIV prevalence trends. These hypotheses were then further confirmed, modified, or refuted by additional sources of data. These additional datasets were often present in only a few select sites or populations. Qualitative data were used to add depth and understanding once the refined hypotheses had sufficient supporting evidence from at least three quantitative data sources.

The Malawi Triangulation Workshop was convened in Lilongwe from 25 to 29 September to complete Steps 7 to 10 of the triangulation process and to begin Steps 11 and 12. Participants represented 27 institutions. Participants were invited to provide insight on the data sources and to learn the methods of triangulation for future efforts in Malawi.

The workshop was organized around brief didactic lectures by the IGH and CDC-GAP facilitators, followed by breakout sessions of smaller groups. Groups were organized to focus on one of the three regions (North, Center, and South) because the preliminary analysis had already shown that the most useful data were available by region. The tasks of the groups were divided into six exercises or practica, each focusing on one step of the triangulation methodology (e.g., making observations from individual datasets, noting trends across datasets) and/or one level of indicator data (e.g., national level, regional level, district level). After each practicum, groups made presentations of findings followed by facilitated discussions with all workshop participants. Because one

goal of the workshop was to build capacity for future triangulation exercises, participants partially repeated the preliminary analysis by determining trends in ANC and DHS data and synthesizing quantitative and qualitative data. However, the workshop participants were able to add their own insights and interpretation to develop a new understanding of the data and to generate hypotheses to explain the temporal trends and differences in the HIV epidemic among the regions.

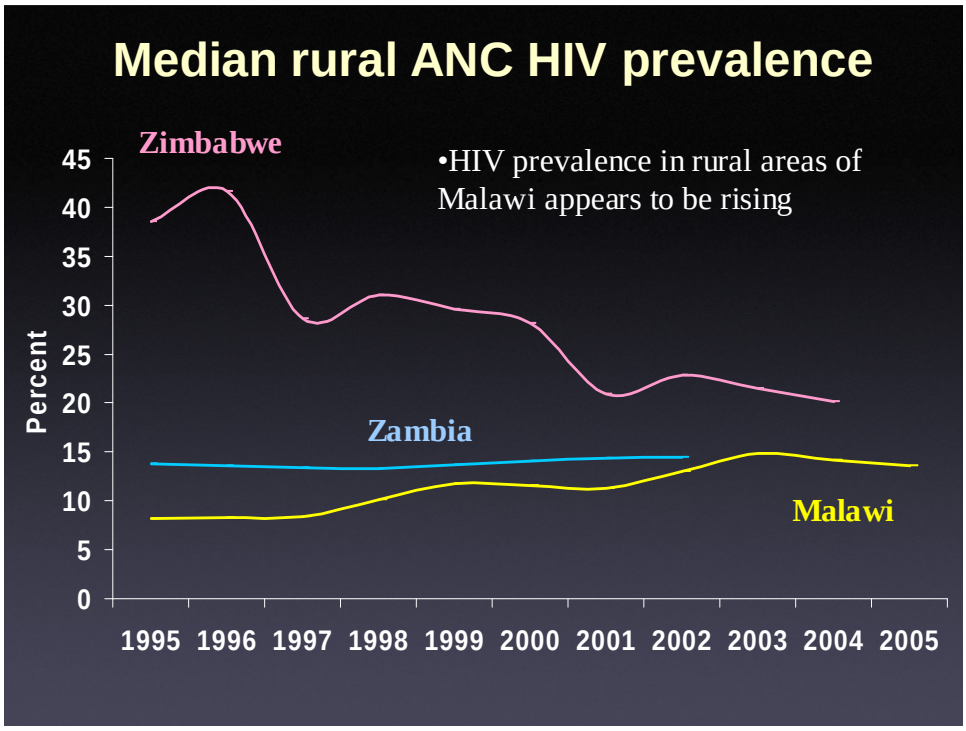
Step 8. Check hypotheses
While triangulation typically does not use measures of statistical significance, the triangulation taskforce chose to check the statistical significance of the ANC findings. While the ANC sentinel surveillance system uses consecutive sampling, the analysts decided the methodology was similar enough to random sampling to warrant using the chi-square test for trends. The analysis found that overall national HIV prevalence among ANC clients had declined between 1999 and 2005 with borderline statistical significance (p=.08), but there was a significant decline in HIV prevalence among semi-urban ANC clients in the 15-24 age group (p=.001) and all semi-urban ANC clients of all-age (p=.004). ANC clients in the 15-24 age group in the Northern region also had a significant decline in HIV prevalence during this time period (p=.05). The statistical analysis confirmed that HIV prevalence was declining significantly in the semi-urban areas, but not in the urban and rural areas, and it also gave a stronger indication that some rural sites might be facing a worsening epidemic.

In one practicum, the workshop participants refined hypotheses to explain the HIV epidemic trends with respect to local districts and regions. The process of refining hypotheses entails determining whether the diverse data sources corroborate, refute, or modify the hypotheses regarding the direction of the epidemic and outlining reasons for this determination. This practicum also was used to identify “hot spots” in greatest need of targeted HIV prevention interventions, their locations at the district or regional level, and the types of interventions needed. Similarly, the participants identified local and regional prevention and treatment “success stories” where HIV/AIDS indicators were moving in the right direction. Finally, this exercise was used to identify information gaps by location and by types of measures. The workshop participants used quantitative data, key findings from the qualitative research reports, and their own insights into the epidemic to check and refine hypotheses.

Step 9. If necessary, identify additional data and return to step 5
This step was repeated throughout the triangulation exercise. After ANC data had been used to determine geographic trends in HIV prevalence, data from blood donors and VCT clinics became available. The blood donor data were limited, but confirmed ANC findings and provided additional evidence for a general decline in HIV prevalence as indicated by ANC data. The VCT data, however, showed that rural HIV prevalence was drastically declining. However, an analysis of the VCT client population found that the number of VCT tests done in the rural areas had greatly increased between 2000 and 2005, which would naturally cause a decline in HIV prevalence. Moreover, the reasons for testing among clients trended towards less critical reasons (e.g., fewer people came to test because they were ill, but more came to test in preparation for marriage),

indicating that less risky clients were coming to be tested. In addition to uncertain representation and selection bias, other data sources were deemed less relevant due to uncertain denominators (e.g., TB cases detected), inconsistent collection (e.g., AIDS case reporting), or small sample size (e.g., behavioral surveillance).

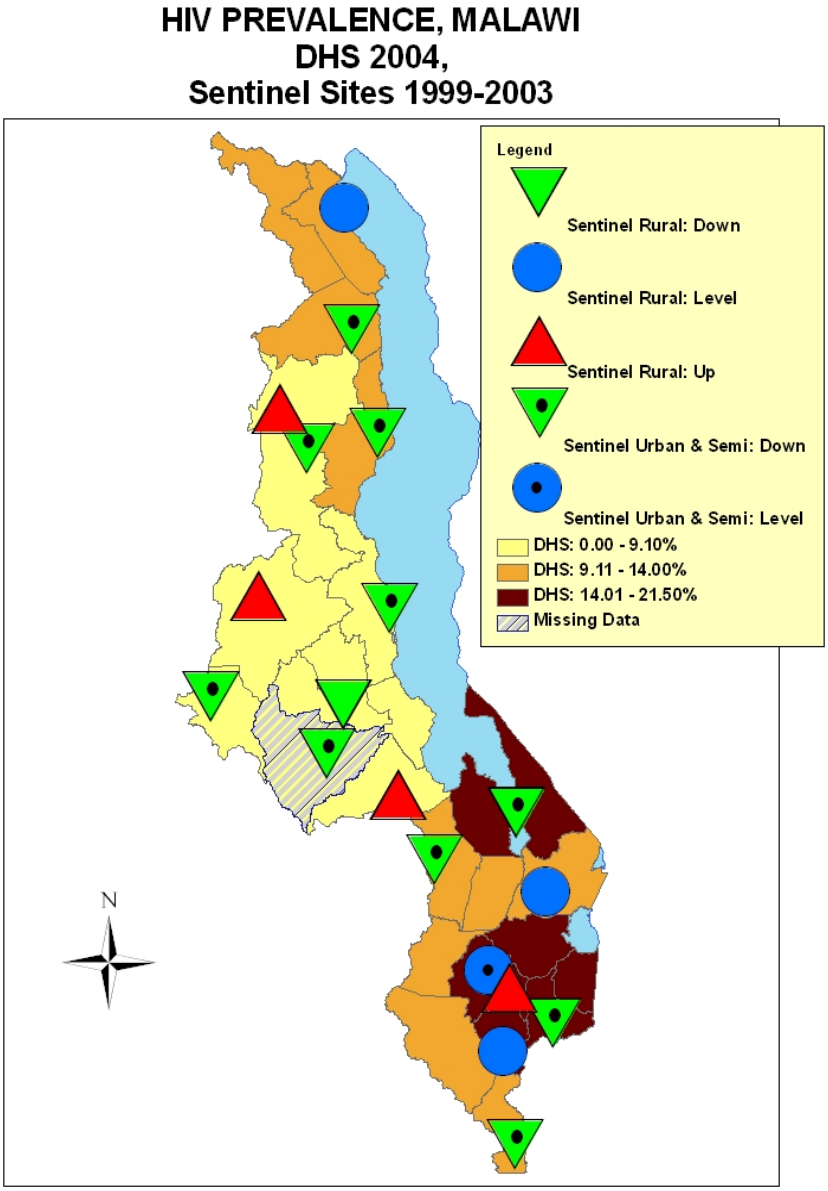
While the overall HIV ANC prevalence was declining between 1999 and 2005, the DHS surveys showed that some risk behaviors were either not improving or were improving at a slow rate. Comparing the ANC data with the ANC trends in neighboring countries confirmed that the Malawi HIV prevalence was declining at a shallower rate than that of its neighbors.



Step 10. Summarize findings and draw conclusions
The workshop participants worked in small groups and as a large group to summarize their findings and draw conclusions about each of the six regional strata. The data indicated that the different strata were characterized by differing trends in HIV prevalence, risk behaviors and prevention efforts. The rural North, for example, was characterized by worsening HIV prevalence, highway developments that improved mobility of people, and an increase in the proportion of men who had casual sexual partners. The urban South, however, was found to have a high rate of "hot spots" with commercial sex work in economically productive areas. Participants described the particular epidemic and prevention efforts in each stratum. They also made recommendations on prevention and surveillance activities needed for each stratum.

Step 11. Communicate results and recommendations
Near the end of the workshop, participants selected three people to work with IGH staff on developing a presentation for policymakers. The presenters developed a PowerPoint

presentation with graphs that combined trends from various datasets, and maps and tables describing both the hypotheses on prevalence and risk behaviors, and the recommendations, for each of the six strata. Recommendations included suggestions for surveillance and research, as well as interventions for at-risk populations. The presentation was given on the last day of the workshop to policymakers and program managers.



Step 12. Outline next steps

The workshop findings and recommendations were used to inform the Malawi annual planning meeting in the following month. The national-level policymakers also planned to disseminate the results to managers and staff at the regional and district levels. In addition, this exercise catalogued a vast amount of recent data that may be applied to

other issues concerning the HIV epidemic in Malawi. The data matrices and the connections made between organizations also provided the foundation for future collaboration and triangulation analyses.

The triangulation taskforce continued to meet after the workshop in order to plan future triangulation exercises. The taskforce subsequently began working on a triangulation to determine the impact of the country's antiretroviral therapy rollout. Continued technical assistance from outside the country (partly due to the lack of in-country analysts who had the time to gather and analyze data) and capacity-building were deemed necessary in the next triangulation exercise. However, organizations in the country that work on HIV issues tend to be unusually open to data sharing. Also, Malawi has a highly centralized government, so the National AIDS Commission and Ministry of Health have a wealth of data at hand.

Appendix D: Summary of ART Impact of Mortality and Morbidity in Malawi

Case Report: Assessing the impact of ART on morbidity and mortality using data sources covering a variety of population groups, settings, and regions from within Malawi.

The following case report summarizes the methodological process used in assessing the preliminary impact of antiretroviral therapy (ART) rollout in Malawi using local, existing research, programmatic, and surveillance data. Overall, evidence from these studies supports the hypothesis that ART rollout reduces general morbidity and mortality in Malawi. However, disparities in ART distribution and benefits are emerging.

Step 1. Identify key questions

During a two-day meeting of stakeholders in April 2006, multiple epidemiologic questions were posed, concerning the future directions of the HIV/AIDS epidemic in Malawi and the impact of current interventions. These questions were narrowed down to a key set of priority questions, using the following criteria:

- Importance: Does the question address significant attributes of the epidemic or society?
- Actionability: Can the answer to the question lead to clear program or policy interventions?
- Data availability: Do data exist to allow us to answer the question?
- Appropriateness of the method: Is the triangulation methodology the most appropriate way to answer the question, or is another method more appropriate? (e.g., cohort study, expert panel, etc.)
- Feasibility: Can the question be answered in the 5-6 month timeframe of the proposed project period?

Two priority questions centered on evaluating the impact of the first years of ART rollout in Malawi, one focusing on the individual-level impact of ART use on patient morbidity and mortality, and the other concentrating on the societal-level impact of ART (for example, on worker productivity). These questions were further refined as the following:

- **What is the impact of ART in Malawi on morbidity and mortality, and what disparities may exist in terms of reach or access?**
- **Has ART increased productivity, employment, and/or human-resource capacity among PLWHA in Malawi?**

The information needed to answer these questions was drawn from a series of triangulation exercises analyzing and synthesizing HIV/AIDS data sources from Malawi. The first in this series of triangulation exercises answered two other top priority questions on the list of six, and is described in Appendix C. This case study focuses on

answering questions concerning the impact of ART in on morbidity and mortality in Malawi, as phrased above.

Step 2. Ensure question is answerable and actionable

During the April 2006 workshop, the importance of answering the original two questions on the impact of ART was determined to be high. However, participants and task force members were not in agreement on the feasibility of answering these questions at that time. Task force members felt that some of the necessary data (employer records, ART case registries, etc.) would be difficult to access in a short timeframe and that there were not yet enough data available on the rollout of ART to show either any potential disparities in their use or increased productivity for those PLHWA enrolled. However, the feasibility of answering these questions increased after the April 2006 workshop and the initiation of this exercise, as additional data were collected and ART coverage expanded dramatically. Therefore, the triangulation questions on the impact of ART on individuals and society were undertaken for this second triangulation round.

Step 3. Identify data sources and gather information

Several key data sources were identified during and after the April 2006 meeting that had particular relevance to ART impact. These included the following:

- A population-based study of mortality in the Karonga district
- Employee mortality data from records within the private sector and the military
- Public sector employee mortality data
- Hospital admissions data at several Malawian hospitals
- Projection models using HIV/AIDS data and estimates along with standard methods and tools, such as EPP and SPECTRUM
- ART case registries from select districts
- Access, impact, and survival data of selected population groups or employment sectors (healthcare workers, teachers, and tuberculosis patients).

Step 4. Refine research question

For the purposes of the workshop, the two priority questions were revised into a single general inquiry: *What is the impact of the early period of ART rollout (2002 – 2006) on mortality and morbidity in Malawi?* Workshop organizers and participants agreed that the data presented at this workshop provided enough information to answer this key question successfully and to offer feasible and actionable recommendations. Additionally, examination of the data stratified by sub-groups would help answer questions on potential disparities in ART rollout.

Step 5. Gather data/reports

Prior to the workshop, a triangulation field team collected and analyzed some of the data to be used during the workshop. Two local analysts, twinned with an experienced

consultant, gathered existing data, abstracted hospital records (including admission diagnosis, discharge diagnosis, vital status, facility and age indicators), met with providers and data owners, and conducted preliminary analyses. To prepare for these activities, data collection protocols and instruments were written and approved by collaborating institutions. The field team also worked with in-country epidemiologists to identify an appropriate sample of hospitals and to coordinate visitation to those facilities.

The two in-country consultants were tasked with collecting additional primary data as well. One local consultant came to San Francisco in late May 2007 and brought with him additional medical chart abstraction data, as well as data from national ART registries. The consultant spent ten days in San Francisco in the lead-up to the workshop, working with the UCSF team to generate hypotheses, analyze data, and prepare for the workshop.

Additional researchers involved in population-based, cross-sectional, and special survey studies in Malawi were asked to prepare and present their preliminary data to provide additional corroborative evidence.

Step 6. Make observations from each data source

On June 7, 2007 in Lilongwe, researchers presented data from seven studies that offered information necessary for evaluating the impact of ART on mortality among the general population in both rural and urban settings throughout Malawi. These studies were diverse in population settings studied and the epidemiologic methods used. The studies are described in greater detail in the following pages.

The Karonga Demographic Surveillance Survey (KDSS): The KDSS is a population-based study of residents living in the Karonga district, both in rural and more densely populated areas. An area in the southern part of Karonga district (population 32,000) has been continuously and comprehensively surveyed from August 2002. All households in the area have been surveyed and repeated censuses conducted. Approximately half (49%) of the population lives > 1 km from the main roads crossing the area. Mortality rates were examined for the period from August 2002 to June 2005 (i.e., pre-ART rollout) compared to the eight months following the opening of an ART clinic in the district (i.e., in Mzuzu).

Figure 1: Evidence of ART benefit in Karonga

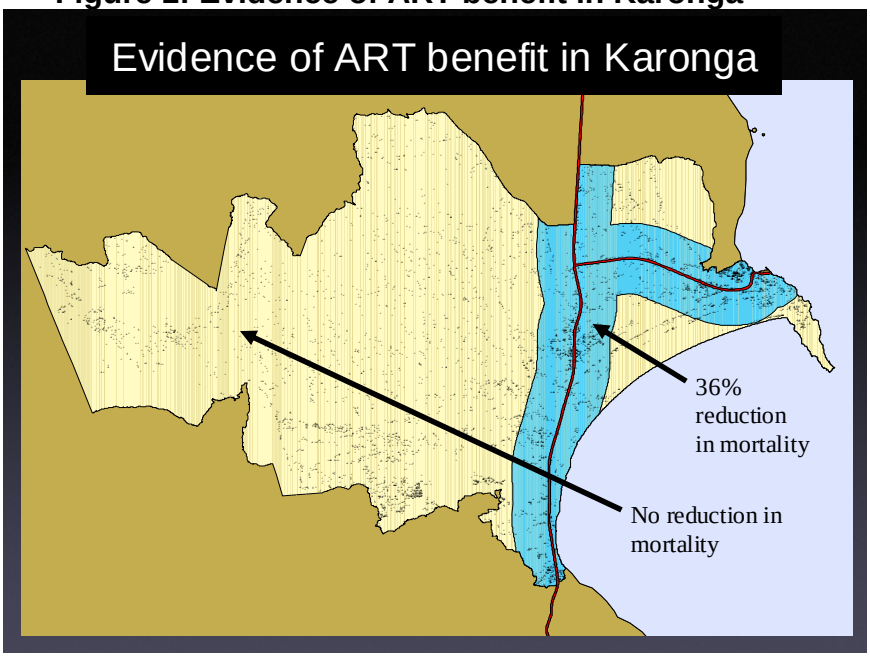
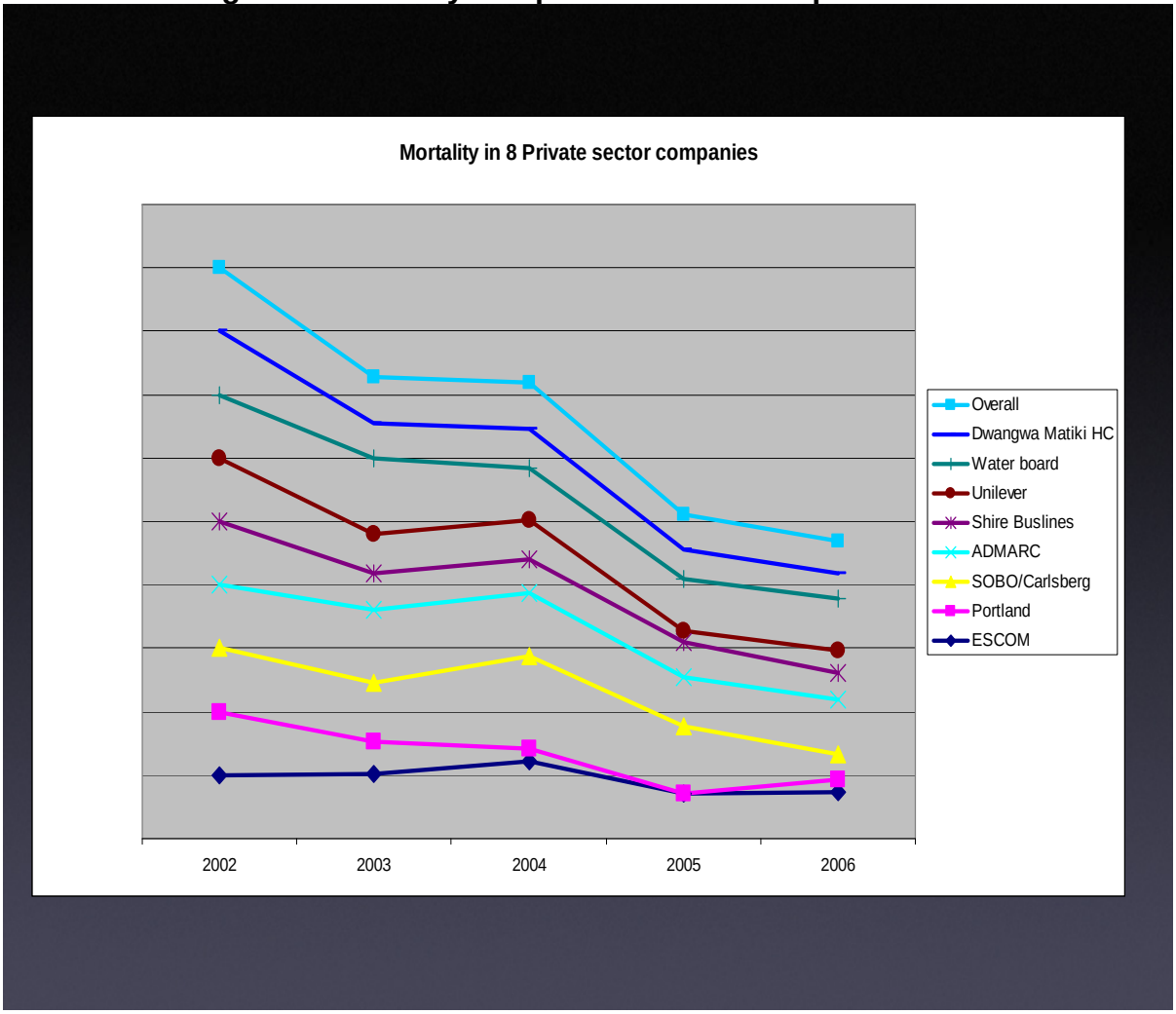


Figure 1 demonstrates the impact of ART rollout on mortality in the Karonga area. Following the opening of an ART clinic in Mzuzu, residents living within 1 km of the main road to Mzuzu (where the clinic was located) saw a 36% reduction in overall mortality. The study found that rural residents living farther than 1 km from the road experienced no significant change in mortality. This study provides early evidence of the community-level impact of an ART program. The finding also points to an important limitation for Malawi, given that the majority of people with HIV live in more rural areas, (as described in 2005 National HIV Prevalence Estimates and 2005 Malawi DHS) and have limited access to ART clinics.

Figure 2: Mortality in 8 private sector companies



Mortality in the private sector: The results of another study of trends in mortality among private sector employees (see Figure 1) echoed the Karonga finding that ART has made an impact on mortality. Data collected from records of several large private companies in Malawi between 2002-2006 found that mortality among employees and their spouses declined. Although the exact dates of the ART rollout are not specified for each company, in qualitative discussions, personnel officers largely attributed the decline in employee mortality to ART availability through the workplace. Personnel officers additionally shared their experiences of a decline in employee absenteeism due to illness, as well as a decline in time taken off to attend funerals for co-workers. Compared to the unemployed, persons employed in the private sector (particularly in urban areas) may be among the first to access ART, and, therefore, may be the first population to demonstrate benefit in reducing morbidity and mortality. It should be noted that private-sector employees are also a relatively well-defined population.

Hospital admission, fatality, and mortality trend data: Data from the HMIS, individual hospital record abstraction (from a total of 17 hospitals across the north, center and south of Malawi), and other electronic data sources were evaluated for morbidity and mortality in hospitals across Malawi. Despite the evidence supporting a decrease in mortality, patient admissions from hospital wards in Malawi offer a somewhat contradictory picture. Data from a study in which patient records were abstracted from a sample of hospitals throughout the country provided seemingly conflicting information by showing both improving survival among AIDS patients along with increasing admissions of persons with HIV (as shown in Figure 3, next page). Many of the workshop participants concurred that hospital data displayed several limitations and lacked the capability to easily distinguish community-wide mortality trends from trends in treatment-seeking. (For example, it is hypothesized that only the sickest patients are coming to the hospital, masking positive mortality trends in the community). This viewpoint is supported by the fact that referral hospitals operate at patient levels above capacity.

Figure 3: Comparison of HIV/AIDS-related patient-level data vs. aggregate hospital abstraction data—Mulanje adult males

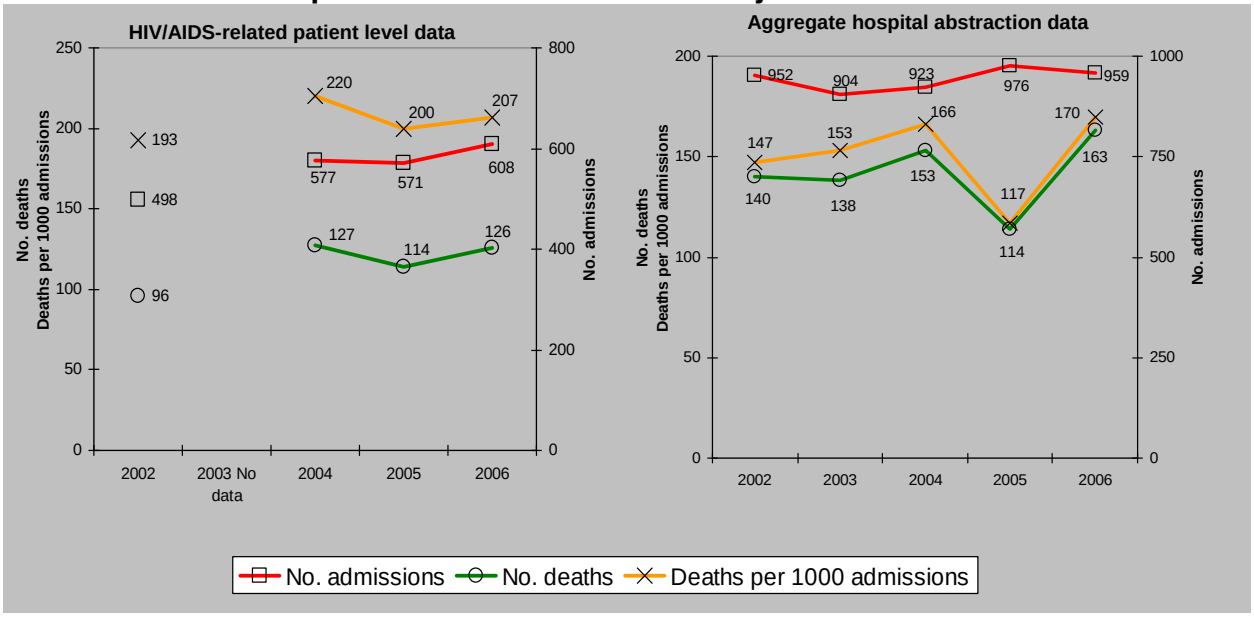
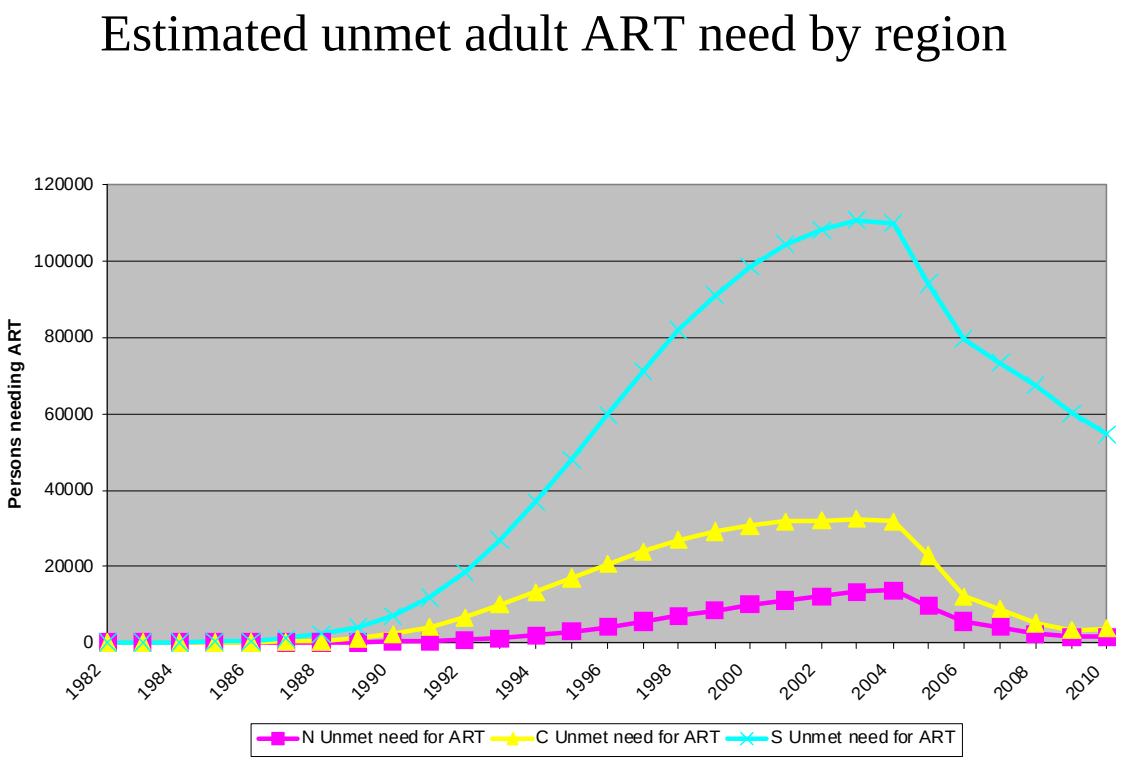


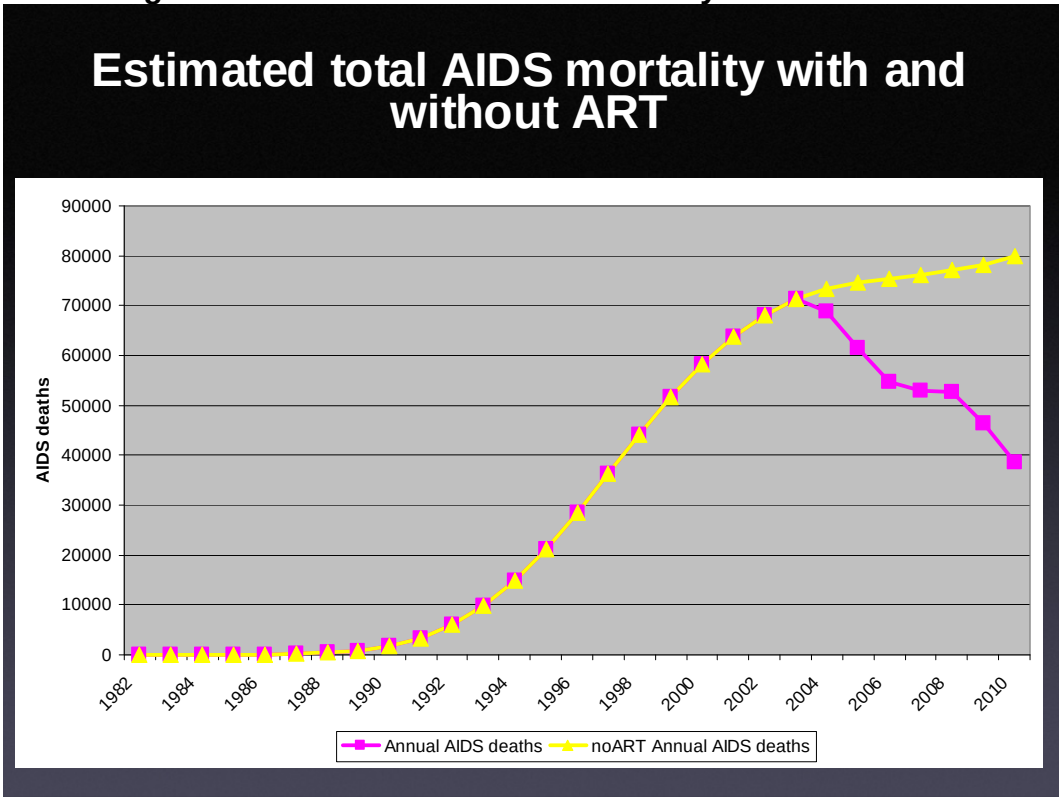
Figure 4: Estimated unmet adult ART need by region



Spectrum modeling: Models estimating the impact of ART on morbidity and mortality, using standard approaches from UNAIDS/WHO guidance and the software package, Spectrum, were also presented to workshop participants. Such models use historical data for inputs, such as estimates of HIV prevalence provided by national surveillance data and demographic health surveys, demographic parameters, epidemiological assumptions, and programmatic data, such as PMTCT and ART in adults and children. Spectrum was used to generate regional projections showing the number of patients on ART. The models project that the South will have many more patients on ART than the other regions by 2010, given higher HIV prevalence and population density. Given the current approach of ART scale-up, which targets all regions fairly equally, it is possible that the South will suffer from a lack of adequate ART access, as demonstrated in Figure 4, above. ART scale-up needs to target areas where there is greater need. Therefore, identifying potential unmet needs is useful in making HIV/AIDS policy decisions.

These models also showed the projected impact of ART rollout in terms of the number of lives saved, providing estimates on the future number of people living with HIV (see Figure 5, below). Many observed that such an increase in the prevalence of persons with HIV infection as a consequence of ART rollout might increase the long-term burden of care and the potential for increased HIV infection from a longer surviving reservoir of infected individuals. However, it should be noted that ART also decreases viral load, and thus HIV transmission.

Figure 5: Estimated total AIDS mortality with and without ART



National ART registers: Workshop participants were also presented data on the treatment equity tabulated from the ART registries sampled from five districts. Notable findings were that 60% of persons receiving ART were women and that men had a 25% higher death rate. Participants suggested the data indicate a gender disparity in survival. One hypothesis forwarded to explain this disparity is that men are recently lagging behind women in HIV testing—and dramatically so in recent years—leading to later diagnosis and worse survival outcomes after diagnosis. Figure 6, below, presents the data regarding treatment access by gender in the five districts.

Figure 6: Treatment access by gender in five districts

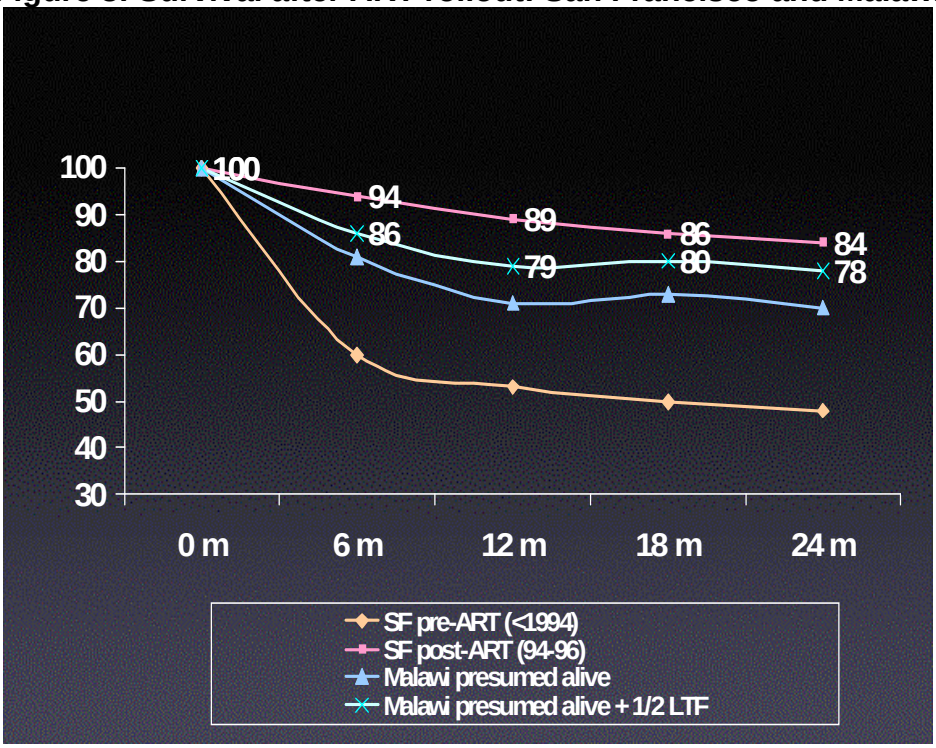
	Male	Female
Chiradzulu	41%	59%
Mangochi	36%	64%
Lilongwe	41%	59%
Rumphi	40%	60%
Salima	42%	58%

Healthcare worker mortality data: Data were also presented to elucidate the economic and social impact of ART on key segments of Malawian society and specific population groups. Prior to ART rollout, HIV infection had exacerbated a shortage of healthcare workers in Malawi (caused by disease among workers themselves and from the increase in the demand to care for the growing number of patients). However, ART rollout increased productivity among healthcare workers who have better treatment outcomes than the general population, as seen in Figure 7, below.

Figure 7: Survival probability among healthcare workers and general patients

Survival probability	HCW on ART	General patients on ART
6 months	85.1%	70.2%
12 months	81.3 %	65.2%
18 months	78.2%	55.6%

Figure 8: Survival after ART rollout: San Francisco and Malawi



The patient survival outcomes during Malawi's early rollout period were compared to those of San Francisco during its rollout (1994-1996), as shown in Figure 8. San

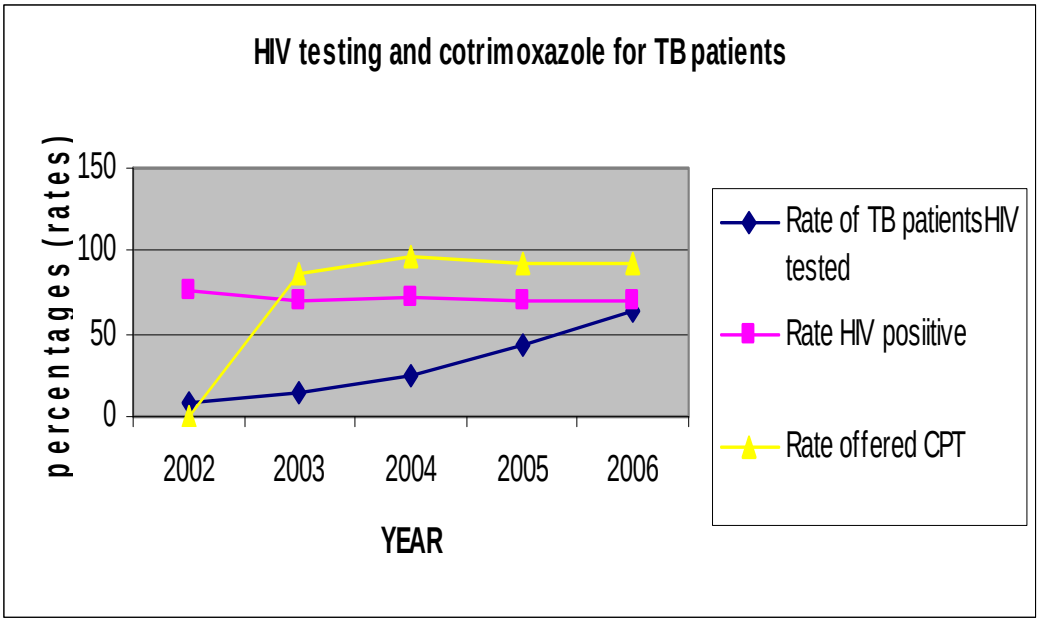
Francisco has high access to ART, but the period of 1994 to 1996 corresponds to increasing uptake among many patients with severe immunosuppression. This scenario may be comparable to Malawi in 2002-2006. The survival gains in Malawi for 2002-2006 appear comparable to San Francisco from 1994-1996. It is important to note that the survival data from Malawi may be less complete than that from San Francisco, and may therefore underestimate survival (that is, Malawi's gains in survival may be closer to San Francisco's than Figure 8 suggests).

Teacher mortality data: Data were presented on the ART impact among teachers, a second group that had early access to ART, and one that forms a key segment of Malawian society. Treatment outcomes for teachers also appear superior to those among other patients on ART, likely due to earlier-stage initiation. As shown in Figure 9, below, and found in the REACH study (which looked at disparities in ART access and outcomes), there also appears to be a gender disparity in survival, with female teachers having better survival than male teachers (with an adjusted Hazard Ratio of 2.05). A later stage of initiation was also associated with higher mortality among patients on ART.

Figure 9: Survival probability among teachers and general patients on ART

Survival probability	Male teachers on ART	Female teachers on ART	General patients on ART
6 months	79%	86%	72%
12 months	74%	83%	64%
18 months	68%	79%	62%
24 months	67%	76%	

Figure 10: Uptake of services for TB patients



TB patient data: Another study of tuberculosis patients found that ART rollout increased HIV testing among TB patients (Figure 10, above). Such studies, although anecdotal, suggest that ART distribution does influence behavior among patients already in medical care. The task force acknowledged that there is a gap between the need for ART and access to ART among TB patients.

Step 7. Note trends across datasets and hypothesize

Following the presentations, participants were divided into breakout groups to identify common themes across all data sources regarding the impact of ART rollout on morbidity and survival and to point out disparities and limitations. The breakout groups identified several key findings driven by triangulating the data presented. These findings were reported back to the main body for discussion.

Two main hypotheses emerged from the data:

1) Hypothesis 1: If ART coverage in a specific area or sub-population was early and high, there is strong evidence that ART rollout reduced morbidity and mortality (as seen in “contained populations with early access”—i.e, private-sector employees, healthcare workers, and teachers). This is also observed in segments of the wider community, including those persons with improved access to transportation in Karonga.

Findings that supported this hypothesis included data that suggest that ART rollout resulted in reduced mortality across several population groups with direct access to ART facilities, such as residents living close to transportation routes (e.g., roads), or persons with access to ART information, such as healthcare workers and teachers. Relative survival also suggests significant disparities in ART distribution, as there are many persons who do not have access to either transportation or information. This is especially true among those living in rural areas. Policymakers should, therefore, consider redistribution of resources to match needs.

2) Hypothesis 2: There are disparities in ART rollout that have resulted in different benefits for groups with poor access to testing and treatment (including rural populations without access to roads, unemployed persons, persons living in the South, and possibly men).

Differential survival by gender was a finding identified by all breakout groups and discussed at length in the main body of this paper. Several studies found evidence that men have lower survival. One explanation for this possible gender disparity is that men are initiating ART therapy later in the course of illness.

Step 8. Refine hypotheses

The two main hypotheses listed above were then refined by participants as they were presented to the larger group. In some cases, sub-hypotheses were developed and/or limitations were noted.

The main workshop body refined existing hypotheses and made several new hypotheses based on group discussions, as well as additional (new) data which was presented for triangulation during the workshop. These hypotheses included: 1) increased survival is associated with the degree of access to ART facilities; 2) men have lower survival rates than women because they initiate therapy later in their illness than women; 3) the southern regions of Malawi will likely experience ART coverage difficulties.

Additional sub-hypothesis were noted, including the following:

- Treatment-seeking behavior, which makes the sickest patients more likely to come to the hospital, is obscuring positive mortality trends in hospital data.
- Early immune reconstitution syndrome (an inflammatory reaction that can occur in some people soon after they begin ART and which can lead to death) is also obscuring positive mortality trends in hospital data.
- Men are initiating therapy later in their illness.
- Most clients of health services are women and children; thus, these groups are more likely to be identify as HIV-infected.
- HIV progression is faster in men than women because of the age difference at the time of infection (disease progression is faster in older people).

- The South is underserved because it has the bulk of infections and bulk of population combined for higher need for ART, compared to Center and North.
- Poor outcomes in rural areas of Karonga (and rural areas in general) are due to poor access to roads and clinics outside of the area.

Step 9. If necessary, identify additional data and return to Step 5

In this workshop, summaries of previously reported data from the last HIV prevalence workshop, such as voluntary testing and counseling data, AIDS surveillance, studies of women presenting at antenatal clinics, and demographic surveys, were made available to all breakout groups to enhance the triangulation analysis. Many of these indicators were broken down by year. Tabular data summaries of surveys and studies presented during the workshop were provided to all members within the breakout groups.

In addition, at this point in the workshop, additional new data did emerge. For example, participants shared results from additional HIV testing data that showed a gender gap in recent years (comparatively more women than men getting tested over time) Additional clinic data that described increased male mortality were also shared, and other relevant published studies were discussed by the group at this point. Some of these new data were used to develop the refined hypotheses, sub-hypotheses and limitations mentioned in Step 8.

Step 10. Summarize findings and draw conclusions

During the final session of the triangulation workshop, the main findings of each data source and the overall synthesis evaluating the impact of the ART roll out in Malawi were summarized and presented to the group. Both successes and disparities were highlighted during the summary presentation, indicating times where ART rollout resulted in a positive impact on reducing mortality, and times in which the data indicated no or differential impact on mortality and/or morbidity. Recommendations were offered on ways to continue on the successes, or how efforts should be redirected to import ART impact. The conclusions from the workshop are presented below in Figures 11 and 12, on the next pages.

When drawing conclusions from the findings, it is important to note limitations to data interpretation. Participants in this workshop identified the following limitations:

- Hospital data may be difficult to interpret due to biases caused by treatment-seeking behavior and/or early immune reconstitution syndrome.
- Issues around ART adherence should be further explored to determine which groups are more or less likely to adhere to drug regimens, and why.

Figure 11: Conclusions and recommendations: ART impact on morbidity and mortality: success, evidence, and recommendations

Success	Evidence	Recommendations
Decreased mortality and/or high survival among of professionals (teachers, healthcare workers), private sector employees, soldiers	Higher survival on ART (teachers, HCW) Rapid decreases in mortality in 8 large companies and MDF post-ART rollout	Rollout and scale-up are working in key sectors of society: continue Attention to potential disparity with low SES parts of society in coverage and outcomes of ART
Significant decline in mortality in Karonga among inhabitants <1 km from main roads May extrapolate to broader urban areas of Malawi	Directly observed mortality pre- vs. post- ART rollout Linked to residents served by site Most profound among young adults	Roll-out and scale up are working: continue Data need: System to measure population-based impact and detect disparities throughout Malawi Need more sentinel demographic surveillance sites

Figure 12: Conclusions and recommendations: ART impact on morbidity and mortality: disparity, evidence, and recommendations

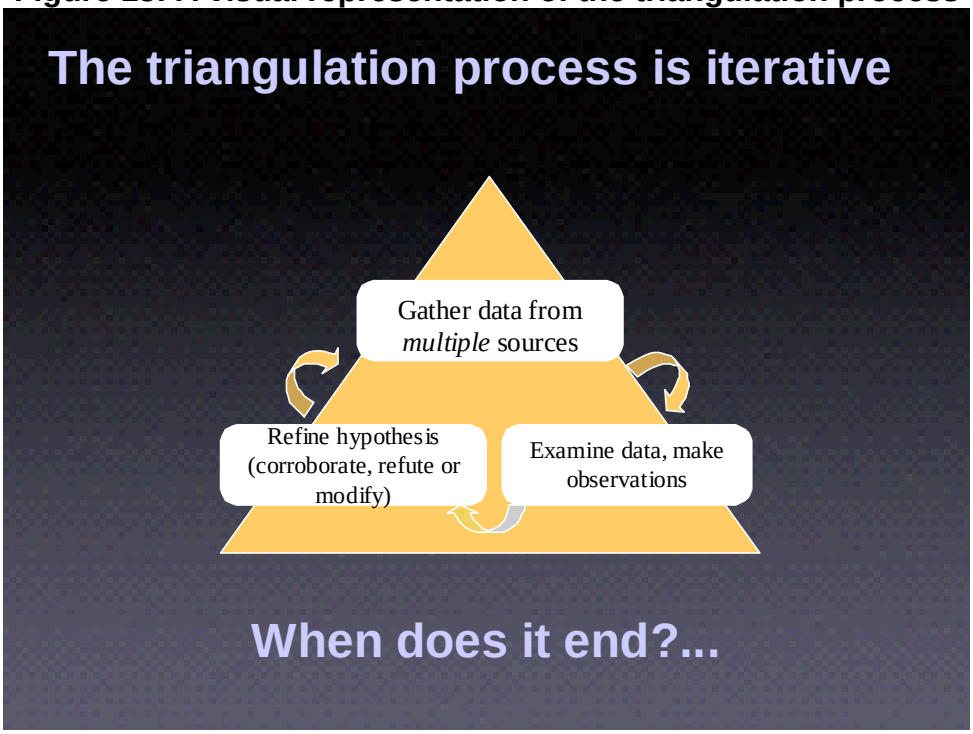
Disparity	Evidence	Recommendations
Potential relatively higher mortality among men on ART May be due to late diagnosis	Observed in teachers Observed in co-trim study Observed in REACH ~20% male-female gap in HIV testing	Verify gender gap in stage of ART initiation, competing mortality, adherence, age Address barriers to HIV testing among men, barriers to healthcare Attention to gender gap with continued ART rollout
No change in mortality among Karonga inhabitants >1 km from main roads May extrapolate to broad areas of rural Malawi—most of the population	Directly observed mortality pre- vs. post- ART rollout (May be increasing post-ART)	Attention to rural disparity with continued ART rollout (narrowing or widening?) Data need: System to measure population-based impact and detect disparities
The South is underserved by ART rollout	DHS: Higher prevalence ANC: Higher prevalence Census: largest population Spectrum coverage projections vs. current scale-up TB coverage low compared to need	Reallocate more scale-up resources to South Increase priority on linkage of TB care to HIV care

Step 11. Communicate results and recommendations

During the presentation of conclusions, many of the participants offered suggestions and additions to the conclusions and recommendations, which were incorporated into the presentation. A summary of the presentation was included in the workshop proceedings, including a synopsis of all data presented. In addition, the presentation itself (a PowerPoint file) was made available to workshop participants.

Policymakers not attending the full workshop were present on the last day of the workshop to listen to findings and recommendations. These findings will be used to produce the Global Fund rolling continuation application for Round 1 and the new Round 7 application, as well as the Global Fund 5 year evaluation. The findings and hypotheses should be used to develop an agenda for further data collection, as well as for research and evaluation going forward (as in Figure 13).

Figure 13: A visual representation of the triangulation process



Step 12. Outline next steps

This workshop was successful in utilizing triangulation methods to answer—if only partially—the key questions. Next steps (as mentioned above) should include identifying and collecting additional data to confirm or refute the hypotheses generated during this

workshop. At the same time, it will be important to utilize the evidence at hand to make programmatic and policy improvements, as recommended during the workshop. Specifically, it was recommended that a programmatic mapping be done to ensure that there is a plan in place to address the important questions and issues raised during the triangulation activity.

The triangulation taskforce will continue to meet after the workshop to plan future triangulation activities. Additional future triangulation topics were suggested during this workshop, including: 1) ARV drug resistance monitoring, with specific questions regarding lines of treatment and projections of ART resistance, and 2) Socio-economic status and HIV prevention and risk behaviors.