OVERVIEW OF TRIANGULATION METHODOLOGY:

Synthesis of multiple data sources for evaluation and decision-making in HIV epidemics based on initial experiences
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Throughout this overview we will use the shaded gray boxes to outline an example of triangulation in the fictional country of “Bundo”. These boxes will walk you through the twelve steps of triangulation and help to clarify key points using this hypothetical example as a case study.
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<tr>
<td>ACHAP</td>
<td>African Comprehensive HIV/AIDS Partnership</td>
</tr>
<tr>
<td>ART</td>
<td>Antiretroviral therapy</td>
</tr>
<tr>
<td>ANC</td>
<td>Antenatal Clinic</td>
</tr>
<tr>
<td>AZT</td>
<td>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.</td>
</tr>
<tr>
<td>BAIS</td>
<td>Botswana AIDS Impact Survey. BAIS-I was conducted in 2001 and BAIS-II was conducted in 2004.</td>
</tr>
<tr>
<td>BHP</td>
<td>Botswana–Harvard AIDS Institute Partnership</td>
</tr>
<tr>
<td>BOTUSA</td>
<td>A collaboration between the Government of Botswana and the United</td>
</tr>
<tr>
<td>BSS</td>
<td>Behavioral Surveillance Survey</td>
</tr>
<tr>
<td>CDC</td>
<td>United States Centers for Disease Control and Prevention</td>
</tr>
<tr>
<td>CDC-GAP</td>
<td>Centers for Disease Control and Prevention’s Global AIDS Program</td>
</tr>
<tr>
<td>CD4</td>
<td>CD4 is 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.</td>
</tr>
<tr>
<td>CSO</td>
<td>Central Statistics Office</td>
</tr>
<tr>
<td>DHS</td>
<td>Demographic and Health Survey</td>
</tr>
<tr>
<td>DHS+</td>
<td>Demographic and Health Survey that includes HIV prevalence data</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome</td>
</tr>
<tr>
<td>HMIS</td>
<td>Health Management and Information System</td>
</tr>
<tr>
<td>HSU</td>
<td>Health Statistics Unit</td>
</tr>
<tr>
<td>IGH</td>
<td>Institute for Global Health, a part of the University of California, San Francisco</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
</tr>
<tr>
<td>IPMS</td>
<td>Integrated patient management systems</td>
</tr>
<tr>
<td>MACRO</td>
<td>See ORC-MACRO</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>MCH</td>
<td>Maternal–Child Health</td>
</tr>
<tr>
<td>MLG</td>
<td>Ministry of Local Government</td>
</tr>
<tr>
<td>MOH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>MSF</td>
<td>Médecins Sans Frontières, also known as “Doctors without Borders”</td>
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<tr>
<td>NAC</td>
<td>National AIDS Commission</td>
</tr>
<tr>
<td>NACA</td>
<td>National AIDS Coordinating Agency</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
</tr>
<tr>
<td>ORC-MACRO</td>
<td>Opinion Research Company’s Macro International Inc.</td>
</tr>
<tr>
<td>PLWHA</td>
<td>Persons Living With HIV/AIDS</td>
</tr>
<tr>
<td>PMTCT</td>
<td>Preventing Mother to Child Transmission</td>
</tr>
<tr>
<td>PSI</td>
<td>Population Services International, a non-profit organization promoting social marketing of public health products, public health services and healthy behaviors</td>
</tr>
<tr>
<td>STI</td>
<td>Sexually Transmitted Infection</td>
</tr>
<tr>
<td>TB</td>
<td>Tubercle Bacillus, also known as Tuberculosis</td>
</tr>
<tr>
<td>UCSF</td>
<td>University of California, San Francisco</td>
</tr>
<tr>
<td>UCSF-IGH</td>
<td>See IGH</td>
</tr>
<tr>
<td>UNAIDS</td>
<td>The Joint United Nations Programme on HIV/AIDS</td>
</tr>
<tr>
<td>UNICEF</td>
<td>The United Nations Children’s Fund</td>
</tr>
<tr>
<td>VCT</td>
<td>Voluntary Counseling and Testing</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
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</table>
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 is 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 care is not taken by the analyst 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 will follow a hypothetical example of a triangulation exercise in a fictional country called ‘Bundo.’ Examples used are adapted from real-life situations in countries affected by HIV/AIDS and are interspersed throughout this overview. Exercises and discussion boxes help clarify key points of triangulation. Though the overview is organized in a step-by-step format, triangulation is actually an iterative process. In other words, the results from any given step will help to formulate or improve upon results from previous steps, and as new information arises, previous steps may need to be re-visited. 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 analysis. Since every triangulation analysis will be different, users should refer back to this overview to help them as they progress through the exercise. Additionally, first-time users should seek technical assistance from experts who have been trained in and have previously utilized this methodology.

One final note: local adaptation is a must. There are a variety of adaptations that should be made during the analysis to address your specific needs. Therefore, the overview serves only as a template, and it is up to the user to decide which parts are relevant and incorporate them as needed, because each individual analysis will depend on available resources and the process of combining them. In addition, although this overview only uses national-level examples, triangulation can also be applied at the regional or district level and to assess programmatic effects.

Included in the appendices are summaries from two triangulation exercises recently conducted in Botswana and Malawi. They are intended to provide the reader with a summary of how an exercise is conducted, and demonstrate some findings. As more and more triangulation exercises are completed, important lessons learned and other experiences will be incorporated as this overview is further refined.
Overview of triangulation

Learning Objectives

After reading the triangulation overview, the reader will 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’s\(^1\). 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.

Triangulation should be distinguished from “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 understanding of the triangulation process. The

\(^2\) http://www.who.int/inf-new/aids1.htm
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*:

   b. *Inductive reasoning*:
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.

<table>
<thead>
<tr>
<th>Box 1. Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Policy-makers and decision-makers (e.g. Ministry of Health officials)</td>
</tr>
<tr>
<td>• Program sponsors and donors (e.g. the Global Fund, World Health Organization)</td>
</tr>
<tr>
<td>• Program managers and staff (e.g. voluntary counseling and testing managers, hospital administrators)</td>
</tr>
<tr>
<td>• Community members and organizations (e.g. NGOs, community leaders)</td>
</tr>
<tr>
<td>• Research community (e.g. national and international university researchers)</td>
</tr>
<tr>
<td>• Clients/users of services</td>
</tr>
<tr>
<td>• Other countries, districts, and communities with similar research themes and objectives</td>
</tr>
</tbody>
</table>

List potential stakeholders in your area:
It is often useful to define a ‘taskforce’ with 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 utilize 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 communications 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.
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.

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.

<table>
<thead>
<tr>
<th>Box 2: Comparison of conventional and triangulation analysis</th>
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<tbody>
<tr>
<td><strong>Conventional Analysis</strong></td>
</tr>
<tr>
<td>• Focus on statistical analysis</td>
</tr>
<tr>
<td>• Designed to provide generalizable data</td>
</tr>
<tr>
<td>• Variables from a single data set</td>
</tr>
<tr>
<td>• Focus on internal validity:</td>
</tr>
<tr>
<td>“Did A cause B to change among</td>
</tr>
<tr>
<td>group C?”</td>
</tr>
<tr>
<td>• Emphasis on generating the highest</td>
</tr>
<tr>
<td>scientific rigor of data for</td>
</tr>
<tr>
<td>interpretation</td>
</tr>
<tr>
<td>• Long delay between data</td>
</tr>
<tr>
<td>collection and presentation of results</td>
</tr>
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<td></td>
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</table>
### 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.
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. 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.

The Ministry of Health in Bundo opted to use triangulation to make better use of the data collected over the past 10 years. In addition, they had several research questions in mind. This triangulation exercise was to be conducted with technical assistance from international NGOs and universities that had previous experience with the process. With trends in HIV prevalence, changes in prevention efforts, and antiretroviral therapy (ART) rollout, there was a plethora of triangulation exercise topics available.
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:

<table>
<thead>
<tr>
<th>Box 4: A 12-Step Approach to Triangulation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Which part of the process?</strong></td>
</tr>
</tbody>
</table>
| 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 through 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 socio-economic 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?
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**

The Ministry of Health (MOH) called a meeting with representatives from the following organizations: National AIDS coordinating body, UNICEF, UNAIDS, WHO, Kilyville Mining Company, MSF, and the University of Bundo. The group brainstormed about 30 questions of interest and data sources that would support each question over a two-day workshop. Ultimately, some questions were combined; some were clarified, while others were prioritized, until the group arrived at a narrower list, with two specific areas of interest to pursue. At the end of the workshop, questions could be classified into two main categories: determining trends in HIV prevalence and behavior, and measuring impact of the rollout of ART.
Triangulation Overview

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**

![Diagram showing the process of identifying and finalizing key questions with criteria for selection including important, current, actionable, data available, method appropriate, and feasible.]
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.

<table>
<thead>
<tr>
<th>Question</th>
<th>Triangulation or Other Method?</th>
<th>Why?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does a two-session intervention reduce unprotected intercourse between young men and women in high school settings?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have increased prevention activities in a country with a concentrated epidemic resulted in a reduction of new HIV infections among injection drug users?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the HIV epidemic slowing in Bundo?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the length of time breastfeeding babies by HIV-infected mothers increase or decrease infant mortality?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are HIV-infected patients satisfied with the level of care and treatment they are receiving at a hospital?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bundo Step 2: Ensure that the question is important, actionable, answerable, and appropriate for triangulation

After further discussion, the group of stakeholders determined that the two question topics—trends in prevalence and behavior, and impact of ART rollout—were equally feasible, appropriate, and important. However, measuring impact seemed to have greater actionability than investigating prevalence. The results from an 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 pilot sites currently in Saziville, Kilyville, and Cisco.

Key Question: What is the impact of ART on mortality, morbidity, and economics?

REGIONAL DESCRIPTIONS:

CISCO (Central Urban)
- Cisco is the capital city 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 and most residents are devout Christians. Church values are strong, with key beliefs being 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.

SAZIVILLE (Southern Urban)
- Saziville is located in the southern region. Historically, it has 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 men on border patrol in Bundo.
- Bundon border patrol guards and tobacco plantation laborers are men away from their families with disposable incomes. Due to these factors, Saziville has a large commercial sex industry.
- Due to the influx of refugees has led to increased crime and scarcity of water and food resources.
- Due to the high HIV prevalence in Saziville, Medicine Sans Frontieres (MSF) and the Ministry of Health have worked collaboratively to roll out ARTs to HIV-infected patients since 2003.

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 and a newly constructed airport, Kilyville receives international traffic from potential buyers of sapphires.
- Due to extreme loss in the workforce from AIDS, three months ago 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.
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.

<table>
<thead>
<tr>
<th>Sources</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>institutional (NGO / University) studies; behavioral surveillance surveys (BSS); demographic and health surveys (DHS)</td>
</tr>
<tr>
<td>Surveillance</td>
<td>sentinel sites; ANCs</td>
</tr>
<tr>
<td>Programmatic</td>
<td>ART registries; VCT, hospital / clinic records; STI treatment; condom distribution; Institutional (NGO / University) programs; other prevention and treatment activities</td>
</tr>
<tr>
<td>Census</td>
<td>national census</td>
</tr>
</tbody>
</table>
**Qualitative and Quantitative Data:**

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

*Qualitative data* includes 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:

<table>
<thead>
<tr>
<th>Comparison of different methods*</th>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use observation and words as data</td>
<td>Use numerical data</td>
<td></td>
</tr>
<tr>
<td>Have a goal of exploration and discovery</td>
<td>Have a goal of verification or proof</td>
<td></td>
</tr>
<tr>
<td>Ask &quot;how&quot; and &quot;why&quot;?</td>
<td>Ask &quot;how many&quot;?</td>
<td></td>
</tr>
<tr>
<td>Use data collected through interviews and observation</td>
<td>Use data collected through surveys</td>
<td></td>
</tr>
<tr>
<td>Are case-oriented</td>
<td>Are population oriented</td>
<td></td>
</tr>
<tr>
<td>Do not have generalizability as a goal</td>
<td>Have generalizability is a goal</td>
<td></td>
</tr>
<tr>
<td>Use sampling that is purposive, convenience, snowball, or quota</td>
<td>Use probability sampling</td>
<td></td>
</tr>
<tr>
<td>Use small sample size</td>
<td>Use large sample size</td>
<td></td>
</tr>
</tbody>
</table>


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:

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

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Key Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Access</td>
<td>Can permission be obtained to use data? What format are the data in (line listed or aggregate)?</td>
</tr>
<tr>
<td>2. Description of the data</td>
<td>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?</td>
</tr>
<tr>
<td>3. Quality</td>
<td>What is the quality of the data? Are there any gaps in data? How complete are the responses to the questions?</td>
</tr>
<tr>
<td>4. Ethics [defined below]</td>
<td>Have data used in the triangulation been obtained according to ethical standards? Was the study protocol approved by an institutional review board (IRB)?</td>
</tr>
</tbody>
</table>
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 Overview

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 health care 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:

- These mortality data were collected from the Saziville Hospital. What do you see as potential issues with completeness of reporting in this data source? Brainstorm on 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 in Bundo conducted two focus groups with hospital nurses about the impact of ART among HIV-infected patients. Upon listening to the tape recordings, little about ART use was 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 was selected, a taskforce was created to guide and see the analysis through to fruition. Participation on the taskforce was voluntary. Recruiting both influential members with access to the data sources identified 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 of the taskforce 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 (institutional review board approvals), biases, limitations, study population, time frame, methodology, and inclusion/exclusion criteria.

The taskforce identified the following primary data sources for each area of interest.

**Cisco:**
- Cisco Central Hospital, Health Management Information Systems (HMIS)
- ART rollout Jan 04, #cumulative on treatment

**Saziville:**
- Saziville Regional Hospital, HMIS
- ART rollout July 03, #cumulative on treatment

**Kilyville:**
- Kilyville, MSF programmatic data
- ART rollout July 04, # cumulative on treatment
### Exercise 3.

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

1.
2.
3.
4.
5.
Triangulation Overview

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 stakeholder 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 triangulation analysts reviewed data as they became available, the taskforce refined the research question to focus on the three cities that had received ART rollout: Saziville, Cisco, and Kilyville. Additionally, the definition of ‘impact’ was more narrowly defined as the effect on overall mortality, though previously it had included morbidity and economics. The population of interest was defined as the overall adult population, which includes more than just those adults on ART.

The analysts also sought to look at mortality by urban/rural, sex, age, socio-economic status, and occupation. As they became more familiar with the data and saw which data they could actually access, the research question evolved over time. This created a cyclical process between steps 2, 3 and 4.

*Revised key question: What is the impact of ART on overall adult mortality in Saziville, Cisco, and Kilyville?*
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, different members attempted to gather data reports that were accessible to them and might be related to the research question. At this stage, the process was exhaustive, in terms of collecting every available and applicable resource. However, since resources were limited, the taskforce focused on first gathering the data sources that were believed to be instrumental in the analysis: mortality and ART rollout data.

The National AIDS Commission provided an anonymized dataset with information on ART patients, including when they began therapy and their current health status. The Ministry of Health was able to provide ANC data. National DHS survey data were also obtained through the MEASURE website. 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.

Ultimately, an inventory of all identified datasets identified was compiled by the taskforce for use in the triangulation. This inventory included descriptions of all the datasets, IRB information, data format, where it was obtained, and primary data source contract information.
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 infant 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 in Bundo, 2006](image)

For data that have been collected at different points in time (such as HIV infections among national 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 of the data and may allow observations that are more meaningful. The next figure shows infant mortality by age group over time. It is important that the data are collected from the same population and measures the same thing. For example, if testing practices for ANC attendees change over time, data may not be comparable.
When time is added, it is even clearer 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 the dimension of time allows inferences of trends in infant mortality over time.

Finally, adding a third dimension—place—further refines interpretation of the data. In the next figure (6), mortality is further stratified by place.
Figure 6: Mortality by Location, Bundo, 1990-2006

**Cisco**

- Infant Mortality Rate, Cisco
- Child Mortality Rate, Cisco
- Adult Mortality Rate, Cisco

**Kilyville**

- Infant Mortality Rate, Kilyville
- Child Mortality Rate, Kilyville
- Adult Mortality Rate, Kilyville

**Saziville**

- Infant Mortality Rate, Saziville
- Child Mortality Rate, Saziville
- Adult Mortality Rate, Saziville
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. An example of a spreadsheet for making these kinds of observations can be found in Appendix A.

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

Based on the data from Cisco (see Appendix A) it was discovered that mortality rates in adults at Cisco Hospital, which had been rising since the early 1990’s, began to decline in 2005. Mortality rose in DHS from 2000 to 2005. ART started in 2004 and the number of people treated increased each year thereafter.
Bundo Step 6: Make observations from each data set (continued)

In Saziville, mortality had risen since the early 1990s until it began to decline in 2004. The mortality rate in DHS was also lower in 2005 than in 2000. The number of ART patients went up between 2003 and 2006.
In Kilyville, non-accidental mortality at the mining company rose from 2000 to 2004 and declined each year thereafter. The DHS mortality rate rose from 2000 to 2005. ART rollout began in 2004 and the number of people treated increased each year thereafter.
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. 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” really 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, one might look at program data from the ART clinic affiliated with the hospital and note that the number of patients on ART is increasing. These are empirical observations. We might interpret our observations to mean that increasing ART coverage is leading to a decrease in HIV/AIDS morbidity (and corresponding hospital stays). Next, we may obtain a report from 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 ART at all.

This step 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 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?

**HIV Prevalence Among Women at ANC Sites, CISCO 1997-2005**

**Percent of ANC Women who Received Post-test Counseling (Among Those who Received Pre-Test Counseling), CISCO, 1997-2006**

**Number of ANC Women on ART, CISCO 2004-2006**

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.

<table>
<thead>
<tr>
<th>Box 9: Bradford Hill Criteria of Causality in Observational Studies Relevant to Triangulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Causality</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>2. <strong>Strength of Association</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>3. <strong>Consistency</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>4. <strong>Plausibility</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>5. <strong>Consideration of Alternate Explanations</strong></td>
</tr>
<tr>
<td>It is important to consider alternate explanations, and they must be ruled out before the hypothesis can be confirmed.</td>
</tr>
</tbody>
</table>

*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 Bundo to mortality data from neighboring Fianga.

![Crude Mortality Rates, Bundo and the neighboring nation of Fianga 1990-2006](image)

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

Qualitative data:
- Focus groups conducted among married women in Bundo indicated that most women felt confident asking their partners to use condoms. Yet a similar study in Fianga 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

In Cisco, Kilyville, and Saziville, the rollout of ART and increase in the number of people receiving ART coincides with the onset of a decline in mortality rates, which had been increasing until ART rollout began.
Bundo Step 7: Note trends across datasets and hypothesize
(continued)

![Graph showing mortality rates and ART uptake in KILYVILLE](chart.png)
Moreover, comparison of different data points within the same dataset showed a potential change in AIDS mortality. The percentage of people who knew someone who had AIDS increased between 2001 and 2005 in the DHS in each site, 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 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?
Hypothesis 1: Increased VCT among ANC attendees should result in increased PMTCT and decreased infant mortality.

Data observations 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**

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 in that time period that could plausibly explain the change in mortality rates.

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

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.

<table>
<thead>
<tr>
<th>Exercise 4.3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New Data:</strong></td>
</tr>
<tr>
<td>Informal interviews with nursing staff at ANC sites indicate that ANC attendees have been weaning their infants early and giving them formula.</td>
</tr>
<tr>
<td><strong>Hypothesis 2:</strong></td>
</tr>
</tbody>
</table>

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 our analysis greatly depends on the accuracy of the mortality data, the taskforce has decided it would be beneficial to validate the mortality data. After some investigation, it was determined that a midnight census was being collected independently at the Saziville hospital. This internal hospital estimate could be used to validate the institutional mortality data collected by MOH.

Moreover, mortality rates in other selected sites that did not have ART rollout continued to rise. 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. Members of the community also provided qualitative data, in terms of summarizing trends in causes of death. The village elders indicated that fewer adults in the 25 to 50-year-old age group were dying of diseases, whereas the number of deaths due to causes such as accidents and violence had remained stable.
Triangulation Overview

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**

<table>
<thead>
<tr>
<th>Important trends noted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example—‘PMTCT among ANC attendees is increasing.’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Your conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example—‘The decline in infant mortality is being driven by PMTCT.’</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Express limitations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example—‘This analysis was limited by the lack of data on cause-specific mortality data’</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discuss which data could be useful in the future:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example—a new system of village-level death registries should include priority causes of mortality.</td>
</tr>
</tbody>
</table>
**Bundo Step 10: Summarize findings and draw conclusions**

Faced with the key question ‘What is the impact of ART on mortality, morbidity, and economics?’ the taskforce concluded the triangulation exercise by planning a workshop and inviting policymakers, analysts, and program managers involved in ART delivery.

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.
  - DHS mortality rates increased from 2000 to 2005.
  - ART started in 2004 and the number of people treated increased each year thereafter.

- **In Saziville:**
  - Mortality rates had risen since the early 1990s, but began to decline in 2004.
  - DHS mortality rates were also lower in 2005 than in 2000.
  - The number of ART patients went up between 2003 and 2006.

- **In Kilyville:**
  - Non-accidental mortality at the mining company rose from 2000 to 2004 and declined each year thereafter.
  - DHS mortality rates increased from 2000 to 2005.
  - ART rollout began in 2004 and the number of people treated increased each year thereafter.

Based on the observations listed above, the following hypothesis was formed: In Cisco, Kilyville, and Saziville, the rollout of ART and the increase in the number of people receiving ART coincides with the onset of a decline in mortality, which had been increasing until ART rollout began. Since our analysis greatly depended on the accuracy of the mortality data, the taskforce validated the mortality data. The midnight census collected at the Saziville hospital validated the institutional mortality data collected by MOH. Based on this, the workshop participants interpreted the data and concluded that the decline in mortality among adults in the three sites is real and associated with the rollout of ART. However, more research needs to be done on whether the rollout of ART has affected all populations equally (e.g., stratifications by gender, income, or education). Future analysis should examine whether ART rollout has improved mortality rates among children, since the survival of parents should improve the survival of their children. Also, we are unsure if the improvement in mortality is only due to survival among AIDS patients, because the survival of income-earners with AIDS could create other benefits.
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 your key question in the format of the hypothesis you generated prior to analyzing across data sources.
   ii. Briefly state why your hypothesis is viable.
   iii. Briefly state what data supports this hypothesis.
   iv. After stating your hypothesis, affirm whether it was proved or disproved based on the triangulation analysis, and 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 other 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.
Triangulation Overview

Box 15. Example of an observation matrix

Observations on HIV indicators North

<table>
<thead>
<tr>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV Prevalence decreasing</td>
<td>HIV prevalence level/up (lowest</td>
</tr>
<tr>
<td>(syphilis level down)</td>
<td>DHS prevalence; syphilis up/level:</td>
</tr>
<tr>
<td>Generally, risk behavior indicators</td>
<td>Risk behavior indicators worst/</td>
</tr>
<tr>
<td>improving abstinence, multiple</td>
<td>worsening abstinence men, NCP men, CSW</td>
</tr>
<tr>
<td>partners</td>
<td>men, condom NCP men, CSW men,</td>
</tr>
<tr>
<td>Testing going up and high in men and women</td>
<td>worsening female testing</td>
</tr>
<tr>
<td>Some knowledge/attitudes poor</td>
<td>Lowest knowledge</td>
</tr>
<tr>
<td>(esp. speaking to spouse about AIDS)</td>
<td></td>
</tr>
<tr>
<td>Program intensity and quality high</td>
<td></td>
</tr>
</tbody>
</table>

Hypothesis: Rising HIV prevalence in the rural area is driven by power imbalances between men and women.
- Polygamy, inter-spousal 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 programmes.
  - Integrate such programs with HIV prevention education, reproductive health, social support, and empowerment.

Bundo Step 11: Communicate results and recommendations

The workshop participants developed a presentation that was shown to major policymakers in Bundo on the last day of the workshop. The presenters, who were volunteers representing NGOs, ART programs, and the Ministry of Health, recommended that the ART program be expanded to at least three more sites in the next year, and that the number of people on ART be doubled in the next year. In addition to the recommendations on research into knowledge gaps shown in step 10, the presenters requested that another triangulation exercise be started immediately that would look at the impact of PMTCT on infant and child mortality.

Following the workshop, key stakeholders and the analyst from the Ministry of Health wrote a report for the stakeholders. Additionally, the results were published 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 sub-national 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 not available in Bundo at the moment, a next step might be to initiate research on this subject. In addition, if additional data exist, it could be beneficial to include them in the analysis and reinstate the iterative process to further confirm support or refute previous findings.
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 to rapidly provide information for program planning and policymaking.

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

1. Data from Bundo: Example observations form multiple data sources
2. Exercise and Discussion Answers
3. Case report: Botswana
4. Case report: Malawi
### Appendix A: Data from Bundo

#### Table 1: Cisco

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cisco Population</td>
<td>100,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>400,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant Mortality Rate, Cisco</td>
<td>10.5</td>
<td>11.1</td>
<td>10.5</td>
<td>9.9</td>
<td>10.1</td>
<td>10.5</td>
<td>12.2</td>
<td>12.9</td>
<td>13.5</td>
<td>15.5</td>
<td>15.9</td>
<td>16.9</td>
<td>20.3</td>
<td>20.5</td>
<td>20.9</td>
<td>18.5</td>
<td>16.9</td>
</tr>
<tr>
<td>Child Mortality Rate, Cisco</td>
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### Triangulation Overview

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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:**
- Post-test counselling 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. Based upon the application of triangulation in Botswana, 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.
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,
Triangulation Overview

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 an ongoing large 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.
Triangulation Overview

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, based on the agreement among stakeholders and researchers, that 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.
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**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.
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.
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.
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/Palapye, where ART uptake appears
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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 principle 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 has 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.
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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 centre providing care and treatment services to HIV/AIDS patients in Malawi); Baylor University; MACRO, a voluntary counselling 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:

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

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
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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 is 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
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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 was 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
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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.
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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 was 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
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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.

![Median rural ANC HIV prevalence](image)

**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 the hypotheses on prevalence and risk behaviors, and recommendations, for each of the 6 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 have the time to gather and analyze data) and capacity-building was 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.