

Estimating the Size of Populations Most at Risk to HIV Infection

Participant Manual

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We welcome your comments on this version of the participant manual.

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Foreword

Measuring the effects and scale of the human immunodeficiency virus (HIV) epidemic presents many challenges. Without accuracy, it is impossible for countries to carry on essential HIV programme activities, such as:

- Conducting HIV surveillance
- Advocating for most-at-risk populations
- Planning and implementing HIV prevention, care, and treatment programmes
- Evaluating programmes.

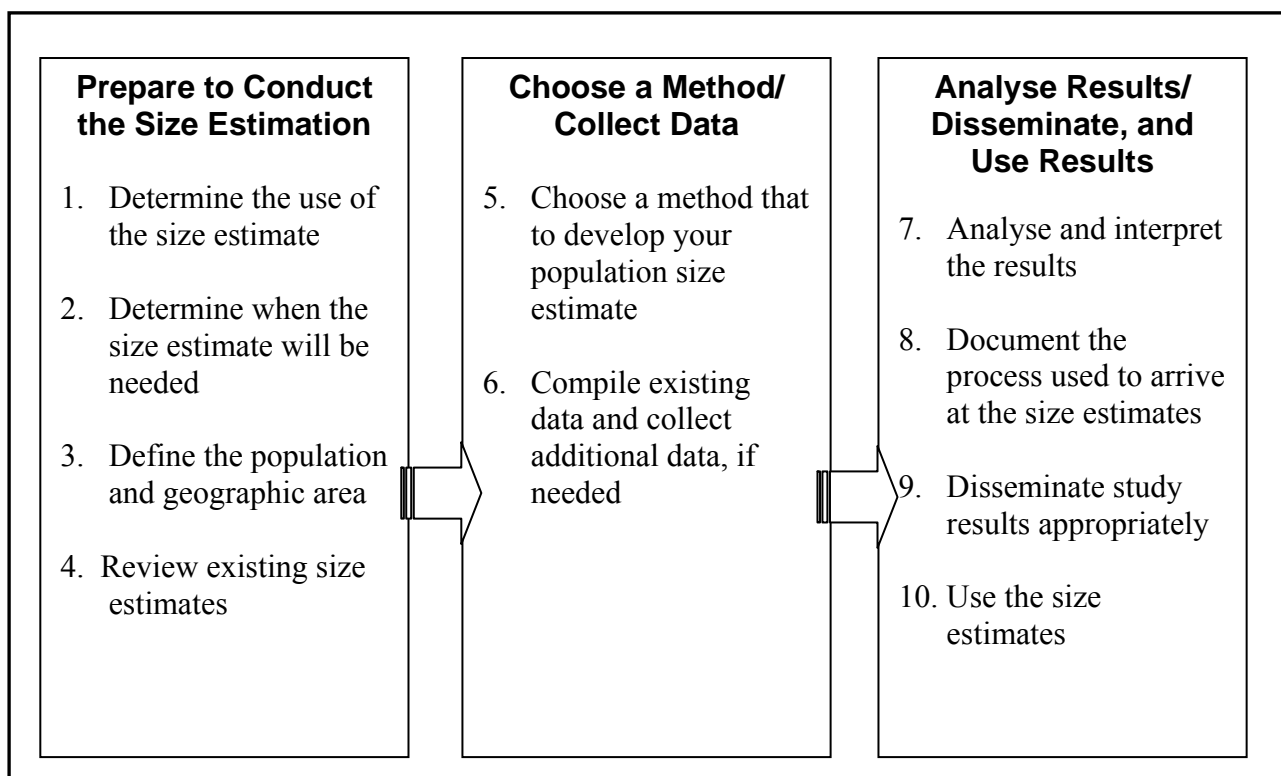
Most countries have developed surveillance systems for tracking HIV infection and the behaviours that spread HIV but may lack the capacity to estimate the size of the populations involved. Therefore, a guideline entitled Estimating the Size of Populations at Risk for HIV was developed in 2003¹ by Family Health International (FHI), the Impact Project, the United States Agency for International Development (USAID), the Joint United Nations Programme on HIV/AIDS (UNAIDS), the World Health Organisation (WHO) and the UN Drug Control Programme.

This participant manual is based upon updated guidelines entitled Guidelines on Estimating the Size of Populations Most at Risk to HIV, developed in 2010 by the UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance. It contains recently developed methods and information on how to create local and national estimates. Use this participant manual in training courses with PowerPoint presentations to learn how to estimate population size and measure the HIV epidemic in your country. How to measure risk behaviours is not addressed here.

This document is organized into 10 steps (**Figure i-1**) covering the following three general areas:

- How to prepare for conducting size estimates
- How to choose a method and collect data
- How to analyse, disseminate, and use results.

Figure i-1. Steps for estimating the size of hidden populations



Please see **Annex 1: Data Needs for a Regional Size Estimation Workshop**.

This document is one of a set that can provide information on how to do surveillance for high-risk groups. Guidelines on the Size Estimates of High Risk Populations, Evaluation of Second Generation Surveillance Systems, and Conducting HIV Surveillance can be found on the UNAIDS website at: www.unaids.org/epidemiology/.

NOTES

Unit A: Introduction to Size Estimation

Overview

What this unit is about

This unit describes reasons for estimating the size of populations most at risk for HIV and AIDS.

Warm-up questions

1. Which of the following is **not** a reason why programme managers need to know the size of a priority population?
 - a. They need to know the seriousness of the epidemic.
 - b. They need to know where prevention efforts are needed.
 - c. They need to be able to identify members of the population.
 - d. They need to know what resources are needed to create good prevention programmes.

2. List three users or consumer groups that use population size estimates. Do they have the same needs?

3. List three reasons why a country would want to estimate the size of a high-risk population.

4. True or False? Focusing studies on most-at-risk populations can lead to increased stigma and discrimination.

True

False

5. Put the following steps in order from one to 10:

Steps to implement population size estimates	
	Compile all existing data and collect additional data
	Analyse and interpret the results
	Document the process
	Determine the use of the size estimate
	Decide on the method
	Determine when the size estimate will be needed
	Use the size estimates
	Disseminate the results
	Review existing size estimates
	Define the population and geographic area

Introduction

What you will learn

By the end of this unit, you should be able to:

- Describe what you need to estimate population size
- Recognize the different users of population size estimates
- Identify and prioritize populations at high risk
- Describe cautions to take when using your estimates.

Why estimate population size?

For current challenges in HIV prevention, and to help with decision making, programme managers must know the size of the response that is needed. To know that, they must know the number of people affected and understand the following:

- The seriousness of the epidemic
- Where prevention efforts are needed
- What resources are needed
- What progress has been made toward prevention.

Definitions

Populations at increased risk for HIV infection or *most-at-risk* populations also can be called *hidden* or *hard-to-reach*. They consist of people whose high-risk behaviours may be illegal or have attached *stigma*. These people can become reluctant to participate in activities that may identify them, such as:

- HIV *surveillance* activities
- HIV prevention, care, and treatment activities and programmes.

Populations at increased risk

The UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance know that intensive surveillance is needed in populations at increased risk and has identified hidden populations that are especially important for HIV surveillance (see **Annex 2: Glossary of Terms**).

- Male and female sex workers
- Clients of sex workers, including migrant workers and military personnel
- People who inject drugs
- Men who have sex with men, including prisoners.

Users of population size estimates

Different users or consumers of population size estimates will use different parts of the estimate:

User or consumer group	Task	Limitation
Analysts or technical experts	Make the estimates and are involved with data quality and methods of estimation	May not always keep in mind the larger meaning of these estimates
Policy makers or decision makers	Need the estimates to distribute funds or justify how they distributed funding	May not have time for in-depth discussion of data quality or methods when interpreting an estimate
Members of the community	Use the programmes or deliver them. Need the estimates to make programme decisions and evaluate their work	

Need for estimating the size of groups

Many countries develop HIV surveillance systems but some lack the capacity to estimate the size of most-at-risk populations. Size estimations are important for:

- Advocacy,
- Planning and implementing prevention, care, and treatment programmes
- Evaluating the programmes.

Size estimation for advocacy

To convince policy makers and funders of the extent of a public health problem and to begin prevention, care, and treatment programmes, you must have a good estimate based on sound methods that can be replicated. It is easier for potential funders to neglect the at-risk population if:

- Data are not available,
- The basis of the estimates is not clear, and
- Inconsistencies between estimates are not explained.

Advocacy also is important at different levels of government. When epidemics are diverse and vary from region to region in a country, local governments may want to use local data instead of national data to influence public health action in their region and to develop interventions that are appropriate for their area.

Size estimation for planning and implementing HIV programmes

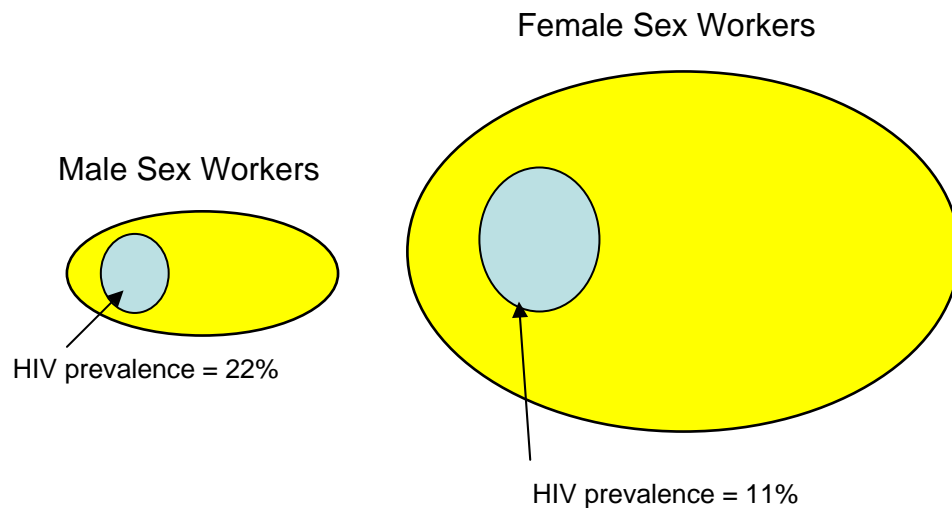
Planning and implementing programmes are more difficult with populations at increased risk to HIV as compared to interventions for the general public. Governments may find it difficult for political reasons to invest in services for people who inject drugs, men who have sex with men, and sex workers and their clients because of the stigma toward these groups. Yet serving these groups has the greatest potential for curbing the *epidemic* in some countries.

Estimates of population size are needed to help with decisions on how resources should be allocated. Please see the example in the box below:

Data on HIV prevalence shows that infection is 22 percent among male sex workers in your area, but only 11 percent among female sex workers. It may seem that twice as much funding should be given to prevention programmes for male sex workers.

You then learn that your area has 5,000 male sex workers and 50,000 female sex workers, then we can estimate that the areas has 1,100 male and 5,500 female sex workers infected. If both groups have about the same number of clients, you decide that more resources for prevention should be dedicated to female sex workers and their male clients (**Figure A-1**).

Figure A-1. Population size and risk behavior.



Preventing new HIV infections means providing services to most-at-risk populations. Adequate services cannot be planned without knowing how many people are at risk. You might have questions like these:

- How many screening kits for *sexually transmitted infection* are needed to conduct regular screening for all sex workers in a community?
- How many clean needles are needed for a needle exchange programme for the country's drug users?
- How many outreach workers are needed to contact, at least once a month, 50 percent of men who have sex with men?

Size estimation for evaluating HIV programmes

Recently, resources for HIV prevention and risk reduction have shifted away from pilot programmes toward larger-scale prevention programmes. International donors expect progress that can be measured. Countries able to document progress are more likely to be funded. Documenting progress will include accurately estimating the size of clearly defined populations to correctly measure HIV prevalence.

At the local level, data should exist to evaluate progress and adjust prevention interventions. At the local or national level, accurate estimates of population size are important for calculating the *denominator* of most coverage statistics. Such data help to evaluate the progress and impact of programmes and to forecast trends.

A word of caution when you use population size estimates

Healthcare researchers assume that estimates will be used for a better public health response; but some populations share behaviours that are illegal or carry stigma. Size estimates of the at-risk populations (for example, people who inject drugs) may lead to:

- Unwanted or inaccurate reporting in the media
- A punitive response by law enforcement, and
- Increased stigma and discrimination.

Take care with how the size estimates and the data collected will be disseminated and whether they will be used constructively.

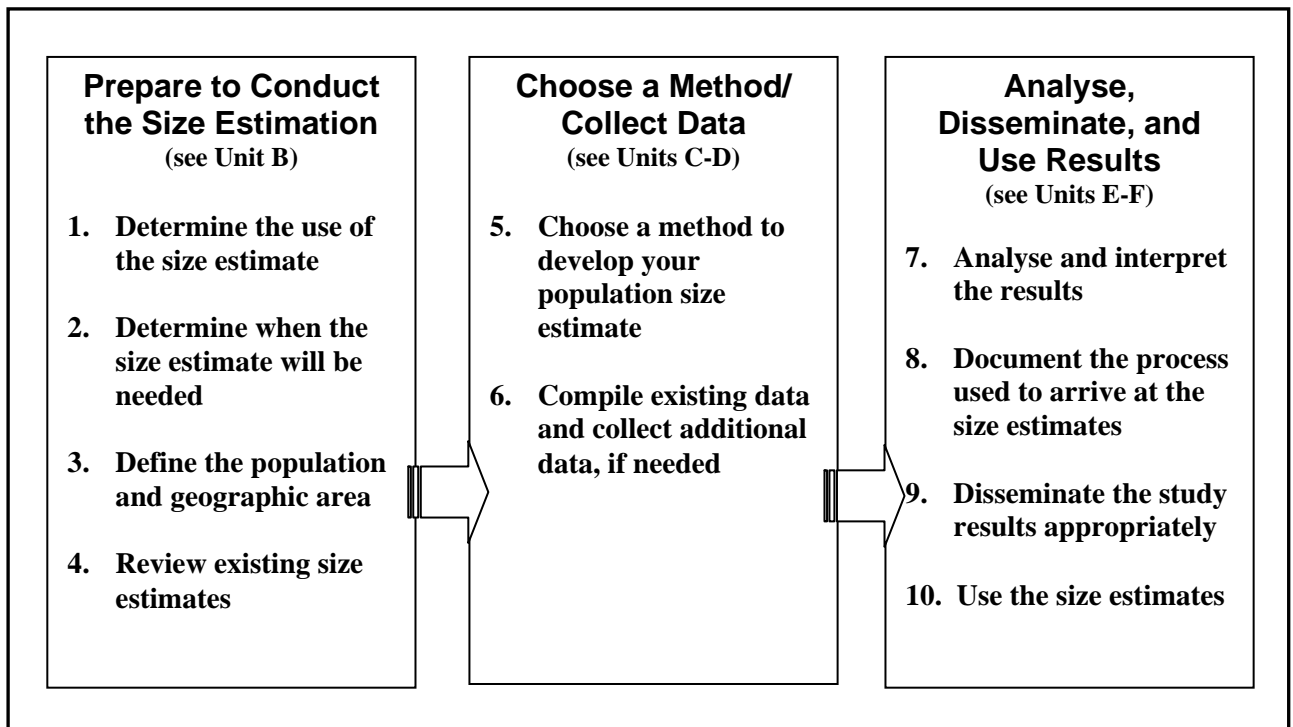
Many methods that provide good estimates of population size use mathematical calculations. No identification is made of at-risk individuals or populations. There is a difference between creating an estimate of the total number of people at risk and reaching those people with effective prevention or other services. This difference is often misunderstood by policy makers.

Good estimates are not sufficient for monitoring the HIV epidemic. These data must be combined with other forms of surveillance data from most at risk populations. Similarly, size estimation should not be considered an intervention.

Steps to implementing population size estimates

Figure A-2 below shows a general process for estimating the size of most-at-risk populations. The 10 steps are shown in three general areas: prepare, choose a method/collect data, analyse/disseminate and use results.

Figure A-2. Process for estimating the size of most-at-risk populations.



Valid and reliable estimates of population size are necessary for advocacy, prioritizing populations, planning, and evaluation. Adequate services cannot be planned without knowing how many people are affected. Remember that different users of population size estimates may have different priorities.

Take care with the dissemination and use of size estimates and the data collected so it helps, not hurts, the at-risk populations that are affected. Do not waste resources repeating size estimation exercises if there is no commitment to provide services based on the results.

Unit A Exercises

Warm-up review

Take a few minutes now to look back at your answers to the warm-up questions at the beginning of the unit. Make any changes you want to make.

Small group discussion

1. What groups are most at risk for HIV/AIDS in your area? Have you prioritized these populations? How did you determine these priorities?
2. What might be the factors contributing to the high rate of HIV in these groups? What measures are important to include in size estimation data?
3. Have estimates been made of the sizes of these populations? If so, how were these estimates made and used?
4. What size estimation tasks have been undertaken in your country or region?

Apply what you've learned/Case study

You are interested in estimating the size of the female sex worker population in District X. You locate a report from a nongovernmental organization applying for a grant for HIV prevention. The report contains the following statements:

- Experts estimate the number of sex workers in District X to be about 1.4 million.
- There are more than 100 brothels in District X and 15 of them are described in detail in the report.
- The average number of women working in these brothels is 117.
- Twenty percent of clients come from neighboring District Y.
- Twice as many sex workers work outside the brothels as in them.
- Only about 10% of brothel-based sex workers in District X receive regular screening and treatment for HIV.
- Rates of condom use are low among sex workers.

Discuss the utility of these estimates? Are you in favor of making a new estimate? Why or why not?

NOTES

Unit B: Prepare to Conduct Population Size Estimates, Steps 1-4

Overview

What this unit is about

This unit describes the first four steps you will do to estimate population size. You will learn about determining the purpose of the estimate, defining a population and geographic area, determining when to conduct the activity, and reviewing existing data and size estimates.

Warm-up questions

1. True or false? Most data used for size estimation have consistent definitions of key populations.

True	False
------	-------
2. List three types of institutions that would help you access most-at-risk populations.
3. Why is timing so important to consider when you plan to do your size estimation?
 - a. Your estimation should coincide with a costing exercise, such as a national strategic planning process.
 - b. Depending on the type of size estimation you do, you should consider the implementation schedules of larger household surveys.
 - c. Your estimation should assist with the larger HIV monitoring and evaluation activities.
 - d. All of the above.
4. List three factors that can affect the prevalence of risk behaviours and, therefore, the size of the population at risk.
5. For certain key populations, can data outside the health sector be useful for estimating population size? Give an example and discuss the appropriateness of using this data.

6. List three potential harms to participants in estimating population size for persons at risk for HIV infection.
7. List at least three ways data on HIV risk behaviors can be protected from disclosure.
8. What is a very useful tool commonly used in the preparation or formative work for size estimation activities?
 - a. Interviewer training
 - b. Mapping
 - c. Providing free treatment
 - d. Creating pamphlets describing the activity

Introduction

What you will learn

By the end of this unit, you should be able to:

- Understand the importance of population definitions
- Identify potential harms and benefits from estimating population size
- Be able to describe ways of accessing priority populations
- Evaluate how estimates compare over time.
- Describe tasks involved in collecting background information, prioritizing information needs, and determining which populations need size estimates
- Discuss the ethical principles involved in estimating population size

Step 1: Determine the use of the size estimate

How you plan to use the estimate influences the method you will choose in step 5. You would choose different methods if, for example:

- You want to estimate how many people inject drugs in a single city so that programmes can provide drug treatment for all.
- You want to estimate national HIV infection or the size of *populations* at risk.

We will learn more about those methods in **Units C and D**. For now, remember that population size estimates are meant to measure the problem, not solve it. That is, you are trying to accurately count and estimate population size, not provide access to it for programmes and services.

Step 2: Determine when the size estimate will be needed

Estimate timing

To decide when to conduct your estimation, find when a size estimate will be needed in the coming years. There can be different purposes or uses for population size estimates, so it may be needed more than once. As an example:

- Consider when national strategic planning or any national or regional costing will be done. Population size estimates provide critical information during these planning periods.
- Do size estimates routinely to provide data to programme and *surveillance* efforts.

Estimating timing, contd.

- Find out about planned HIV monitoring and evaluation activities so that you can coordinate your plans.
- Determine household survey schedules.

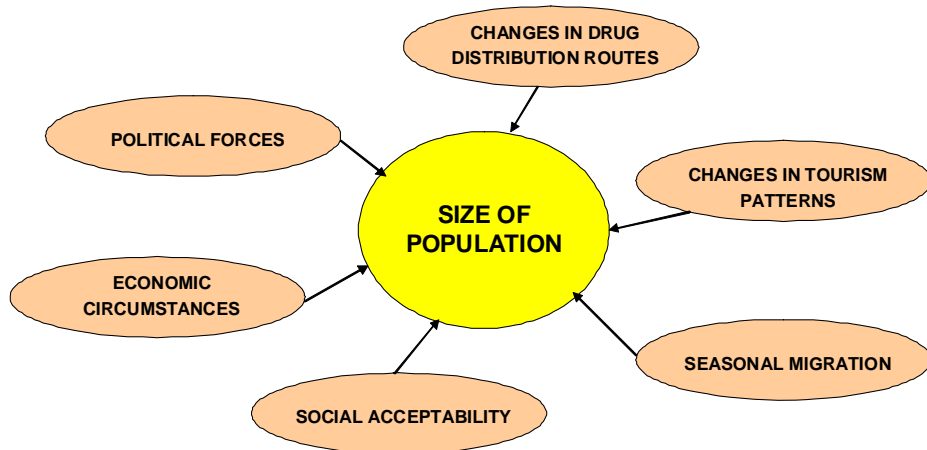


Try to do a new estimation every two years because the population size will change over time.

Changes over time

Risk behaviours change over time for many reasons, as shown in the figure below. These changes will affect the prevalence of risk behaviours and the size of the population.

Figure B-2. Factors that can affect the size of an at-risk population



Some examples of how the population size could change are:

- A local election may lead to increased attention on sex workers. The sex workers may go to other cities or stop selling sex temporarily to avoid possible harm.
- An outreach programme targeting drug injectors may reduce risk behaviours. This would change the number of persons considered to be injecting drug users.
- The introduction of fees at a clinic may lower attendance.

Changes over time, contd.

Methods that rely on a stable population or institutional records may be influenced by these events.

Document and consider any changes likely to affect estimates over time.



Step 3: Define the population and geographic area

Define the population

Often, the most difficult problem in population size estimation is defining the population. For HIV, the general concern is finding the people whose behaviour puts them at increased risk of infection.

Not all members of a population are at the same level of risk. As an example, the drug injecting population may include healthcare workers who have access to sterile equipment and a strong motivation to conceal their drug use. This population has little risk of HIV infection. You probably would not capture this group in your population size estimate of persons who inject drugs.

Think about how to capture your population of interest entirely. As one example, males may acquire drugs for their female partners. To find this hidden population you must ask male injectors whether they procure drugs for a partner.

The same definition should be used consistently throughout the size estimation exercise. The population definition should reflect the population which is of interest and should be directly related to the behaviour that results in the transmission of HIV; for example:

- “men who have had anal sex with other men in the past six months” would be a more accurate definition than “prisoners”
- “sex workers who have received cash for vaginal sex in the past two weeks” would be a more accurate definition than “women frequenting bars”
- “men who have paid for sex in the past one year” would be a more accurate definition than “truck drivers”

The definition should be very specific (including criteria related to frequency or how recently they have done the behaviour) and should be relevant to the purpose of doing the estimate.

Define the population, contd.

In your results, acknowledge populations you may not have captured either by the way the population was defined, or the limitations of the method used.

Proxy definitions

It is often necessary to use proxy definitions for at risk populations which are not a distinct social group. A proxy definition uses a socio-demographic characteristic of a group, such as occupation, or places associated with risk behaviour where risk groups are often found (such as men at beer halls, male migrants living in dormitories, etc.). The proxy definition is not the cause of the increased risk to HIV. For example, truckers are often used as a proxy definition for clients of sex workers, because some studies show a higher proportion of truckers reported being clients of sex workers than men in the general population. However, driving a truck on its own is not a risk for acquiring HIV.

A proxy definition is almost always imperfect. Some people who meet the proxy definition may not engage in the risk behaviour, and vice versa, some people who have the risk behaviour may not meet the proxy definition.

The proxy definition is only useful if there is evidence that a high proportion of individuals in the group practice the high risk behaviour of interest. When using data from proxy groups to describe the epidemic, be clear why a proxy group is adopted and document any local data that demonstrate the proxy group does define a population with higher risk behaviours.

Define age

Age is important when defining the population for a size estimate and later when designing effective programmes. In some countries, for example, a large *proportion* of sex workers are below 18 years of age. If your estimate does not include this group, you will have a significant undercount of sex workers. If people below 18 (or 25) years are not included in the estimate for ethical reasons, state this clearly in your plan.

In your results, document populations you may have missed entirely.



Define the geographic area

Population members at different locations may have different behaviours. These differences will be important for planning your size estimation exercise.

Estimates will need to be adjusted based on local differences. You may need to stratify areas of high, medium, and low *prevalence* of the risk behaviour. Also, you may need to *aggregate*, or combine, estimates from key provinces to create a national estimate. Later in this manual, you will see how this is done.

Aggregating local estimates may be difficult. Local estimates tend to focus on the total number of people needing services over a certain time, such as a year. But the target population may not be in the geographic area for the whole time; for example:

Sex workers may sell sex in a city for only six months before moving to another city where they are considered “new stock” and can command higher prices. If you were to do a population size estimation of these women, your annual total would be twice as high as the total at any one time.

Sex workers who work in the capital on weekdays might travel to resort islands to serve holiday clients on weekends. National estimates based on a sum of capital city + resort islands estimates will count the same women more than once, as they move back and forth between capital city and resort islands.

The *migration* described above likely will result in inaccurate estimates. An understanding of migration in the sex industry and other predictors of mobility is useful to make good estimates.

Improve your definitions with formative research and mapping

When you are preparing to do a size estimate, *formative research* should be used to improve your understanding of the population of interest. Formative research is research conducted during the planning of your study to determine the best ways to reach the population. The results of this research should help you decide on the population definition and the geographic definition.

Formative research often involves qualitative techniques such as open ended interviews, observation, focus group discussions. Formative research for size estimation might include:

- talking to members of the population at increased risk to HIV,
- talking to persons who provide services to that population, persons who reside or work in areas where the population congregates
- observing the population
- reading existing literature on the population.

By conducting formative research it is possible to learn:

- whether the population is visible
- which sub-groups of the population are not visible
- where the population congregates
- where the population receives services
- what time of day the population is approachable for data collection
- how the population networks
- who the gatekeepers are to the population
- how they react and interact with public officials such as survey implementers or police

Most importantly, this information will help you determine possible data sources and sampling methods.

Geographic mapping

For most size estimation exercises, *geographic mapping* will also be useful. Geographic mapping describes the universe of places where the population congregates. Geographic mapping can also provide a rough estimate of the population size and characteristics of the locations where the population congregates.

Mapping is a process or tool and is not a size estimation method on its own. It is often used with census and enumeration but is also useful to help with the other methods described in this document.

Geographic mapping, contd.

Mapping is also essential for planning programmes and services for at risk populations. Interaction with members of the population or persons familiar with the population will be useful when designing and improving HIV prevention programmes.

For example, a city map can show:

- Areas where drug dealing or drug use activities occur by neighborhoods,
- The locations of gay bars and cruising areas where men who have sex with men congregate, or
- Where there are brothels, hotels, and streets where female sex workers work.

In addition to the physical locations, a “social map” can be created to describe the characteristics and behaviors of the at-risk population, including:

- The specific areas where young injecting drug users may be found,
- The hours when the greatest number of men who have sex with men appear at certain gay bars, saunas, or cruising areas, or
- Where male sex workers, transgender sex workers, or female sex workers predominate in an area.

The “map” may also mark the area where clients served by different prevention and care programs live or congregate.

In this context, “mapping” refers to a tool used in the formative phase that guides population size methods (*census* and *enumeration*) and informs the results and interpretation of population size methods (e.g., who is included, who may have been left out in a multiplier method).

Mapping entails using existing data, key informants, and field observation to determine where at-risk populations congregate or live. For example, police records may indicate street corners where drug dealing occurs, taxi drivers may inform the areas where sex workers can be found, men who have sex with men activists can help create a list of gay bars and areas where men who have sex with men congregate. A thorough “mapping” includes field observation to verify the presence of the at-risk population, describe the characteristics of those present, the environment, and the approximate numbers present at different times of day and days of the week.

The map created can lead to population size estimation through census and enumeration methods described later. In this case, the map or list of places serves as a *sampling frame* from which all individuals are systematically counted (census) or from which a random selection of places are chosen and individuals within these places are counted (enumeration).

Geographic mapping, contd.

The map itself may be drawn by hand or the venues can be geo-positioned using software such as arc view™ (see www.esri.com). **Figure B-1** below presents a map hand drawn by key informants from the community.

Figure B-1. Map created by community members of sites for female sex workers



Source: Australian International Health Institute, Emmanuel Health Association Project, Avahan India AIDS Initiative

Once the map is collected, counting must be done by a *census method*, in which you visit all sites, or an *enumeration method*, in which you visit a *sample* of sites. Counting must be accurate and rapid. Skill is needed to identify members of the key population. Increased possibly harmful attention or other influences may cause members of the key population to leave these locations.

Limitations of mapping include:

- The estimates based on mapping (census and enumeration) are only as good as your map is complete and up to date;
- The map is only as good as your qualitative research, which depends on your program data, guides, or key informants;
- Mapping may miss large parts of highly hidden populations;
- Mapping is difficult for highly mobile populations; and
- Mapping typically has high cost, takes a long time, and is very complex.

Despite these limitations, mapping can help provide a good lowest limit for size estimation because mapping describes the population that is visible and can be reached. Ethnographic and community characteristics can be depicted as an overlay, allowing further analysis of these populations.

Geographic mapping, contd.

In summary, formative research provides the social mapping for the size estimation exercise. It will help you define and describe the population of interest, it will help you understand the factors which influence their behavior, and determine the best way to reach the population. While geographic mapping will provide the physical description and the characteristics of the area where you will be working.

Step 4: Review existing size estimates

Before beginning your size estimation exercise, list what data are available for the populations you will study.

What data are available

Many of the methods described later in this manual rely on data taken from existing sources. Before starting your population size estimation, find out if existing data are available.

Do not assume that one government agency has a complete idea about what data are collected by other agencies; for example:

- A ministry of public health may not have access to data collected by law enforcement.
- Law enforcement may hesitate to share numbers because they feel that the presence of sex workers or drug users reflects a failure on their part.
- Clinics may be reluctant to share data due to *confidentiality* concerns.

What data are appropriate?

Now you can evaluate the existing data. First ask if they are appropriate for population size estimation:

- Do the data allow identification of members of the population? Prison records, for example, may not identify which inmates are drug users because many drug users in prisons may be in prison for other offenses.
- Is the quality of data good? Workers in clinics, for example, may not ask about risk behaviours to avoid alienating people in treatment. This means there will be missing data that will *bias* population size estimates.
- Do legal or other regulations prevent the use of existing data sources by public health analysts? Some data sources cannot be used if they:

What data are appropriate, contd.

- Do not clearly identify the target population
- Do not contain large amounts of data that can be matched
- Do not collect stratifying information
- Do not provide data in electronic format.

Data sources do not need to include every possible member of the target population, but they do need to be accurate, with correct information to identify someone as a “*case*.”

If existing data are inadequate, consider collecting new data. Again, think about existing data sources. A survey can be revised with additional questions to provide information for population size estimates. You might use:

- A national census
- An HIV surveillance activity
- A national health status survey.

What previous size estimates are available?

When you review previous estimates, consider:

- The method used
- The definition of the population
- The results
- How the estimate was used.

Find out what problems were overcome in previous size estimates studies and try to avoid them.

Examine the source of existing estimates. Find possible conflicts of interest. Some assume, for example, that results underestimate the size of at-risk populations because of concerns about *stigma*.² But organizations may want high estimates, which mean more funding for HIV activities and programmes.

Address ethical issues in population size estimation

You must use ethics when collecting data on most-at-risk populations that could be *vulnerable populations*. Collecting and storing of data on people and their risk behaviours may place excess risk of harm to these populations due to stigmatization, economic loss or legal liability.³

Ethically, it is important that you:

- Give target populations special protection, including privacy during data collection and confidentiality of the information afterwards. Respect for privacy protects subjects and creates an atmosphere of confidentiality that enhances the completeness of reporting.
- The ethical principal of “beneficence”, or do no harm, as it applies to size estimation activities, at a minimum should include:
 - Being ready to refer individuals to available services and information
 - Ensuring that the data are used to develop needed programs for the benefit of the population
- Depending on the method you choose, there may be additional minimal ethical obligations. For example if you are doing a population based survey or survey of the at-risk population then you need to be prepared to give the following:
 - Information about HIV and AIDS
 - Counseling and treatment or participation in future services
- Consult the guidelines⁷ for how to collect data from adolescents. Young people are particularly vulnerable to exploitation, abuse, and other harmful outcomes.

Legal penalties and safeguards against unethical dissemination of data are important because some risk behaviours may be illegal in many countries and legal protection for confidentiality may be changing.⁴ It is best to include representatives or legal counsel from the target population in your planning.

Develop a protocol for your population size estimation exercise

Unit E of this manual provides advice on documenting your size estimation exercise, including how to add to your original protocol so that your team or others can reproduce your results. Review that unit before you begin your size estimation exercise so that you have a clear picture of where you are going.

Your protocol must include:

- An explanation of why the population was chosen
- The definition you used for the population
- The geographic area of the estimate
- The method chosen for the estimate
- The assumptions required for the method
- Any violations of those assumptions.

Summary

Before starting your size estimation, define and access the population through institutional records or population surveys. Fluctuations in population size caused by, for example, migration, can affect your estimate. Determine the best timing for your estimation to make the best use of resources. Mapping is used for all methods of size estimation and can help you gain access to at-risk populations. Analysts should know what data are available at what geographic level and what is needed for access. Implementers must consider ethical issues, such as ensuring that subjects have privacy, confidentiality, and benefit from their participation.

Unit B Exercises

Warm-up review

Take a few minutes now to look back at your answers to the warm-up questions at the beginning of the unit. Make any changes you want to make.

Small group discussion

1. In your country or region, what is most important in choosing a method for estimating population size?
2. How useful are population size estimates in assessing the growth rate of populations?
3. What are some things to consider when you define the population of female sex workers in your country?
4. Have estimates been made of the sizes of these populations? If so, how were the populations accessed?
5. Do you know of a case where problems have occurred when an individual was identified as HIV-infected? What happened in that case?
6. What high-risk groups have been identified in your district, region, or country? What are some special considerations in dealing with high-risk populations?

Apply what you've learned/Case study

1. Consider the problem in Unit A of interpreting estimates from a non-governmental organization about the size of the population of female sex workers. What is important for tracking such estimates over time?
2. You are the health officer in charge of HIV surveillance for Province X in Y Country. You have been asked to design and implement a special HIV risk survey among male patients with acute urethritis who attend the clinic at the provincial referral hospital.
 - You decide to proceed by first assessing HIV seroprevalence. You are weighing two choices:

- A self-administered questionnaire and an additional blood test for HIV and syphilis.
 - A blinded survey of all patients who have blood drawn for syphilis serologies. Approximately 50 percent of patients with acute urethritis have serum samples drawn for syphilis. There is no standard protocol for when to order these serologies.
-
- For which option would you need informed patient consent?
 - How likely are each of the two options to yield an accurate estimate of the prevalence of HIV infection in this population?
 - In which option would individual confidentiality be better protected?

Unit C: Overview of Methods: Based on data collected among the population at risk, Step 5

Overview

What this unit is about

In this unit we discuss methods based on data collected among the population at risk: census and enumeration, capture-recapture, and the multiplier method.

Warm-up questions

1. List one strength and one weakness of the census method for size estimation.
2. True or false? A list of all places that members of a population frequent is necessary for many enumeration methods.

True False
3. In the capture-recapture method, if the assumption that the two sources of data are independent is violated, what would be the effect on the population size estimate?
4. True or false? When using the multiplier method, both sources of data must be randomly selected.

True False
5. True or false? Multiplier methods can be used for making national estimates of population size.

True False

Introduction

What you will learn

By the end of this unit, you should be able to:

- Choose and use methods based on how to access the population at risk
- Use census and enumeration methods and evaluate their results
- Understand the strengths and weaknesses of nomination methods
- Use capture-recapture and multiplier methods and evaluate their results.

General information on methods and populations

Using methods systematically will lead to more useful estimates of population size. Be careful not to make simple before and after comparisons and not to report selective estimates.

Access to hidden populations

Populations at increased risk for HIV are often referred to as *hidden* or *hard-to-reach* populations, although some are easier to access than others:

Less hidden sex workers	More hidden sex workers
Sex workers based in brothels. Your study will be conducted in the brothel.	Call girls without a base who go where the client requests. You cannot access them at specific locations.

It is important that you understand what level of access to the *population* you have when you are choosing a method for your size estimation method.

Accessing the population through institutions

Persons at increased risk for HIV infection often are clients of institutions, such as drug treatment clinics, emergency wards, the justice system, and schools. These institutions can give you access to individuals or to their records. One problem is the *sample* may not be representative.

The following provides some examples of groups that are not representative:

- Newer drug users and users who are not dependent on criminal activity to support their drug use will not be well-represented in jails and the criminal justice system.
- Emergency wards will over-represent users of more toxic substances.
- Services for sexually transmitted infection will over-represent sex workers with the riskiest behaviours.

When you collect data from institutions, it is important to document what segment of the population is actually represented.



Overview of the methods

Table C-1 introduces two categories of size estimation methods which will all be discussed in this unit (**Unit C**) and in **Unit D**:

- Methods based on data collected in an at-risk population (**Unit C**)
- Methods based on data collected from the general population (**Unit D**).

Overview of the methods, contd.

Table C-1. Twocategories of methods for estimating population size

Category 1: Methods based on data collected in an at-risk population		
Method	Short description	Characteristics when used for estimates
<i>Census & enumeration</i>	Census counts all members of the population. Enumeration maps an area, counts a fraction of the population in selected areas, and inflates the value to create an estimate.	<ul style="list-style-type: none"> ▪ Method requires most-at-risk population sampling frame (hidden populations will not participate) ▪ Census is expensive. Enumeration less. ▪ Method tends to underestimate the true most-at-risk population
Capture-recapture	Calculates the total size of a population based on two independent captures of population members. The number of members captured in both samples is used to derive an estimate of the total number in the population.	<ul style="list-style-type: none"> ▪ Hidden population members must identify themselves ▪ Method requires programme data ▪ Over- or underestimate uncertain
Multiplier	Compares two independent sources of data for populations to estimate the total number in the population.	<ul style="list-style-type: none"> ▪ Hidden population members must identify themselves ▪ Method requires programme data ▪ Over- or underestimate uncertain
Category 2: Methods based on data collected from the general population		
Population survey	Includes questions on high- risk behaviours in a general population survey	<ul style="list-style-type: none"> ▪ Hidden population members must identify themselves ▪ Method tends to underestimate the true population
<i>Network scale-up</i>	Includes questions on <i>high-risk</i> behaviours of respondents' acquaintances in a general population survey	<ul style="list-style-type: none"> ▪ Method tends to underestimate the true population ▪ Requires estimation of personal network size

Source: Adapted from Monitoring and Evaluation Guidelines for HIV Prevention for Men Who Have Sex with Men. MERG Technical Working Group on Most at Risk Populations. Draft December 2009.

Methods that use data collected from the population at risk

Census and enumeration methods

Census and enumeration methods count people. Census methods are used to count every person in a population and enumeration methods count every person within a sample of places.

Census and enumeration methods are straightforward to calculate. They have the advantage of being understood by policy-makers who may not be experts in statistical or sampling methods used in public health. Where a list or sampling frame exists and where the population of interest is well defined and accessible, the census method consumes less time and resources than other methods. However, creation of a complete sampling frame or map of the at-risk population can be logistically complicated and resource-intensive in itself.

Census methods

Census methods try to count every individual in an at-risk population. This requires developing a complete list or map of places that the population may congregate. For example, you might conduct a census or count of the number of sex workers based in each brothel in the country. This count must take place in a very short period of time. Otherwise, sex workers moving between sites may lead to double counting.

Enumeration methods

Enumeration methods are very similar to census methods. However, instead of counting every person, you count only people within chosen locations where the population can be found.

To do enumeration:

- Start with a *sampling frame* or list. A sampling frame is the complete list of individuals (or sites) from which a sample can be chosen. For example, a list of all the places where female sex workers are found working, such as brothels, hotels, bars, karaoke clubs, and streets. Or, the places where drug use activity occurs such as shooting galleries or corners where drug dealing occurs.
- Choose a random or systematic sample of units from that list. You could choose every third brothel, for example.
- Count only the individuals within those chosen units.
- Scale up the number counted by the size and structure of the sample frame. For example, you could multiply the average number of female

Enumeration methods, contd.

sex workers per sampled brothel with the total number of brothels in the city.

For a size estimate of sex workers in brothels in a city, for example:

- Divide the population into quadrants of a city or districts within a country
- Count the number of brothels in each area
- Visit a third of the brothels (chosen randomly) to get an average number of workers per brothel
- Multiply the average number of workers per brothel by the total number of brothels you counted.

In this example, the sampling frame is your list of all brothels in the city or country.

Strengths and weaknesses

Census and enumeration methods share similar strengths and weaknesses:

Strengths and Weaknesses of the Census and Enumeration Methods for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Census method counts all members of the population ▪ Enumeration method maps then covers just a fraction of the population 	<ul style="list-style-type: none"> ▪ Most-at-risk populations are often hidden. Census method will miss members of the population. Enumeration can provide better access if community guides are used. ▪ Census is time-consuming and expensive to conduct. Enumeration is less time-consuming and expensive (just a fraction of the population). ▪ Both methods tend to underestimate.

Both census and enumeration methods are highly dependent on the completeness of the *mapping* that is used for the systematic counting of everyone (census) and the counting within a sample of places (enumeration). While straightforward in principle, the logistics of conducting census and enumeration size estimates of at-risk populations

Strengths and weaknesses, contd.

require a high degree of coordination. Field teams need to be trained to identify the population at risk, with the assistance of guides, and rules need to be established to avoid duplicate counting, account for absences, and conduct quality control (e.g., re-counting in a sub-sample).

The census method does not perform as well for hidden populations or for situations where the population at risk is geographically dispersed. In these situations, the count cannot be completed in a short enough time to compensate for migration so you may count individuals two or more times. Your estimate will be too high. Also, a census is expensive to conduct.

The enumeration method shares some of the strengths and weaknesses of the census method. However, since enumeration covers a fraction of the population, it usually requires fewer resources and is less expensive to conduct. With well-trained community guides covering small areas, enumeration can provide better access to hidden populations. If you choose to use the enumeration method, assess whether data collected from the regions or types of establishments differ in important ways.

If the population is very hard to reach, census and enumeration methods tend to underestimate population size when compared to other methods because some members of the population may not be visible or included in the map. On the other hand, if the population is poorly defined and persons who are not truly part of the population are captured in the count, the population will be overestimated. If the census or enumeration is conducted over a period of time individuals might be counted twice leading to an overestimate.

Capture-recapture method

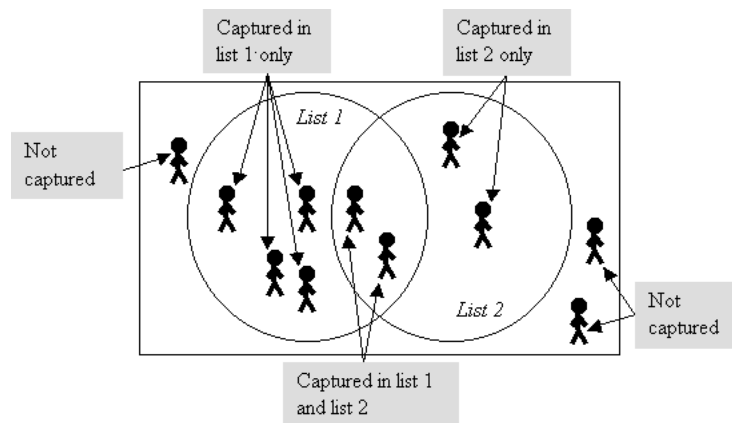
Capture-recapture techniques were first used in 1662 to estimate the population of London. It was not until 150 years later that LaPlace laid out the mathematical formulation for capture-recapture. In the early 1900s, the method was adapted to study wildlife populations.^{5,6}

The method has been known as the Lincoln-Peterson estimator in wildlife, Chandra-Sekar-Deming method in demography, and sometimes the dual-system estimator.⁷ Other terms sometimes used include “capture, mark, and recapture” or “capture and release”.⁸

The basic *capture-recapture* method is as follows (**Figure C-1**):

- Map all the sites where the population can be found
- Go to the sites and tag all the members of the population at the site (either give them a card or some memorable gift).
- Keep a count of the persons tagged.
- Return to the sites a week later and retag all of the persons encountered.
- In the second visit, count:
 - People who were counted in the first sample
 - People counted for the first time in the second sample.
- The number of individuals in each sample and in both samples is recorded. These numbers are used to estimate population size. This is done by multiplying the number captured in the first sample by the number captured in the second sample and dividing by the number captured in both samples.

Figure C-1. Illustrating the capture-recapture method



Source: Crowcroft N. Health Protection Agency, London. Epi-Et class slides

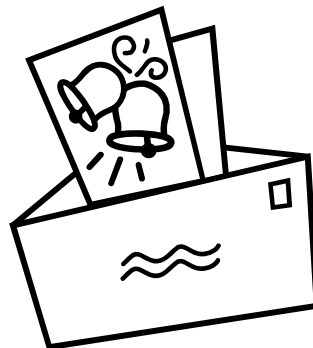
Capture-recapture method, contd.

In situations where it is not feasible to visit all of the sites or all of the sites are not known, a variation of this method can be used:

- Select a sample of individuals from the population. Ideally the sample will be random, with each member of the population having an equal chance of being selected. (This sample can be a list of sex workers attending an STI clinic, or a survey).
- Note persons selected in some fashion (for clinic attendees you might have their names or clinic patient identifier number, or survey respondents might have been given a card or will remember completing the survey).
- Collect a second sample at a later time. The second sample should be independent of the first sample (either sample from a different clinic or institution or conduct a different survey).
- In the second sample, determine:
 - How many people were also counted in the first sample (sex workers who visited the STI clinic or respondents interviewed in the first survey)
 - How many people are being counted for the first time in the second sample.
- The number of individuals observed in each sample and the number in both samples is recorded.

In at-risk population estimates, two approaches to capture-recapture have been used:

- In the *direct contact approach*, the field team contacts all members of the target population at a venue and gives them some token, such as a blue invitation card to a free health clinic. Later, the field team revisits the site, takes another count and distributes a different token, such as a yellow invitation card to a clinic. While distributing the yellow card, the field team asks whether anyone has previously received a blue card. If so, they are recorded.



Capture-recapture method, contd.

- In the *no direct contact approach*, the team uses existing lists, such as STI clinic registration data and a brothel registry, to determine if the same person is captured on both lists.

In the *no direct contact approach*, the investigator must decide what constitutes a match. Even if names are available, someone may be Thomas Jefferson in one data source and Tom Jefferson in another; birth dates may differ slightly or age computed from birth date may differ from reported age. The use of names for many at risk populations will not be possible or may result in under matching due to the reluctance of most people to give their real names and the endangerment to at risk populations if services insist on capturing personal identifiers. More likely the matching would be done on identification numbers or with a probabilistic algorithm, all of which have challenges.

Whatever criterion for a match is chosen, it is important to be clear and specific. A good way to proceed is to adopt a rigid definition and do the analysis; then relax the matching criteria, repeat the analysis, and compare the results.⁹

Strengths and weaknesses

Strengths and Weaknesses of the Capture-Recapture Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ A simple capture-recapture method is relatively easy to use ▪ Does not require much data ▪ Does not require statistical expertise 	<ul style="list-style-type: none"> ▪ Relies on assumptions that are hard to meet: <ol style="list-style-type: none"> 1. The two samples are independent and not correlated 2. Each population member should have equal chance of selection 3. Each member is correctly identified as ‘capture’ or ‘recapture’ 4. There is no major in or out migration 5. Sample size is large enough to be meaningful.

Assumptions of capture-recapture

There are some important assumptions in the capture-recapture method:

1. The population is closed. That is, the population available to be captured in the second sampling (recapture) includes exactly the same set of individuals as it did for the first. That is, there is no in- or out-migration. This assumption is easily violated in studies of persons who inject drugs or sex workers, where there is a large turnover (people joining or leaving the population) and often lots of movement.

The change in population between sample 1 and sample 2 can be caused by several things, for example:

- People who inject drugs who are included in the first sample are more likely than others to leave the population by moving away, dying or ceasing to use.
 - New drug users might enter the population.
 - People who inject drugs who attend treatment programmes may be more likely to reduce their use of drugs for a period.
2. Identifying information is collected in both samples. Individuals captured in both samples can be matched; through distributing objects, anonymous identification numbers, or if identifying information is collected.
 3. Capture in the second sample is independent of capture in the first. That is, people in the first sample are not more or less likely to be included in the second sample than people who were not included in the first sample.

If being included in the first sample increases a person's chance of being included in the second sample, the total population will be underestimated. For example, if the study team returns to the same street corner or brothel to recapture sex workers, certain sex workers will probably be favoured in the recapture sample. Techniques have been developed to detect dependencies between samples.¹⁰

4. Each person in the population should have an equal chance of being included in the sample. This would suggest that the sample is random.

5. Capture-recapture estimates based on small samples or too few matched individuals can be misleading.¹¹ *Make sure there are enough members in the samples to produce meaningful results.*

When distributing objects, it should not be so cheap that it is easily forgotten, but not so valuable that people want more than one. It should also not be marking or stigmatizing, meaning too “flashy” and/or recognized by others as something that only men who have sex with men or female sex workers have. It should also not be something that members of the population would want to share or pass around.

Assumptions of capture-recapture, contd.

Assumption... and effect if it is violated	How to plan your study to avoid violating the assumption
<p>The population is closed (there is no in or out migration). If this assumption is violated:</p> <ul style="list-style-type: none"> ▪ Out-migration for the second sample will produce an overestimate of the population size ▪ In-migration for the second sample will produce an underestimate of the population size 	<ul style="list-style-type: none"> ▪ Shorten the time between samples ▪ Avoid sampling on unusual days, such as festival days ▪ Carefully define the boundaries of selected sites ▪ Enlist community support ▪ Make sure your team understand these points
<p>Matching is reliable (you can identify persons captured in both samples)</p> <ul style="list-style-type: none"> ▪ If you do not identify a match, your estimate will be too high ▪ If you identify a match incorrectly, your estimate will be too low 	<p>Collect sufficient data for each member of your samples so that you can tell who has been captured before.</p>
<p>Every member has an equal, or known chance, of being captured in a sample.</p> <ul style="list-style-type: none"> ▪ If some members of the population are less likely to be included in the sample, your results will likely be an undercount. 	<ul style="list-style-type: none"> ▪ Before your study begins, investigate how the local community defines the population ▪ Carefully select study sites
<p>The two samples are independent, meaning selection in the first capture is not related to selection in the second capture.</p> <p>If not, your results will be biased.</p>	<ul style="list-style-type: none"> ▪ Use separate teams to collect each sample ▪ Use different informants and local guides for each sample
<p>The sample size for each capture is large enough to be meaningful.</p> <p>If not, your results will not be precise.</p>	<p>Increase the size of the target population for both lists or survey.</p>

Based on: Donna Stroup, Data for Solutions.

Calculating the capture-recapture method

Capture-recapture begins with a *random sample* from the population you have chosen.¹² If the assumptions hold, estimated population size is given by:

$$N = \frac{MC}{R},$$

Where:

- N = Estimate of total population size;
- M = Total number of people captured and marked on the first visit;
- C = Total number of people captured and marked on the second visit; and
- R = Number of people captured on the first visit that were then recaptured on the second visit (that is, the number included in both samples).

It might be useful to consider this method in the context of a 2×2 table (Figure C-2).

Figure C-2: Capture-recapture analysis

		Were they captured in the second sample?		
		Yes	No	
Were they captured in the first sample?	Yes	R	b	M = R + b
	No	c	x	
		C = R + c		N = R + b + c + x

- The top row includes all the people captured in the first sample
- The first column includes all the people captured in the second sample.
- The total number, N, includes all those in both samples as well as those missed by both samples.

Sample size calculation

To calculate the sample size required for this method, consider the following. The combined total of sample 1 and sample 2 should be larger than the total number expected in the population ($M + C > N$) and the number captured in both samples is larger than 7 ($R > 7$). Naturally you will not know the total number of people in the population (N) so you will need to make a rough guess.

**Example:
how to use
capture-
recapture
data**

A study team is using the capture-recapture method to determine the size of an at-risk population. After mapping the study area, a member of the team goes to the area to “capture” individuals:

- 50 people are marked on the first visit
- 25 of those people are recaptured on the second visit the next day.

The field worker concludes that the probability of capturing a previously marked individual on the second visit is:

$$R / M = 25 / 50 = 0.50$$

The field worker assumes that on the second day all individuals in the actual population, N , have the same capture probability as the recaptured individuals. On the second visit, the field worker thinks, "I know that today I recaptured 50% of the people I marked during my first visit. Today I probably also captured 50% of the individuals that I did not mark on my first visit. In fact, today I probably captured 50% of all the individuals present in the study site regardless of whether or not they were marked on my first visit." This can be expressed as:

$$\frac{C}{N} = \frac{R}{M}$$

You can see, then, how the formula for N , total estimated population size, is derived.

Example: how to use capture-recapture data, contd.

It is also possible to calculate a *confidence interval* to give a *range* of error for the estimate of total population size:

$$95\%CI = N \pm 1.96\sqrt{Var(N)}$$

Where $Var(N)$ is calculated as:

$$\frac{MC \cdot (M - R) \cdot (C - R)}{R^3}$$

Using capture-recapture with programme data

To implement capture-recapture using programme data, identify the people captured in two data sources.

Be specific when you decide how to match. You might adopt a rigid definition, do the analysis, then relax the matching criteria, repeat the analysis, and compare the results.¹³

Unless your data sets are very large, the best way to match is manually. Spreadsheets and electronic databases can help by sorting in different ways.

- Two lists sorted by sex and date of birth may assist in matching people. Birth dates may differ slightly or age computed from birth date may differ from reported age.
- If names are available, they may not help because names can be similar, people may give different versions of their name, or people may not wish to give their name because of stigma or fear of harm.

Additional information

For additional information on capture-recapture methods and variations of the method, some useful references are:

- International Working Group for Disease Monitoring and Forecasting. Capture-recapture and multiple record system estimation I. History and theoretical development. *Am J Epidemiol* 1995;142:1047-58.
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- King R, Brooks SP. On the Bayesian Estimation of a Closed Population Size in the Presence of Heterogeneity and Model Uncertainty. *Biometrics* 2008;64:816-824.
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Nomination methods

Nomination methods are not recommended for estimating the size of hidden populations. Rather, nomination methods are sampling methods. They sometimes can be used with multiplier or capture-recapture methods because often there are no alternatives to asking visible members of a hidden population to nominate more inaccessible members for your study. Nomination also may be useful for pre-surveillance activities or to access populations in need of services.

Nomination methods start with a small but visible and accessible part of a larger population, such as drug users in treatment programmes. These people are asked by the field team to participate in the survey. Referred individuals are asked to refer other members, and so on. Variations of this method are often called respondent-driven, snowball, or chain referral sampling methods.

Strengths and Weaknesses of the Nomination Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Can be easy to conduct if you identify good key population members to help make the introductions ▪ Does not require much field work or site visits because key population members recruit peers 	<ul style="list-style-type: none"> ▪ Not recommended for size estimation for the following reasons: <ul style="list-style-type: none"> ○ Populations with behaviours that are illegal or stigmatized will fear harm, so collecting identifying information to prevent duplication is difficult ○ Begins with visible members of key population who may not be representative of the complete population at risk ○ Depends on key members being networked, but too highly networked can mean duplication ○ Sophisticated statistical methods are necessary to analyse data

Multiplier methods

The multiplier method is highly dependent on the quality of existing data. It is necessary to review how the existing data were collected before using the data to produce estimates.

The method relies on two sources of data.

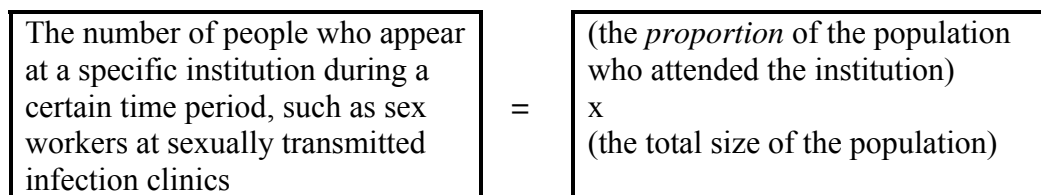
- The first source should be a count or listing from programme data including only the population whose size is being estimated (number of sex workers who attended an sexually transmitted infection clinic in the last month, number of persons who inject drugs visiting a needle exchange programme)
- The second source should be a representative survey of the populations whose size is being estimated.

In the survey ask the respondents whether they received the service. Divide the number who received the service by the proportion reporting receiving the service in the survey to estimate the population size. This can be expressed as:

$$S = \frac{\text{\# of key population in STI registry records}}{\% \text{ population reported being registered}}$$

The basic principle behind the *multiplier method* is shown in **Figure C-3**.¹⁴

Figure C-3. The basic principle behind the multiplier method



Multiplier methods, contd.

Consider the following example box:

- If the number of injection drug users in treatment in 2009 is known to be 1,000 from clinic records, and
- If approximately 10 percent of injection drug users attended treatment in 2009, then
- The treatment figure can be multiplied by 10 (or divided by 10 percent) to get an estimate of the size of the injection drug user population.

As an illustration, suppose the following:

- S = estimated total number of sex workers,
- P_1 = proportion of female sex workers on a list of sexually transmitted infection clinic attendees
- P_2 = proportion of female sex workers who attended the sexually transmitted infection clinic among a *cross-sectional survey* of sex workers
- M = number of individuals on the sexually transmitted infection clinic attendee list

Then, the estimated population size can be expressed as:

$$S = \frac{P_1}{P_2} * M \quad (D-1)$$

This estimate is mathematically equivalent to a capture-recapture calculation, but the interpretation is somewhat different.

Table C-4 (next page) provides a sample list of data sources for multiplier methods when the target group is injecting drug users.

Multiplier methods, contd.

Table C-4: Example of potential data sources for estimating the number of persons who inject drugs ¹⁵

Data Source	Example
Drug treatment programme	Drug users attending treatment agencies or in residential care
Drug agencies	Drug users contacted by outreach workers
Needle-exchange programmes	Drug users registered at needle-exchange programs
Hospital/emergency department	Drug users needing emergency treatment due to overdose
Laboratories	Drug users tested for HIV, hepatitis B or C virus
Police/prisons	Drug users arrested for drug use or other crimes
Probation	Drug users on probation
Social services	Drug users assisted by social services
Mortality statistics	Deaths due to opiate overdose

Consider also the example of estimating the number of female sex workers in China .¹⁶

For one province in China, two epidemiologic surveys were carried out.

In the first survey, 92 female clients at one of 16 registered sexually transmitted infection clinics were enrolled after informed consent. The total number of female attendees over six months (*M*) was determined from medical records to be 842. Of the 92 attendees interviewed, 45 (48.9%) were classified as female sex workers. It is assumed that this sample of 92 is representative of the 842 women attending the clinic.

A second survey was conducted among the community female sex worker population through anonymous interviews at their place of work. They were asked whether they had visited any of a list of sexually transmitted infection clinics in the past three months. From the survey of female sex workers in the community, 16.2% (47/327) had visited one of the sexually transmitted infection clinics. Thus, the estimated size of the female sex worker population (using equation D-1) is:

$$S = \frac{48.9\%}{16.2\%} * 842 = 2,500 \quad (D-3)$$

Strengths and weaknesses of multiplier methods

Multiplier methods are preferable to census and enumeration methods if the sampling frame is questionable or when the population is difficult to reach. Multiplier methods can use existing surveys, so they could be used to produce estimates on a national level.

Strengths and Weaknesses of the Multiplier Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> • Straightforward if data sources are available • Flexible method, useful in many circumstances 	<ul style="list-style-type: none"> • The two data sources must be independent • The data sources must define population in the same way • Time periods, age ranges, geographic areas must match • Data collected from existing sources may be inaccurate

Assumptions of multiplier methods

Multiplier methods have several assumptions about the two sources of data which may be difficult to evaluate:

1. The two sources of data must be independent (everyone with a chance to be on the list should have a chance to be in the survey). Similarly, everyone on the list should be a member of the population you are trying to estimate and this populations should also be captured randomly in the survey. In reality, most surveys will have some amount of selection bias and the survey team needs to decide whether that bias is independent of the likelihood of being included on the list.
 - a. The first data source (multiplier) need not be random but should be specific to the group being estimated. That is, if the team is using STI clinic data to estimate size of the sex worker population, they must exclude non sex-workers from the list. This is in direct contrast to capture-recapture estimates.
 - b. The second source (the survey) should be random and encompass the group in the multiplier but it can include others as well. That is, it can include both brothel and street-based sex workers even if the multiplier includes only brothel-based sex workers.
2. The two sources of data must define the population in the same way (the two populations for the data sources are equivalent)

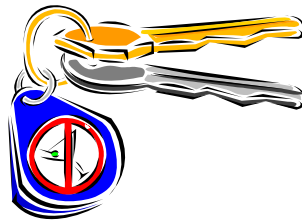
Assumptions of multiplier methods, contd.

3. The two sources of data must have aligned time periods, age ranges and geographic areas

Unique object multiplier

Another version of a multiplier method involves the distribution of a *unique object* to members of the population. The number of people receiving the unique object, or the number of unique objects distributed to individuals, is the count of the first population. The survey captures the proportion of participants reporting that they received the unique object. This is very similar to a capture-recapture method and is mathematically equivalent.

If distributing objects or tokens, choose objects that are memorable and easily identified.



Use the unique object multiplier method when services do not exist or service data are not available for the population of interest.

The multiplier team controls:

- How many objects are handed out to the population,
- What type of object is handed out. It should be memorable for people in a certain setting,
- Who receives the object. It must be given to a member of the correctly defined population
- When the object is handed out. It should be handed out at the right time around the implementation of the survey.

Summary

It is important you choose your method based on how you can access the population. Census methods are used when you can count every person in a population and enumeration methods when you can count every person within a sample of places. Nomination methods are used when you need available members of the population to refer more hidden members. Nomination contains selection bias and should not be used for estimating population size except where no alternatives exist to survey hidden populations.

Capture-recapture methods are used when you can contact all members of a population at one venue and gather two independent sources of information (counts) using tokens to prevent duplicate counting. In a variation, you can use existing lists at an institution to determine if the same individual is captured on both lists. The multiplier method is used when there is existing data from one source which may not be random. The number of people on an existing list equals the total size of the population multiplied by the proportion of the population on the list.

Unit C: Exercises

Warm-up questions

Review your answers to the warm-up questions for this unit and make any changes you want to make.

Apply what you've learned/Case study

Case study C-1: Census and enumeration methods

Programme managers in a city suspect the number of female sex workers may have changed and they need an updated estimate to apply for funding from international AIDS organizations for this population.

The programme managers decide to consider whether the reported population varies by type of establishment so that future services can be targeted correctly.

Staff members visited every entertainment establishment within the study area and counted the female sex workers working and not working that day.

A total of 3,521 were identified. Of these, 42% were found in karaoke centres and 26% in hair salons; 7% were street-based, and the remainder were found in massage centres and night clubs.

- a. What type of estimation method is being used here?
- b. Using these data, make an estimate of the number of female sex workers in the country.
- c. What sources of error are important in interpreting your estimate?

**Case Study C-2:
Capture-recapture
with two samples**

A country is experiencing rapidly expanding drug use associated with HIV infection. The country needs to estimate the number of injection drug users to evaluate the feasibility of intervention programmes.¹⁷ The health ministry has available data from two existing data sources:

- Data source one is a database of records from a social insurance system based on residency. It includes information on people receiving drug treatment or who have had a drug overdose.
- Data source two is a police database with information on criminal offences, including if illicit drugs are injected.
- Both data sources contain information on gender, day/month/year of birth, and initials.
- Investigators restrict analysis to persons 15-44 years old. Records outside this age range, records without full identifying information, or multiple records with the same unique set of identifiers are deleted from the analysis.
 - Insurance records identify 1,299 injection drug users
 - Police records identify 5,311
 - 873 persons are identified to be in both data sources.

From the above data, how would your team do the following:

- a. Draw the table useful for capture-recapture analysis and fill in the appropriate cells.
- b. Estimate the total number of injection drug users in this population.
- c. Suppose that persons who appear in the police database are denied access to the social insurance system. What effect will this relationship have on your estimate?
- d. Consider the difficulty of distinguishing injection drug users from non-injection drug users from arrest records. What are the implications of this problem and would it lead to an underestimate or overestimate of the size of the population?

**Case Study C-3: ¹⁸
Multiplier-method
using programme
based and unique
object multipliers
in India**

Programme managers uses two multipliers to estimate the size of the sex worker populations in 6 states in India. They conducted a series of integrated biological and behavioral surveys among sex workers to use with the multipliers. , conducting 30 surveys among sex workers in 25 districts in six states, 12 surveys in high-risk men who have sex with men in 11 districts in four states, and five surveys of injection drug users in five districts in three states.

For the purposes of this estimation, two data sources were used:

Data source 1: Programme based multipliers and unique object multipliers

- Multiplier 1 came from service statistics recorded by organizations working with female sex workers,
- Multiplier 2 came from a unique object distributed to female sex workers.

Data source 2: Survey

- The integrated biological and behavioural surveys were sampled using either respondent-driven sampling or time-location sampling. These sampling methods approximate probability sampling methods to obtain a random sample.

a. Were these multipliers from randomly selected samples?

The questions used in the survey were designed to be compatible with the data routinely collected and available from local service providers.

Indicators included:

- Proportion reporting being registered with the service provider,
- Proportion reporting contact by a peer in the past month,
- Proportion reporting receiving a project health card in the past year, and
- Proportion visiting the service provider in the past year or in the past three months.

b. List three difficulties that you might encounter when using these types of sources for multipliers.

The investigators had no control over what data the service providers tracked. Due to anticipated challenges with these methods an additional

multiplier was used that would be controlled by the survey team. This was known as the unique object multiplier.

In this case, the unique object was a key chain designed to be uniquely memorable and distributed in several of the districts in advance of the survey. The key chain was distributed to persons within the bounds of the survey coverage area who matched the definition of the population whose size was being estimated. Respondents were asked in the survey if they had received the key chain.

- c. In the majority of cases both the programme based multipliers and the unique object multiplier combined with the survey yielded lower size estimates than existing data from programme data. List some of the reasons for this discrepancy.
- d. What do you think are the main safeguards against these biases?

Unit D. Overview of Methods: Based on data collected from the general population, Step 5 - continued

Overview

What this unit is about

This unit covers methods based on information from surveys of the general population. It discusses how a country can estimate population size by adding direct questions about the respondent to population-based surveys or by using the network scale-up method which asks questions about the respondent's acquaintances.

Warm-up questions

1. True or false? Adding direct questions in population-based surveys to estimate population size is most useful when a behaviour is rare.

True

False

2. Identify one significant advantage that the network-scale up method has over other methods.

3. True or false? The main challenge of the network scale-up method is asking respondents to estimate their average personal network size.

True

False

4. List two methods used for estimating personal network size.

5. Which of the following is **not** a bias associated with the network scale-up method?
- a. The size of a network varies among individuals.
 - b. All individuals will be asked the same questions in the same way.
 - c. Some subgroups may be less likely to associate with members of the general population.
 - d. A respondent may be unaware that someone in his/her network is a member of the subpopulation of interest.

Introduction

What you will learn

By the end of this unit, you should:

- Understand the role of surveys in estimating population size
- Be able to add direct questions in population-based surveys
- Recognize the potential use of network scale-up methods.

Methods based on data collected from the general population

Hidden populations are hidden because they are stigmatized or engaged in illegal activities. Members of these populations are especially hesitant to identify themselves as members of populations at increased risk for HIV for fear of stigma or harm, to name a few. An ideal method for conducting surveys would be not to require members to identify themselves to anyone in the survey team.

Adding direct questions in population-based surveys

As described above populations at increased risk to HIV are likely to avoid answering such questions truthfully. In addition, behaviours that put people at increased risk to HIV are often so rare that a very large sample size would be required from a survey to establish the prevalence of such behaviours within a population. A description of the method of adding direct questions in population-based surveys is included in this manual because it is commonly used to collect public health data and can in rare situations be used to collect behaviours with low stigma; however, usually population-based surveys are not recommended for estimating the size of most-at-risk populations.

Surveys of the general population are common in most countries. They are most often administered to residents of a household drawn from a *sample frame* that is representative at a national or regional level:

- In industrialized countries, telephone surveys are possible.¹⁹
- In developing countries, data are generally collected by survey teams visiting households and doing face-to-face interviews.²⁰
- Youth in school can be reached through school-based surveys. Be careful to consider the *representativeness* of individuals attending school versus the remaining population²¹ of the same age that is not in school.

To estimate the size of the hidden population, respondents in a general household survey are asked if they inject drugs, sell sex, purchase sex, or, if male, have sex with other men. These are not always easy questions to insert in a survey given the stigma, discrimination and illegality of these behaviours. The wording and location of these questions in the interview instrument are important aspects to consider.

Posing questions to determine if a respondent is a member of an at-risk population such as men who have sex with men, persons who inject drugs, or female sex workers in a household or other population based survey is challenging. Stigma, discrimination, legal consequences, and privacy threaten accurate. In general, questions should be posed towards the end or middle of the questionnaire, after a rapport has been developed and respondents are more comfortable sharing personal information. Moreover, the section asking such questions should prepare the respondent for what is about to be asked (e.g., questions on sexual behavior, questions on drug use). To the extent possible, the question should be asked in a neutral manner and, to the extent possible, attempting to “normalize” the behavior (e.g., “some people may use certain types of drugs...”).

**Example of
adding direct
questions**

Below are some examples of questions used in surveys to determine at-risk population membership to use as guidelines. Questions should be adapted to your local situation.

For men who have sex with men, the issues of sexual identity or orientation, sexual attraction, and sexual behavior are complex and have implications for population size estimation. A three-part framework that attempts to measure these aspects would comprise several questions along the lines of the following:

Behavior:

"Some people have sex with women, men, or both. In your lifetime, have you had sex with _____?"

- a) Women only
- b) Men only
- c) Both men and women
- d) Neither"

With a follow-up question for those who respond "c" to the above:

- "In the last year, have you had sex with _____?"
- a) Women only
 - b) Men only
 - c) Both men and women
 - d) Neither"

Attraction:

- "Which best describes you?"
- a) I am attracted mostly or only to women
 - b) I am attracted mostly or only to men
 - c) I am attracted to both men and women
 - d) None of the above."

Sexual identity or orientation:

- "Which word best describes you:
- a) Straight
 - b) Heterosexual
 - b) Gay
 - c) MSM (men who have sex with men)
 - d) Homosexual
 - e) Bisexual
 - f) Local term 1
 - g) Local term 2
 - h) Local term 3
 - i) Other, specify: _____"

The local terms in common use in the area need to be determined in the formative phase of the survey. Decisions also need to be made concerning whether transgendered persons are included in this framework, determined what population size estimation is being made and how the data will be used.

HIV prevention and epidemiology are mostly concerned with sexual behavior. Therefore the second of the above questions may be practical if the objective is to measure the size of the population who has had male-male sex recently, if space in the questionnaire is limited, or if the situation limits the suitability of the questions on attraction and identity. Nonetheless, if the main objective is to determine the size of the men who have sex with men population that may be at risk now or in the future, is it worth considering questions on sexual attraction and orientation regardless of the behavior engaged in up to that point. This is particularly important for young respondents who may be not yet be sexually active with either

gender.

Another approach to measuring male-male sexual behavior is indirect or more subtle. For example, many sexual risk behavior surveys review the characteristics of each partner for up to several partners in the period preceding the survey. In this structure, each partner can be described by several key variables, such as age (in years), sex (male/female), relationship status or partner type (spouse, regular partner, casual partner, commercial partner), HIV status (positive, negative, unknown). In asking this pattern of questions of all respondents, men who have sex with men status happens incidental to male respondents reporting the male sex of one of their recent partners. However, there may be a misperception of the intention on the part of the respondent or interviewer if face-to-face. An example of this approach is the following:

“This next set of questions is about sexual experiences you may have had during the past 6 months. While some people have had a lot of sexual experience, others have not, so questions may or may not apply to you. Please answer these questions as accurately as possible and remember that your responses will be not be reported to anyone or traced back to you.

To start, I will ask you about sexual experiences within the past 6 months since _____ (MONTH/YEAR).

How many different people have you had sex with in the last 6 months?
_____ persons

Starting with the most recent partner you have had sex with, please describe the most recent 5 partners in the last six months.

PARTNER NUMBER →	1	2	3	4	5
RECORD INITIALS OR NICKNAME →					
A. Sex (M = male, F = female)					
B. AGE (in years)					
C. TYPE OF PARTNER (S = spouse, R = regular, C = casual, E = exchange, gave or received money for sex)					
D. IF EXCHANGE PARTNER: Did they pay you or did you pay them? (R = I received money for sex, G = I gave money for sex)					
E. [Other partner characteristics, e.g., HIV serostatus, disclosure, episodes of sex, condom use, STIs, concurrency, etc.]					
F. [Other partner characteristics, e.g., HIV serostatus, disclosure, episodes of sex, condom use, STIs, concurrency, etc.]					
G. [Other partner characteristics, e.g., HIV serostatus, disclosure, episodes of sex, condom use, STIs, concurrency, etc.]					

In addition to determining if male respondents had same-sex behavior, the above framework also provides measures of the number of respondents engaging in commercial sex, producing population size estimates for the number of female sex workers, male sex workers, and the clients of each.

Note that the framework can be extended to measure other partner characteristics and sexual risk behaviors with each partner and partner type.

In isolation, a single question on current injection drug use may not accurately assess whether someone is a person who injects drugs due to confusion over whether the drug was prescribed for a medical reason, whether the drug in question is considered an illicit drug, the time frame concerned, or whether the drug was taken through other routes. Measures of injection drug use are therefore often included within a series of other questions on alcohol and drug use. The following is an example of a framework to collect information on drug use that includes injection drug use.

Many people have tried different drugs, others have not. From the list in the survey box below, which drugs have you ever used? Used in the last 12 months? Injected in the last 12 months?

	Ever used	Used in the last 12 months	Injected this drug in past 12 months?
a. Alcohol	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	NA
b. Marijuana	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	NA
c. Painkillers prescribed by a physician	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
d. Painkillers prescribed by a physician	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
e. Cocaine	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
f. Steroids prescribed by a physician	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
g. Steroids not prescribed by a physician	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
h. Methamphetamine	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
i. Morphine prescribed by a physician			
j. Morphine not prescribed by a physician	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
k. Heroin	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
l. Other Please Specify	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
m. Other Please Specify	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂
n. Other Please Specify	<input type="checkbox"/> ₀	<input type="checkbox"/> ₅	<input type="checkbox"/> Yes ₁ <input type="checkbox"/> No ₂

The choice of drugs and terms used for the drugs should be locally adapted. Note that reporting any drugs injected, whether obtained from a pharmacy or on the street may designate someone as a person who injects drugs for population size estimation purposes.

For confirmation and clarity, it is often wise to directly ask a second time whether the respondent has injected drugs regardless of their responses above:

“In your lifetime, have you ever injected a drug that was not prescribed by a physician?:

- A) Yes
- B) No
- C) Decline”

“If yes, have you injected in the last 12 months?

- A) Yes
- B) No
- C) Decline”

Strengths and weaknesses

Surveys are generally easy to implement. Surveys are longstanding methods in the statistical literature,²² so results will be relatively easy to analyze and defend and are politically influential. In general, it is fairly easy to find a sample frame for a general population survey.

Population-based surveys are less useful for measuring rare behaviours because they may not be reflected in the sample selected or when those at risk are not found in households, schools, or other institutions.

In addition, if behaviour has been stigmatized within a society, respondents may report stigmatizing behaviours less often than non-stigmatizing behaviours, especially if the interview is not conducted in a confidential setting. Furthermore, high-risk populations may not be found in general household settings.

Strengths and Weaknesses of the Population Survey Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> • Surveys are common and familiar • Easy to implement if there is a list of key population • Straightforward to analyse and easy to defend 	<ul style="list-style-type: none"> • Difficult to use when behaviours are rare or <i>stigmatized</i> • Only reaches people residing in households, schools, or other institutions • Respondents unlikely to admit to high risk or stigmatized behaviours if interview is not conducted in a confidential setting

Network scale-up method

The *network scale-up* method is a pilot that is being considered at the time of publication of this participant manual. There still are a number of adjustments that need to be made to estimates produced from network scale-up. The method is presented here because in the near future it may provide an additional estimate to compare to other size estimates.

Principles of the network scale-up method

The network scale-up method uses information collected in general population household surveys to estimate the size of hidden populations. However, instead of asking about the respondent's own HIV risk behaviours, this method asks about the behaviours of the respondent's acquaintances.

Based on the average number of individuals that respondents know in hidden populations and the average personal network size of the respondent, the proportion of people in the most at risk population is estimated.

There are three steps to the network scale-up method:

1. Estimate the respondent's average personal network size for the general population.
2. Ask the respondent how many individuals s/he knows in each of the hidden populations of interest.
3. Calculate the estimated population and adjust for known biases.

Please see the example in the box below:

A country has a total population of 300 million people. A respondent to a general population survey knows two people of 300 who inject drugs. From this response, we can estimate that $2/300$ th of the general population are injecting drug users.

Combining that estimate with the total population size of the country, we could estimate that there are 2 million people who inject drugs in the country.

The estimate can be improved by averaging over many respondents with different network sizes and the number of persons they know who inject drugs.

Step 1: Determine personal network size

Step 1 of the network scale-up method is estimating personal network size. That is, how many people does the respondent know? In most cultures, the idea of knowing someone (network size) and who we know is not specific.²³

- Does who you know apply to current acquaintances or everyone known during your lifetime?
- How well must you “know” someone to count them in your network?
- If you name someone as your acquaintance, must they also name you as one of theirs?

A definition of personal network should be used consistently over time to reduce *bias*. Previous network scale-up studies have used the following definition of a personal network member:

Someone who knows you and you know them by sight and name. You can contact them or they can contact you. You have had contact with them in the last 2 years. The person lives in [specific area of reference].

Estimates of average network size in developed countries have *ranged* from 1700 for an unusual study using a phone listing to a more consistent estimate of 290 in the United States.²⁴

Two methods have been explored for estimating personal network size: the *summation method* and the *known population method*.

Summation method

In this method, you will ask respondents for a direct estimate of their personal network size. To break this down into a manageable task, the respondent is asked to count how many acquaintances he has in each of a set of mutually-exclusive, but exhaustive, categories. By summing up the number of acquaintances in each category we have a direct estimate of the number of people the respondent knows.

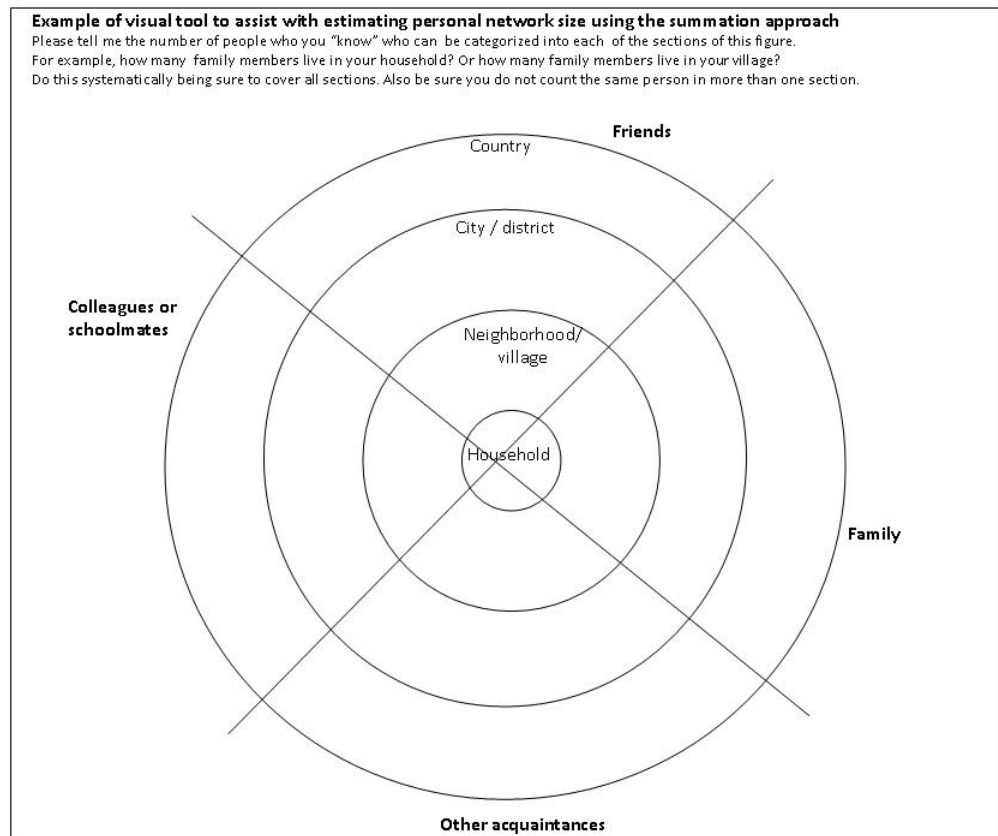
You must adjust the categories to fit the situation in your country. As a rule, people are able to count up to 20 individuals without writing out a list. If a category is likely to contain more than 20 people routinely, subdivide the category. A partial list of categories is provided in **Table D-1**.

Summation method, contd.

Table D-1. Possible breakdown categories for the summation method

- Immediate family
- Other birth family/family of spouse/partner
- Co-workers
- Other people at work
- Best friends
- People known through hobbies/recreation
- People known through ... (religious organizations, neighbourhoods, school)
- People known through others
- Childhood acquaintances or friends
- People who provide a service

One option to get accurate answers on a personal network size is to provide a visual prompt (Figure D-1). The respondents will know in advance what categories will be covered and should be able to avoid counting an acquaintance in multiple categories.



Summation method, contd.

Clearly, the choice of categories for a summation method is culturally dependent. Develop this list at the country level and test it to ensure that the list avoids overlap as much as possible and is exhaustive.

Known Population Method

Using the known population method you will ask respondents about the number of people they know in specific populations for which the number of people is known.

If *census* data show there are 3,200 people named Michael in a country with 300,000 people, and the *mean* number of acquaintances named Michael (calculated from the respondents) is 5.57, the estimated personal network size can be calculated as²³:

$$\frac{5.57}{3200} \times 300,000 \approx 522 . \quad (D-2)$$

Continuing with this example, imagine a survey done in the general population of 300,000 individuals. In addition to the set of questions to estimate respondents’ personal network size, respondents were also asked how many people they knew who were drug injectors. Subpopulations used in the hypothetical study are given in **Table D-2**.

Table D-2: Example subpopulations used for the known population method to estimate average network size

Sub-population	Size of known subpopulation in country	Mean number known to respondents
Had a child in last 12 months	4,000	3.20
Has diabetes	6,500	2.43
Opened business in last 12 months	630	0.83
Moved house in last 12 months	8,200	1.68
Voted for X in last election	20,000	3.33
Was born in a different country	22,000	4.76
Is widowed & < 65 years of age	3,300	2.83
Is named Michael	3,200	5.57

To estimate average network size, the same calculation that was done for the name Michael is done for each of the known populations.

Below are several tips on selecting known populations:

Known population method, contd.

- Ideally, 20 to 30 known populations will be used to create a reliable estimate of personal network size.
- To make a fairly accurate estimate the known populations should be on average 0.1% to 4% of the total population.
- This method works best if the known populations are similar to the general population, such as the same age group or same sex.

Strengths and Weaknesses of the Network Scale-Up Method using the Known Population Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> • Allows quantification of uncertainty and a “reality check” of the estimates of hidden population size 	<ul style="list-style-type: none"> • The accuracy of responses is unknown • Biases may be introduced by the type of questions asked • Relatively accurate administrative records are required

Step 2: Ask the survey respondents who they know in the hidden population

In a general household survey, respondents are asked how many people they know who inject drugs, sell sex, purchase sex, or are men who have sex with men. These questions are not always easy to insert in a survey because of stigma, discrimination, and possible illegality of these behaviours. The wording and the location of these questions within a survey are important aspects to consider.

Also keep in mind that:

- Interviewers should be trained on how to ask these questions.
- The *confidentiality* of the interview must be assured.
- The wording of these questions is most important. If the wording is left to each interviewer, there will be variations in interpretation and responses among people being surveyed.

Step 3: Calculate the estimated population size and adjust for known biases

In step 3, calculate the size estimate by dividing the average number of people in the known populations by the average network size and multiplying by the total adult population.

There are several problems associated with the approaches described for estimating personal network size and the resulting size estimates:

- The size of a network may vary among individuals.
- A respondent may be unaware that someone in their network is a member of the population of interest (known as “transmission error”).²⁵
- The position of a respondent may cause him/her to know fewer members of the population of interest than would be expected (*barrier effects*). For example, people who live in rural areas may be less likely to know someone who injects drugs.²⁶
- Some populations might not admit knowing individuals with the hidden behaviours.

Current efforts are focused on how to adjust for these biases. For example, studies are underway to measure transmission error based on surveys of most at risk populations. In addition, statisticians are looking into the sample size required to conduct a network scale-up survey and the estimation of variance.

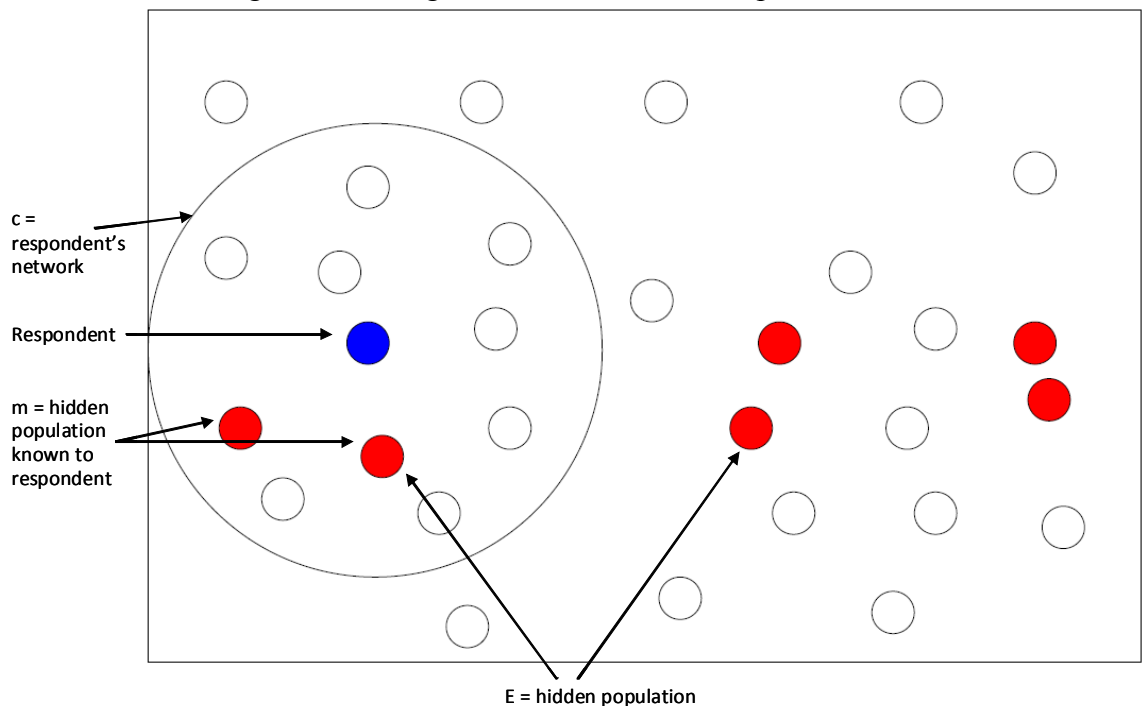
Step 3, contd.

The concept of the network scale-up method is displayed in **Figure D-1**.

Consider the following:

- The whole box to be the total population T
- c is one individual's acquaintances (or personal network size)
- m are persons who inject drugs among those acquaintances
- E is the size of the hidden population (the value of interest)
- N is the total number of people in the survey.

Figure D-1: Diagram of Network Scale-Up Method



(Source: Adapted from McCarty et al.)

We can then estimate E using the below formula where the subscripts are the survey respondents, 1 through N .

$$E = \frac{c_1 + c_2 + c_3 \dots c_N}{m_1 + m_2 + m_3 \dots m_N} \bullet T \quad (D-1)$$

Strengths and weaknesses

Network scale-up may have significant advantages over existing methods:

- It does not require members of hidden populations to identify themselves to a survey team.
- The questions can be incorporated into existing household surveys so estimates can be generated at the level of those surveys, typically national or provincial.
- The method can create size estimations for multiple hidden populations in one survey.

In addition, the box below lists the strengths and weaknesses side by side:

Strengths and Weaknesses of the Network Scale-Up Method for Size Estimation	
Strengths	Weaknesses
<ul style="list-style-type: none"> ▪ Can generate estimates from the general population rather than hard-to-reach populations ▪ Does not require asking detailed sensitive questions or doing a lengthy behavioural survey ▪ Can be used to create a size estimate for multiple hidden populations. 	<p>At the time of this publication, there are still a number of adjustments required for estimates produced from network scale-up:</p> <ul style="list-style-type: none"> ▪ Adjustments to account for barrier effect in that some subgroups may not associate with members of the population. ▪ Adjustments to account for the transmission effect in that a respondent may be unaware someone in their network engages in the behaviour of interest.

Additional information on the full network scale-up method is available at <http://nersp.osg.ufl.edu/~ufruss/scale-up.htm>

Summary

Network scale-up methods may be effective in estimating sizes of populations at risk of HIV because they require only contact with the general population and not with the population at risk. The method is inexpensive and lets you estimate the sizes of different populations in a single survey. Proper implementation depends on access to the prevalence of several known characteristics in the population, and the performance of the method seems better with the increasing number of subpopulations. Validation of the method will depend on comparison with other methods of population size estimation.

Exercises: Unit D

Warm-up exercises

Review your answers to the warm up questions for this unit. Make any changes you want to make.

Case study D-1

To estimate the size of a population of injection drug users, a network scale-up approach is implemented in a region of approximately 19,000 people. In this region, a Demographic and Health Survey has been conducted. Thus, the investigators have access to national estimates of population sizes in several categories:

- Characteristics of households
- Fertility
- Family planning
- Early childhood mortality
- Maternal and child health and nutrition
- HIV knowledge and behaviors
- Malaria knowledge and behaviors

A second survey is now conducted in the region by village health workers who make household visits. Among other questions, respondents were asked: “How many members of <subpopulation> do you know?” The list of subpopulations used as well as best national estimates are given in Table D-4.

Table D-4. Subpopulations used, demographic and health survey estimate, and mean number known to respondents

Subpopulation	Size of subpopulation	Mean number known to respondents
Women aged 14-25 years with no education	657,000	2.43
Has at least one telephone	10,600	5.76
Can name any method of contraception	18,500	1.68
Has had a child die aged < 1 month	6,200	3.42
Women smoking tobacco	10,000	4.06
Heard of HIV/AIDS	16,000	3.20
Know an injection drug user	?	0.56

1. How would you describe a barrier effect in this context? How could you assess the effect of this potential bias?
2. Describe a transmission effect for this context and the potential effect it may have on your estimate.
3. In this context, which of the three assumptions is likely to be most important? Why?
4. How could you use this information to estimate the size of the injection drug user population? Comment on how this estimate could be used.

NOTES

UNIT E: Choosing a method then collecting data, Steps 5-6

Overview

What this unit is about

In estimating the size of populations at high risk for HIV infection, different approaches are needed. You must adapt these methods to make them suitable for your area and subpopulations. This unit lists what you should consider when choosing a size estimation method, compiling existing data, and collecting additional data.

Warm-up questions

1. Which method is best for use with brothel-based sex workers?
 - a. Census method
 - b. Multiplier method
 - c. Capture-recapture method
 - d. Network scale-up method
 - e. None of the above
2. What method should be considered for injection drug users when the existing and available data are fairly good?
 - a. Census method
 - b. Multiplier method
 - c. Capture-recapture method
 - d. Network scale-up method
 - e. None of the above
3. What method should be considered for use with men who have sex with men if no data sources are available and a new population-based survey is planned?
 - a. Census method
 - b. Survey method
 - c. Capture-recapture method
 - d. Network scale-up method
 - e. None of the above
4. List two issues to keep in mind for estimating the size of the most-at-risk adolescent population if data are available.

5. What are three key questions to ask yourself after doing an inventory of existing data to determine whether they are appropriate for population size estimation?

Introduction

What you will learn

By the end of this unit, you should be able to:

- Understand the use of population size estimation
- Recognize how to select a method
- Examine what data are available
- Discuss the use of multiple methods
- Discuss special considerations based on country or culture, or both.

Special considerations for choosing a method for different populations, Step 5

Risk behaviours vary by country and region, and estimates should not be generalized to groups. Estimation results are subject to political as well as scientific use. The discussions in this document are intended only as general guidance. Survey teams in various cultural situations should make adaptations for that area.

Estimating the size of sex-work client populations

In countries where buying or selling sex is fairly prevalent and not highly *stigmatized*, a household survey is an appropriate method of estimation; for example:

- In some countries in Asia, 5% to 25% of adult men report having paid for sex in the past year. The *proportion* of respondents reporting buying sex can be applied to *census denominators* in various strata, such as age.
- If population surveys already exist, adding a few questions can be cost effective.
- For countries uncomfortable asking sensitive questions about paying for sex on surveys, multiplier methods can be used with behavioural data on number of partners from surveillance of sex workers.

Estimating the size of sex-worker populations

- Census methods are useful for brothel-based sex workers.
- Use *enumeration* for situations where there are large numbers of venues and the sex workers do not move quickly between locations.
- Use *capture-recapture* to estimate the size of street-based sex-worker *populations* when it is not possible to create a list of venues or conduct a census.
- *Multiplier methods* will be useful for local estimates; however, it might be challenging to find lists from administrative sources to provide a multiplier for a national estimate.

Estimating the population size of persons who inject drugs

- General population surveys are not useful for estimating the size of injecting drug populations because the *sample* size is not large enough to capture drug users. Expect underreporting with this group due to their fear of legal repercussions.
- In most countries, there are more existing data sources, such as treatment data, arrests, and registries, on drug use than for other risk behaviours. However care should be taken to make sure these sources are complete and accurate.
- Capture-recapture methods should be considered when programme data sources are reasonably good and in the absence of a strong law-enforcement approach to persons who inject drugs. Any procedure relying on names or other identifying information in a context where the risk behaviour is punishable by death or imprisonment will produce inaccurate estimates.
- Multiplier methods can be useful where treatment service records are of good quality. In this case, since multipliers vary by location, the national estimate should aggregate as many local area estimates as are available.

Estimating the population size of men who have sex with men

This population often is well hidden and not captured in routine data collection.

- If men are open about having sex with other men, a census conducted at gathering locations could be useful.
- If no programme data sources are available, a cost-effective option is to include same-sex behaviour on existing general population surveys. However, these estimates are likely to be underreported, especially in settings where such behaviours are highly stigmatized.

Estimating the size of most-at-risk adolescent populations

Programmes aimed to prevent HIV infection often need to be targeted to specific age groups, especially among populations such as sex workers or injecting drug users, because:

- Programmes for people who recently initiated the behaviour (or younger people) focus on changing lifestyles, such as developing alternative work skills or entering drug treatment programmes.
- Programmes for persons who have had the behaviour for a number of years, and who are generally older, tend to focus on changing specific behaviours, such as increasing condom use or using safe needles.

When possible, collect local size estimates by different age groups. This might be challenging if you are using the methods described in this manual because age information is not commonly collected.

Where Data Are or Are Not Available When Estimating the Size of Most-at-Risk Adolescents	
Where data is available from a recent survey	Where data is not available
<ul style="list-style-type: none"> ▪ Identify the proportion of the population in different age groups ▪ If there are large <i>biases</i> in the sampling structure (such as the use of respondent-driven sampling) the proportions in different age groups might be biased ▪ Know the inclusion criteria in the survey: adolescents under the age of 18 years might be excluded because of ethical concerns---these data would provide a biased response 	<ul style="list-style-type: none"> ▪ Add a component to the proposed survey methods that allows you to make an estimate of at-risk adolescents

Estimating the size of most-at-risk adolescent populations, contd.

Likewise, various size estimation methods entail different requirements and challenges.

Table E-1: Estimating the size of most-at-risk adolescent populations

Size Estimation for Most-At-Risk Adolescents	
Method	Challenge or solution
Enumeration or census methods	<ul style="list-style-type: none"> ▪ The addition of a simple classification by age could be added to the enumeration tool.
Unique identifier	<ul style="list-style-type: none"> ▪ A mark on the object or color of the object could be used to identify whether the recipient is less than 25 years old.
Multiplier method relying on programme records	<ul style="list-style-type: none"> ▪ Service providers might not always have the age of the attendees.
<i>Network scale-up</i>	<ul style="list-style-type: none"> ▪ Ask an additional question for each population of interest, such as "Among the sex workers that you know, how many are under age 25?" ▪ The results of these questions will introduce additional biases so this method should only be used as a last resort.

Address limitations

Each of the methods considered in this document have limitations that are important to recognize and address. When you are interpreting population size estimates, always ask:

- Who is reporting the estimate?
- How was it obtained?
- Has that method been peer-reviewed?
- What are the underlying assumptions?

Be wary of simple before/after comparisons or reporting selective estimates. Keep in mind that population size estimation is meant to quantify the problem of HIV risk, not to solve it. Although some methods share elements that also can be used in building programme access (enumeration exercises, for example, may use *mapping* techniques that share much in common with the implementation of surveillance),

Address limitations, contd.

estimates exercises are intended to count people, not to access them for prevention and care services.

Annex 4 summarises the different methods for creating size estimates and the strengths and weaknesses with each method.

Step 6: What data are available?

Many countries maintain data sources which could be useful for estimating population size. Even if existing data are insufficient to do so, they can be valuable for assessing *representativeness* or for augmenting new data.



After finding existing data, determine whether they are appropriate for population size estimation:

- Does the data allow identification of members of the particular subpopulation?
- How good is the quality of data? Workers in clinics may not pursue information on *risk factors* to avoid alienating people in treatment; this may bias population size estimates.
- Do legal or other regulations prevent sharing the data with public health officials?

If existing data are judged inadequate, consider other regular data collection activities in the country. The following can provide information for population surveys and multiplier methods:

- A national census
- HIV surveillance
- A national health status survey.

Selected additional questions may be added when these country data systems are revised.

Summary

Since risk behaviours vary by country and region, estimates should not be generalized to groups. Estimation results are subject to political as well as scientific use. Keep in mind that there are special considerations for choosing a size estimation method depending on the specific population. Before estimating population size, find out what information already exists, including data outside the health sector. Respect respondent *confidentiality* and protect their information from breaches of security.

Unit E: Exercises

Warm-up review

Take a few minutes now to look back at your answers to the warm-up questions at the beginning of the unit. Make any changes you want to make.

Small group discussion

1. You need to make an estimate of the injection drug user population among sex workers in your country. List aspects that you will need to consider in defining this population.
2. In your county, what is the most important consideration in choosing among the methods for estimating population size?

Apply what you've learned/Case study E-1 ²⁷

A local study in region R produced an estimated injection drug user population of approximately 37,000. Use this finding to estimate the number in the entire country.

If one third of the population of the country resides in the local area, provide an estimate of the number of injection drug users in the country. What is one major problem with this approach?

NOTES

UNIT F: Analyze, Disseminate, and Use Results, Steps 7-10

Overview

What this unit is about

This unit considers aspects of analyzing population size estimation activities, including discussing bias and sampling error, validating an estimate, and principles for extrapolation.

Warm-up questions

1. True or false? Extrapolation refers to the use of known data from some regions to apply estimates for other regions.

True

False

2. List one advantage and one disadvantage of extrapolation.

3. What is the difference between reliability and validity?

4. True or false? Unlike other surveillance activities, it is not necessary to document the process when undertaking size estimation.

True

False

5. What is the main reason to time the dissemination activities based on the priority level of the stakeholder?
 - a. To make sure funding is available for all necessary dissemination activities
 - b. To incorporate feedback before the final report or next dissemination meeting
 - c. To ensure the findings demonstrate what the primary stakeholders want to hear
 - d. All of the above.

6. How can data from size estimation activities be used?
 - a. To design interventions
 - b. To understand your epidemic
 - c. To report UNGASS indicators
 - d. All of the above

Introduction

What you will learn

By the end of this unit, you should be able to:

- Identify issues related to bias and *sampling error*;
- Recognize the relationship between reliability and validity; and
- Discuss how to extrapolate data to a national population size estimate.

Step 7: Analyse and interpret the results

In the final phase of population size estimation, you will analyse, disseminate, and use the size estimates. Estimates of the size of most-at-risk populations are likely to be uncertain. As we discussed in **Units D-E**, each method has specific biases to remember when you analyse results. This unit describes some of the issues to consider and provides real world examples.

Sampling error and bias in size estimates

Analyse and report on the sampling error of the size estimate. Even in a perfect survey, a sample selected randomly from a population will almost never be exactly the same as the entire population. This is the result of sampling error. Most statistical methods allow for estimation of sampling error (e.g., the variance, or a confidence interval).

You have probably heard or read statements such as the following:

- The survey was based on 570 interviews conducted between March 20 and 31. The sampling error was plus or minus 4.5 percentage points.
- 48% felt that there may be too many sex workers in the country. The poll of 996 adults was conducted 1-3 May and has a margin of sampling error of plus or minus 3 percentage points.

These descriptions are reporting confidence intervals. The technical definition of a (95%) confidence interval is this: if you repeat the same data collection procedure many times, with the same methodology and same sample size, approximately 95% of the intervals that you compute will contain the true value for the population. The confidence interval gives us some idea of the range of error that may be expected for an estimate.

We use confidence intervals to compare the results of different estimation activities. For example:

- An estimate of the female sex worker population in a region 5 years ago was $5,767 \pm 215$.
- A new estimate for that same region today, using the same estimation method was $6,102 \pm 178$.
- Can we say that the size of the sex worker population has increased?
- Clearly, the new estimate of 6,102 is greater than the previous one of 5,767.
- However, if we consider the confidence intervals, the estimate five years ago (5,552 to 5,982) seems to overlap the updated estimate (5,924 to 6,280).
- Thus we would say that the estimates are really no different, and the apparent difference in estimates can be explained by sampling variability.

Bias results when the data were collected incorrectly or the sampled population does not adequately represent the population of interest. Bias can result from several sources; the two most important for population size estimation are:

- Measurement bias – measurements are taken (questions are asked) incorrectly.
- Sampling bias – data are collected from a non-representative sample

Bias can be present in surveys and other data sets even if sampling and analysis are done correctly. Neither a large sample size nor statistical methods can correct for bias. In most cases, bias cannot be quantitatively measure or calculated.

Since we cannot control for bias by larger samples or statistical methods (there is no cure), it is important to prevent it. This prevention is most effective if done prior to data collection by ensuring that survey questions are valid and reliable, using correct measurement techniques, and carrying out the sampling correctly and randomly. Thus it is recommended that you have experts review your survey plans, provide ongoing training to field workers, ensure field supervision, and perform interim quality checks on data.

Implications of not knowing whether you have bias in your survey include making inappropriate decisions about programmes based on invalid results. You might:

- Fail to provide needed services,
- Waste resources on providing unneeded services, or

- Lose credibility by providing invalid estimates.

At the very least, you have wasted the resources and time because the results do not reflect the true situation in the population.

Annex 3 walks you through further detail regarding bias and sampling error.

The reliability and validity relationship

In estimating the size of populations, we want to use methods and measuring instruments that are valid (have high *validity*) and reliable (have high *reliability*).

A *valid* estimate is one that accurately measures what it is supposed to measure. The validity of data collected in populations most at risk for HIV infection depends partly on accurate answers to sensitive questions about sexual practices, drug use, and incarceration.

A *reliable* estimate is one that provides similar results when repeated with the same respondents in the same time period. For population size estimation, we are concerned about consistent data received from multiple sources; for example:

- Persons reporting injecting drug use in one question would be expected to give that same answer in a later question.
- Persons give consistent answers about the use of a service would give close to those same answers later.

Extrapolate local estimates to national estimates

Most methods are more easily applied at the local level than at the national level because:

- Programme data are usually applicable to a geographic region that is smaller than a country.
- It is easier to develop lists of venues where the populations of interest congregate in a city or district. It would be much harder to develop a national list of all venues that sex workers or person who inject drugs frequent.
- Programme data collection may be more consistent at a local level. If several regional treatment clinics provide data for persons who inject drugs, then methods and the quality of record keeping may vary widely from region to region.

How to use local study results to reach a national estimate

Can population size estimates from local studies be used to *extrapolate* to a national population size estimate? In this case, *extrapolate* means using the data from some locations or areas to estimate for other areas.

The purpose of *extrapolation* is to generalize from a series of local studies. You want to provide estimates of the national target population size. To be valid, the larger regions should have the same data sources as the local areas. You would:

- Map the larger area, such as country, divide it into smaller areas, combining areas with similar characteristics
- Find data that may already exist or you can collect new data in some of the small areas.
- Use an extrapolation procedure with your data to create a national estimate.

Strengths and Weaknesses of Extrapolation	
Strengths	Weaknesses
x t r a p o l a t i o n s <ul style="list-style-type: none"> ▪ Uses existing data sources ▪ Provides ways to get estimates when little data is available about specific populations 	<ul style="list-style-type: none"> ▪ Must consider geographic variability and whether the same percentage applies to the entire population ▪ Data must be local and able to be extrapolated to other areas ▪ Definitions from data must match definition of the population

**Extrapolation
Example 1**

Extrapolation methods may be simple or complex. Consider the example in the box below:

Extrapolation Example 1: Detailed example of using local estimates to develop a national estimate

You live in a country that wants a national estimate on people who inject drugs to improve prevention and treatment services.

A local study in region R produced an estimate of approximately 37,000 people who inject drugs. If one third of the population of the country resides in the local area, there are 111,000 ($3 \times 37,000$) persons who inject drugs in the country. A major problem with this approach is that it assumes no regional differences in drug use. If region R were a major urban area, port city, or border crossing, then it may not be representative of all rural regions.

Now suppose we have national data on drug treatment and fatal drug overdoses, and these data show consistently that approximately half of persons in treatment and half of drug deaths are from region R. You may assume that the national number of persons who inject drugs is proportional, not to population but to numbers of drug deaths. This approach assumes that the fatal drug rate, not the prevalence of use, is constant geographically.

Using this approach, we would estimate that $2 \times 37,000$ or 74,000 is the size of the injection drug using population in the country.

Source: Lynskey M, Hall W. Jurisdictional trends in opioid deaths 1988-1995. Australian and New Zealand Journal of Public Health. 1998;23:519-24.

**Extrapolation
Example 2**

Extrapolation Example 2: Using biased estimates

Your government wants an estimation of the number of sex workers in the country. There are results of a study that estimated the number of sex workers based on one region or city. If a national survey exists with a biased but representative estimate of the proportion of sex workers in the country you could use the locally collected “true” estimate of sex workers to derive the undercount in the national survey. The undercount could then be applied as appropriate to the remainder of the country.

Simple extrapolation might apply the same percentage to all areas. More complex extrapolation tries to account for other factors: socio-economic factors, geographic area, and different sub-populations. Ask yourself these questions:

- Does your country’s geography vary? If so, applying one percentage to a whole population may not be appropriate.
- How local are the data? If the area is too large, the local estimate may not be truly local and thus may be inaccurate.
- In the local surveys, do the definitions of the at-risk population match?
- Do the local data apply to the specific at-risk population? For example, does sex work in urban areas refer to sex work in all types of locations: brothel-based, street-based, and entertainment-establishment based? Do the local data consider only a subset of these groups?
- What type of men who have sex with men are included in the local data you have obtained: higher-risk, venue-based, any man who has sex with a man?

Extrapolation methods *range* from simple to complex. Simple extrapolation might apply the same percentage to all areas. More complex extrapolation might:

- Try to account for factors related to differences between the proxy data and size in areas where you have both types of data
- Characterize by these factors all the areas you are extrapolating
- Try to develop formulae that apply in different *epidemic* scenarios or socio-economic areas or to different sub-groups.

Extrapolation
Example 3

As an example of complex extrapolation, of Indonesia's 440 districts, only some had data estimating the size of the sex worker population. However, a national survey of village leaders was conducted in villages in each of the 440 districts. In this survey, village leaders were asked "Are there sex work spots in your village?"

- Investigators calculated the percent of district villages whose leaders said YES to this question.
- All 440 districts were ranked by the percentage of villages in that district with sex work spots. This ranking was distributed into quintiles (that is ranked 1, 2, 3, 4 or 5). In other words, districts with the highest proportion of villages with sex work spots were assigned to the highest quintile, 5, and districts with the lowest proportion of villages with sex work spots were in the lowest quintile 1.
- For each district with size estimation data, investigators used these data to calculate the average percentage of the adult female population that are female sex workers.
- These data were aggregated to come up with an average size of sex worker population for each of the five quintiles, ranging from 0.05 percent of the adult female population in Quintile 1 to 0.73 percent in Quintile 5 (see **Figure F-1**).
- These averages were then applied to districts without data in the matching quintile group as shown below. **Table F-1** shows how this calculation was done for four districts, based on the known size of the district's adult female population and its ranking by quintile.

Figure F-1: Extrapolation for female sex workers, Indonesia
(Source: adapted from PEMA presentation)

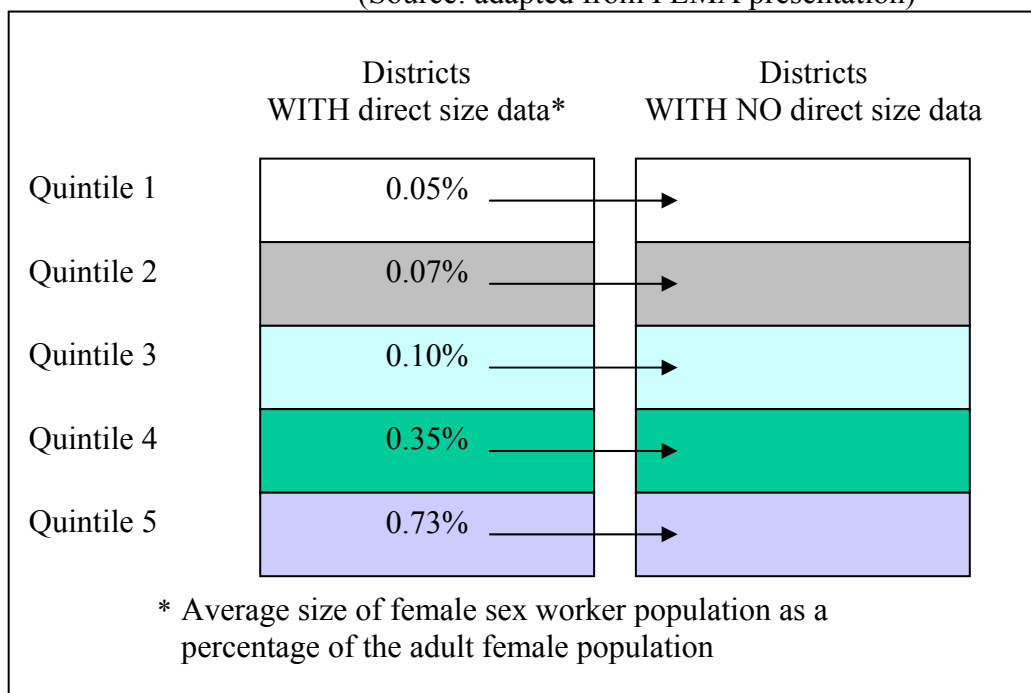


Table F-1: Estimated population size by district

District	Adult female pop size (a)	Quintile (b)	% from quintile (c)	Estimated # of sex workers in district (a) x (c)
District A	250,456	2	0.07	175
District B	1,329,875	5	0.73	9708
District C	546,982	2	0.07	383
District D	356,968	3	0.10	357

Using Multiple Size Estimates to Create the Best Estimate

Many of the methods discussed in this manual are *indirect methods*. That is, they arrive at population size estimates indirectly rather than by straightforward enumeration (counting). The validity of these methods often depends on assumptions that are difficult to verify. Several estimates may be quite different. Try to determine why they are different. Decide which estimate seems closest to the truth.

There is no reason for your country or local area to limit itself to a single method for estimating the size of a population most-at-risk to HIV. Find as many data sources as you can to improve your estimate.

- Using estimates from multiple methods allows for checks and balances. If results are vastly different we can go back and consider the assumptions and the method to find out which one is incorrect.
- Estimates from multiple sources which are similar will improve the credibility of the final estimate.

Before evaluating different estimates it is important to make sure the estimates are comparable. This might be documented by creating a matrix that explicitly describes the different estimates that will be compared.

- Describe the definition of the population for each estimate
- Describe the geographic region covered by the estimate
- Describe the method and the possible violations of the assumptions for that method
- Based on the violations of the assumptions document whether the estimate is likely to be an overestimate or an underestimate
- Finally include the estimate created by each method

Such a matrix will provide a clear and transparent description of the evidence available for determining the final estimate.

Detailed Example of using multiple estimates

Country X was recently estimating the number of persons who inject drugs in City Y. They had a number of different data sources from which to calculate size estimates.

- A recent general population survey had asked questions for network scale up.
- Programme data provided information on the number of persons who were registered in their “narcology” registry.
- Programme data were available on the number of people enrolled in a harm reduction project.
- 328 persons who inject drugs were handed a key chain (or unique object) by outreach workers.
- A survey using respondent driven sampling provided information on the proportion of persons injecting drugs who were enrolled in the harm reduction programme, who were registered with narcology, and who received the harm reduction key chain.

The different results for persons who inject drugs showed a range of estimates.

Method.....	Estimates of persons who inject drugs in City Y
Network scale up (adjusted for stigma).....	7,896
Multiplier method (needle exchange).....	7,774
Multiplier method (unique object).....	8,548-42,620
Multiplier method (narcology).....	3,483
Programme records (narcology).....	2,220

The programme managers compared the results and determined:

- Results were fairly consistent between the programme data multiplier and network scale-up: 7,774 and 7,896.
- Only 3 respondents in the survey reported receiving key chains. The small number of key chains returned in the survey resulted in a very large confidence interval for the unique object estimate: 8,548-42,620, however the lower bound is close to the other estimates.
- The narcology data even when combined with a multiplier, gives a very low number: 3,483. The narcology registration is likely to be incorrect for City Y since the registry classifies people by where they enrolled and not where they are currently living.

Based on the understanding of different biases and strengths and weaknesses of the methods the programme managers were able to determine a best estimate: they estimated that the number of persons who inject drugs in City Y was approximately 8,000.

Step 8: Document the process

The most important step in size estimation comes after you create the estimate. Consider how to improve the long-term use of the estimate.

- Carefully document all details of how the method was done. This is essential if the method is to be replicated to produce comparable results.
- Use clear and appropriate language.

Size estimates are much more useful when they are updated over time and can be studied for changes. Increases or decreases in the size of most-at-risk populations are more useful if they can be associated with interventions.

The methods described produce estimates with a large degree of uncertainty. This could make it difficult to measure significant changes in the population size. Also consider changes in the larger population, such as in total population size or numbers of young people, when you look for long-term trends.

Stating the steps, assumptions, techniques, and calculations taken to create the estimate will allow future replication of the process. Having comparable measures should be a high priority for managers who need to measure the effects of their programmes and policies.



Start your documentation with the protocol as it was initially developed.

The protocol must include:

- An explanation of why the population was chosen
- The definition used for the population
- The geographic area of the estimate
- The method chosen for the estimate
- The assumptions required for the method
- Any violations of the assumptions.

Document the process, contd.

In addition, you should do the following:

1. Clearly describe the sources of data you used. If you made decisions about whether to use a data source, include a decision-tree diagram.
2. Amend the protocol to explain any challenges that came up during the estimation exercise and how they were handled. Challenges with sampling could have biased the results. Data processing issues may have changed the analysis plan.
3. Document which parts of the at-risk population may be missed entirely, such as a survey at a drug treatment clinic may miss drug users who receive drugs from partners.
4. State whether and why you believe the estimate is an underestimate or an overestimate.

Step 9: Disseminate the results

Size estimates of populations at increased risk for HIV can be politically sensitive, and the media may misinterpret the results. Before you release the results, carefully study the wording and mechanisms you will use.

There are several ways to release the results, such as by:

- Press release
- Technical report
- Briefing to policy-makers
- Briefing with members of the population
- Briefing with civil society organisations that provide services or represent that population.

Develop a list of *stakeholders* who will access the results along with the method of release that you have chosen, the timing of the release, and any other useful information (**Table F-2**). Timing the dissemination activities to meet the needs of the stakeholder means the size estimation team has time to incorporate feedback from earlier sessions into a final report.

Table F-2: Example of dissemination plan matrix

Stakeholder	Method of sharing	Timing of dissemination
Civil society organisations and most-at-risk population	Briefing	First
Policy and programme managers	Briefing, executive summary	Second
Development partners	Technical report	Third
Media	Press release	Fourth

Use caution when disseminating results

Sometimes the results of the size estimation may threaten a community. As an example, if the community (general population) learns that there are more than 2,000 persons who inject drugs in their city, there might be a harmful response toward persons who inject drugs.

Incorporating messages about how to prevent or treat drug addiction in your final report might avoid such situations. Programme managers who work with most-at-risk populations should be involved in the development of the report and other products you plan to disseminate.



Step 10: Use the size estimates

It is essential to use the estimates appropriately for programme and planning activities.

Design interventions

Size estimates should be used for designing and developing intervention programmes to help people avoid risky behaviours. The estimated number of people in the populations will help determine the size of the response and the resources needed for interventions, such as the following:

- Condom distribution
- Clean needle exchange
- Drug treatment programmes
- Microfinance programmes for sex workers.

Know your epidemic and use of the estimate

Size estimates also should be included in the process of knowing your epidemic. The size estimates are used in creating national prevalence estimates in countries with low and concentrated epidemics. In addition, the size estimates are needed for creating models about the locations of future infections. Teams developing and costing national strategic plans will need the estimates to determine the resources needed for most-at-risk populations.

Finally, the size estimates are often used as denominators for reporting on international monitoring indicators, such as the UN General Assembly Special Session on HIV indicators. When applying for grants from international organisations, countries are asked to include size estimates for their most-at-risk populations.

The implementers of the size estimation exercise ideally should ensure that the size estimates are being used, and being used correctly, in these different applications.

Summary

Bias may produce incorrect estimates that, if sampling error is small, might cause inappropriate credibility for the estimate. The purpose of *extrapolation* is to generalize a size estimate from a series of local studies. Using multiple size estimation methods results in checks and balances. There is no reason for a country to limit itself to a single method and only a few data sources for estimating the size of a population most-at-risk for HIV. Documenting the process of your size estimation project is extremely important. Stating the steps, assumptions, techniques, and calculations taken to create the estimate will allow future replication of the process. Use caution when disseminating results. Size estimates of populations at increased risk for HIV can be politically sensitive, and the media may misinterpret the results. Before you release the results, carefully study the wording and mechanisms you will use. The results of your size estimates should be used for designing and developing intervention programmes, assisting with the knowledge of your epidemic, and as denominators for reporting on international monitoring indicators.

Unit F Exercises

Warm-up review

Take a few minutes now to look back at your answers to the warm-up questions at the beginning of the unit. Make any changes you want to make.

Small group discussion

Country X has a generalized HIV epidemic and growing concern about the rise of injecting drug use in the capital city. The National AIDS Commission recently conducted an Integrated Biological and Behavioural Survey of Persons who Inject Drugs in the capital city using respondent driven sampling. They incorporated Population Size Estimation into this activity as well. The surveillance team used two methods to estimate the size of the injection drug user population. This included three service data multipliers and a unique object multiplier.

Population Size Estimation Methods:

HIV Care: A local HIV Care clinic provides ongoing care and treatment for HIV-infected individuals. During the initial visit for HIV care, the nurse records the most likely mode of transmission in the patient charts through patient history and physical exam. The clinic was able to provide the surveillance team with a count of the number of patients for whom injection drug use was the most likely source of their HIV infection. There were a total of 3241 patients identified as injection drug users who received care and/or treatment at the clinic during the previous calendar year. In the subsequent respondent driven sampling survey, participants were asked if they had ever received HIV care from that specific clinic in the previous calendar year. A total of 13.2% of survey respondents reported that they had received care or treatment for their HIV infection at that clinic during this time period.

1. Calculate the population size estimate of persons who inject drugs using the clinic data and the survey response:

Police Arrests: The Capital City Police Department provided the surveillance team with a count of the number of individuals who were arrested for injection drug use in the last calendar year. There were a total of 2760 different individuals arrested in the previous calendar year for injection drug use. In the subsequent respondent driven sampling survey, participants were asked if they were arrested for injection drug use in the

previous calendar year. A total of 12.3% of survey respondents reported that they were arrested during the previous calendar year for injection drug use.

2. Calculate the population size estimate of persons who inject drugs using the police data and the survey response:

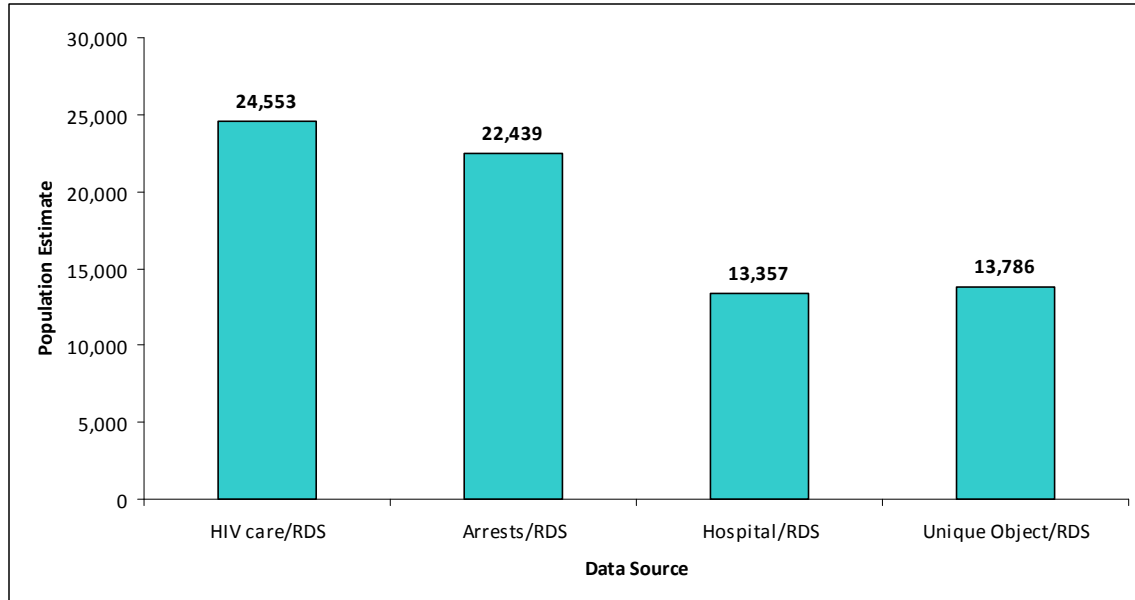
Hospital Emergency Room Data: The surveillance team received a count of the number of individuals admitted into the emergency room at the Capital City Hospital for wound care in the 6 month period between July and December of the previous year. There were 187 individuals treated for wound care in the emergency room during this period. Based on information in patient records, hospital staff were not able to exclude people who received care for wounds unassociated with injecting drug use, but considered this number to be small. In the subsequent respondent driven sampling survey, participants were asked if they had received wound care in the emergency room at the Capital City Hospital between July and December of the previous year. A total of 1.4% of survey respondents reported that they received wound care at the Capital City Hospital during this time period.

3. Calculate the population size estimate of persons who inject drugs using the Capital City Hospital emergency room data and the survey response:

Unique Object: Two weeks prior to the respondent driven sampling survey, peer educators from a local community outreach project were sent out to distribute 500 unique beaded bracelets to people they identified as persons who inject drugs. They attempted to ensure that each person received only one bracelet and asked recipients to keep the bracelet because they might be asked about it in the future by project staff. After the unique object distribution was completed. The surveillance team found out that only 386 bracelets were actually distributed and peer educators distributed the bracelet to people they were friends with. In the subsequent respondent driven sampling survey, participants were asked if they had received the beaded bracelet in the preceding two weeks along with verification questions to ensure that they had really received one of the bracelets distributed by study staff. A total of 2.8% of survey respondents reported that they received a beaded bracelet from study staff.

4. Calculate the population size estimate of persons who inject drugs using the unique object data and the survey response:

The population size estimates calculated using the various data sources are in the figure below. Did you get the same estimates?



5. What are some potential biases associated with each estimate? What steps could you take to limit these biases?

6. Of the four sources used to generate the population estimate, are there certain sources that may be more reliable than others? Why?

7. What number will you decide to present in your report as the size estimate of persons who inject drugs in Country X?

8. What other method would you use to estimate the population size of persons who inject drugs in the Capital City of Country X? What biases might these methods have?

Annex 1. Data Needs for a Regional Size Estimation Workshop

- The groups usually considered for size estimation are any or all of the following:
 - Female sex workers by subtype (based in brothels, bars, streets, hotels, residences)
 - Men who have sex with men
 - Male sex workers
 - Transgenders at risk
 - Injecting drug users
 - Clients of female sex workers
 - External migrants

It will be helpful to think in advance about the relevant most-at-risk populations in your country, and where concentrations of these populations might exist. Be prepared to discuss how geographic locations with high concentrations of these populations are identified in your country.

- Try to compile all available data sources with potential relevance for the size estimation process:
 - For as many years as possible
 - For specific time periods, if possible
 - For populations fulfilling specific definition criteria, if possible
 - Organized by the smallest geographic or administrative area possible (district, province).
 - Broken down by the smallest available sub-groups (among female sex workers, entertainment-based sex workers, street-based sex workers)
- Data sources may include but are not limited to:
 - Size estimates from situation assessments and *mapping* exercises by all methods (GIS, social mapping, rapid situation assessments, census, enumeration, *nomination*)
 - These studies may have been conducted by the programmes or “external” research groups. Both are valid.
 - Be sure to track down whatever documentation is available on how the exercise was conducted, including definition of the population “counted,” whether the exercise was done for the whole geographic area or only a portion (e.g. biggest towns, urban areas, where interventions planned/existing). This type of information can be critical for interpreting the data

- Monitoring data from programs conducting interventions among most-at-risk populations. The most helpful data will have the following characteristics:
 - Will pertain to *individuals who meet clear definitional criteria*
 - Will be unique for *individuals* (as opposed to contacts)
 - Be specific by time-period (e.g. available month-wise)
 - Will be specific to individual intervention programs

Examples of useful program data:

- Numbers of *individuals* contacted by peers/outreach worker
- Number of *individuals* receiving condoms from peers/outreach worker
- Number of *individuals* receiving needles/syringes
- Number of *individuals* screened for sexually transmitted infections
- Number of *individuals* treated for sexually transmitted infections
- Number of *individuals* visiting the drop in centres
- Number of *individuals* treated for abscesses
- Number of *individuals* referred for counselling and testing services
- Number of *individuals* referred to sexually transmitted infection centres
- Number of *individuals* registered with specific non-governmental organisation programs
- Number of *individuals* enrolled in long or short-term treatment (e.g. short or long-term detoxification for injecting drug users) by treatment centre

It can also be useful to note whether the programme uses unique identity numbers to track individual beneficiaries, or if the programme has a method for tracking drop-outs (i.e. those people who have moved or died or no longer participate in the programme). If yes, note the definitions and protocols used to maintain this tracking system.

- Survey data with following characteristics:
 - Uses *probability sampling* methods (e.g. cluster sampling, time-location sampling, or respondent driven sampling)
 - Measures exposure to program indicators (e.g. as outlined above), and can be linked to specific programs (i.e. to be used in conjunction with program data of specific programs)

It will be helpful to bring copies of questionnaires, results, and information about how the survey was done.

- Drug-related arrests (pertaining to specific time periods):
 - Number of individuals arrested for using drugs
 - Number of individuals arrested for selling or trafficking drugs

- Drug seizure data
- Country specific data on the proportion of drug users who are injectors
- Information from official government departments, such as Overseas Workers, Manpower, Emigration, and from unofficial agencies, that pertains to numbers of individuals (segregated by gender) leaving the country for work in foreign countries, lengths of contracts, reasons for deportation, etc.
- General population size data by geographic division, segregated by age and gender

Also bring:

- Any information from specific size estimates exercises that have been done in your country using any method
- District level maps of the country (digitized if possible so that you will be able to show visual representations of population sizes by geographic

NOTES

Annex 2. Glossary

Acquired immunodeficiency syndrome (AIDS): The late stage of HIV infection that includes development of one or more opportunistic illnesses (illnesses that occur because of low levels of CD4 lymphocytes, or immunodeficiency).

Anonymous: Having no known name or identity. For example, removing all personally identifying information from a data collected on HIV risk to protect the respondent's identity.

Barrier effect: when the network position of respondent causes him/her to know fewer members of the subpopulation than would be expected.

Bias: A systematic error in the collection or interpretation of data.

Capture-recapture: Studies used to estimate the size of a population when a census may be infeasible or impossible to conduct. The basic idea of capture-recapture studies is to sample and identify individuals, or cases, from a population and then resample the population to see what fraction of individuals, or cases, in the second sample were identified in the first.

Case: a condition, such as HIV infection (e.g. an HIV case) or AIDS (e.g. an AIDS case) diagnosed according to a standard case definition.

Census: a method for population size estimation that attempts to count every member of a population.

Confidence interval: The compound interval with a given probability (for example, 95%) that the true value of a variable such as mean, proportion, or rate is contained within the limits. Also known as 'confidence limits.'

Confidentiality: Protecting information that concerns a study participant or patient from release to those who do not need to have the information.

Cross-sectional survey: A survey that is conducted at a given point in time, such as during one year, rather than studying a group over time.

Denominator: The population (or population experience, as in person-years, etc.) at risk in the calculation of a proportion or rate. The denominator is the lower portion of a fraction used to calculate a rate or ratio.

Enumeration: Instead of counting every individual, enumeration generally starts within a sample frame or list, a sample of units within that list are chosen, and only the individuals within those chosen units are counted. The number counted is then projected according to the size and structure of the sample frame.

Epidemic: The occurrence of a disease (or other health-related event) at a level of increase to a baseline. For example, the high prevalence of HIV found in many parts of the world today, including sub-Saharan Africa, Latin America and South and Southeast Asia.

Epidemiology: The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.

Extrapolation: The use of an estimate made in one situation to apply to a larger or different situation or population.

Geographic mapping: Documenting the physical locations and compositions of population(s) of interest. A complete census or sampling enumeration can then be used to count population members at each site selected.

High-risk behaviours: Behaviours that increase the risk that a person will contract a disease.

Mean: The measure of central location commonly called the average. It is calculated by adding together all the individual values in a group of measurements and dividing by the number of values in the group.

Network scale-up: A method to obtain estimates of the size of hidden populations by using respondent's knowledge of the occurrence of certain behaviours in his/her social network.

Nomination methods: Methods of estimating population size in which initial members of a population are asked to name ("nominate") other members of the population.

Population: The total number of inhabitants of a given area or country. In sampling, the population may refer to the unit from which the sample is drawn, not necessarily the total population of people.

Prevalence: The proportion of persons in a given population with a disease or condition at a given point in time.

Probability sampling: A sampling scheme that ensures that each entity in a population has a known, non-zero chance of being selected.

Proportion: The relationship of a part to the whole, in which the numerator is included in the denominator; often depicted as a percent by multiplying by 100.

Random sample: A sample derived by selecting individuals such that each individual has a known and non-zero probability of selection.

Range: The difference between the largest and smallest values in a distribution.

Rate: An expression of the frequency with which an event occurs in a defined population.

Reliability: the extent to which a measuring procedure gives similar results with repeated use with the same respondents

Representativeness: The extent to which the sample resembles the true population.

Risk: The probability that an event will occur; for example, that an individual will become ill within a stated period of time.

Risk factor: An aspect of personal behaviour or lifestyle; an environmental exposure; an inborn, inherited, or demographic characteristic. Associated with an increased occurrence of disease or other health-related event or condition.

Sample: A selected sub-set of a population. There are specific types of samples used in surveillance and epidemiology such as convenience, systematic, population-based and random.

Sample size: The number of subjects to be used in a given study.

Sampling error: A measure of the variability of a single sample design. Sampling variability is determined by the sample design, the sample size, and the variability of the characteristic of interest in the population.

Sampling frame: A complete list of individuals (or sites) from which a sample can be chosen.

Sampling scheme: Procedure for choosing individuals to be included in a sample.

Selection bias: A systematic error in the process respondent selection for a study or survey.

Sexually transmitted infection: Diseases that are spread by the transfer of organisms from person to person during sexual contact.

Stakeholder: Those with an interest in the results of surveillance activities.

Stigma: A mark of disgrace or shame. For example, in some societies, being infected with HIV causes a person to be stigmatised.

Sub-population: A smaller group made up of people with similar characteristics or behaviours within the general population.

Surveillance: The systematic collection, analysis, interpretation, and dissemination of health data on an ongoing basis, to gain knowledge of the pattern of disease occurrence and potential in a community, in order to control and prevent disease in the community.

Transmission Effect: bias that may occur in some methods of population size estimation because members of some populations may not share (“transmit”) the fact of that behaviour of interest.

Validity: The degree to which a measurement actually measures or detects what it is supposed to measure.

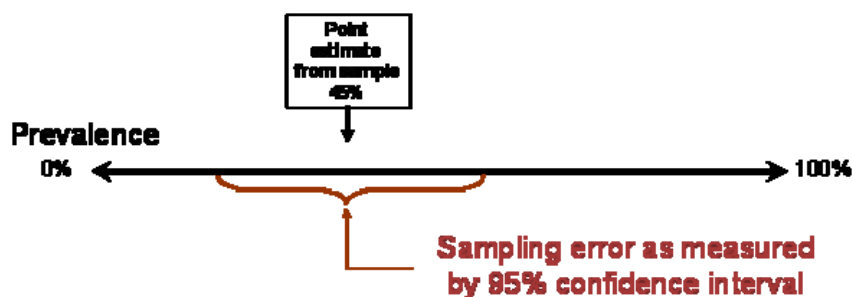
Annex 3: Bias and Sampling Error, an Expanded Discussion

Consider a schematic drawing of a 95% confidence interval (Figure A3-1). The horizontal line represents the range of possible values of prevalence for our behavior of interest, say exchanging sex for money or drugs. Suppose we obtain an estimate of 45% in some high risk population; because this estimate is based on some sample that may not include the entire population of sex workers, it may be subject to sampling error.

The confidence interval means that if you did many surveys in the same population using the same sample size and the same methods, for 95% of these surveys, the confidence intervals will include the true population value. As a result, if we have only one survey, we would be about 95% sure that the true population value falls within the confidence interval. This is because for 95% of the hypothetical replications of the survey, the true population value does lie within the confidence interval.

Although we know that the true prevalence of sex work in the entire population is probably not exactly 45%, we are 95% sure that the true prevalence is somewhere within the bracket. This is a confidence interval.

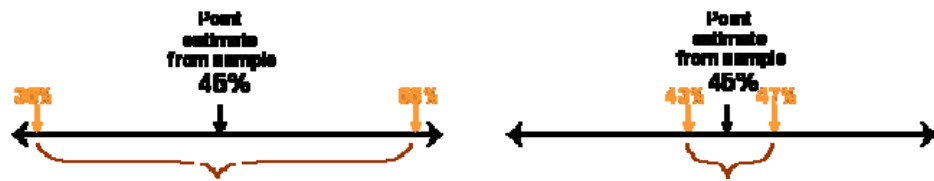
Figure A3-1: Schematic Representation of Confidence Interval



If we add some numbers to this schematic drawing, it may help to understand what you see often see in published reports, for example, “prevalence of sex work = 45%; 95% CI: 35% to 55%”.

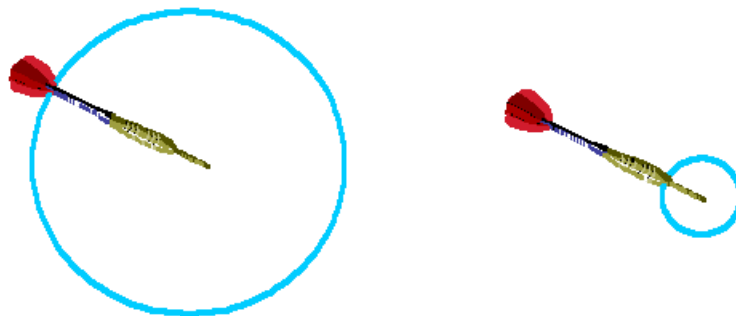
The left drawing in Figure 2 below shows a survey with large sampling error, probably because it had a small sample size. The right drawing shows a survey with a much smaller sampling error, probably because the sample size was larger. Note that the point estimate is the same for both surveys, 45%.

Figure A3-2: Effect of Sampling Error on Confidence Intervals



We can visualize confidence intervals in another way by imagining that a single survey is a dart which produces a single estimate of some health outcome, for example, the prevalence of injecting drug users (Figure A3-3). If the sampling error is large because the sample size of the survey was small, the dart might have a large circle of uncertainty. We may be 95% sure that the true population value is somewhere in the large circle, but this survey result may not be very useful. If the sampling error is small because the sample size was large, the circle of certainty may be much smaller, as shown on the right. Now if we are 95% sure that the true population value is within this small circle, the survey result will probably be very useful.

Figure A3-3: Depiction of Sampling Error



Accuracy or bias

Bias can result from several sources; the two most important for population size estimation are:

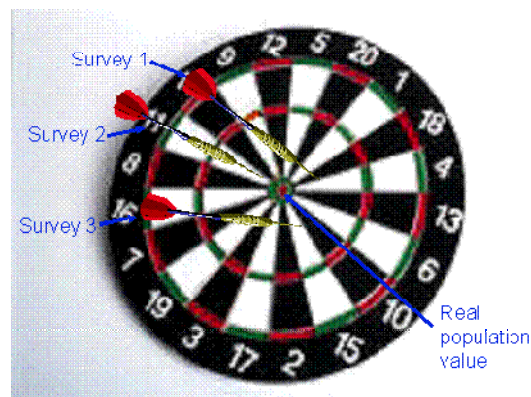
- *Measurement bias* – measurements are taken (questions are asked) incorrectly.
- *Sampling bias* – data are collected from a non-representative sample

The problem is that bias can be present in surveys and other data sets even if sampling and analysis are done correctly. Neither a large sample size nor statistical methods can correct for bias. In most cases, bias cannot be quantitatively measure or calculated.

But how do sampling error and bias relate to precision and accuracy, terms which are often confused? *Precision* in epidemiologic estimates corresponds to the reduction of random (or sampling) error.²⁸ *Accuracy* is the degree to which an estimate represents the true value of the attribute being measured.²⁹ In short, an estimate is precise if it obtains similar results with repeated measurement (or repeated surveys). An estimate is accurate if it is close to the truth with repeated. An erroneous estimate may be expressed precisely but will not be accurate. Measurements should be both accurate and precise, but the two terms are not synonymous. Let's explore these concepts further returning to our dart analogy.

Imagine a dart board with the center representing the true population value (Figure A3-4). Each of the three darts is a repeated survey using the same methodology and sample size. Clearly, we probably would not measure the same indicator or outcome in the same population three times, but this helps to understand the concept of sampling error and bias.

Figure A3-4: Results of Three Surveys



The situation in Figure A3-5 shows great precision but very poor accuracy; the result of none of the three surveys is anywhere close to the true population value. The investigators selected very large samples, so sampling error was very small. However, they selected a biased sample or didn't perform their measurements very well; thus all their estimates are biased.

Figure A3-5: High Precision, Low Accuracy



The situation in Figure A3-6 shows poor precision (the three darts are far apart), but if we threw many more darts (or did many more surveys with the same methodology), the *average* of all the results from all the darts (or all the surveys) would be close to the truth. The researchers selected small samples, so sampling error was very large. However, they were very careful and selected an unbiased sample and did their measurements very well; thus the estimates are unbiased.

Figure A3-6: Poor Precision, Reasonable Accuracy



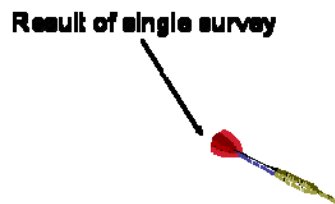
Of course, the best situation is pictured in Figure A3-7. The survey results are both precise and accurate; the darts are clustered and they are close to the true population value. The researchers selected a large enough sample size to achieve good precision, selected an unbiased sample, and did the measurements well.

Figure A3-7: Good Precision and Accuracy



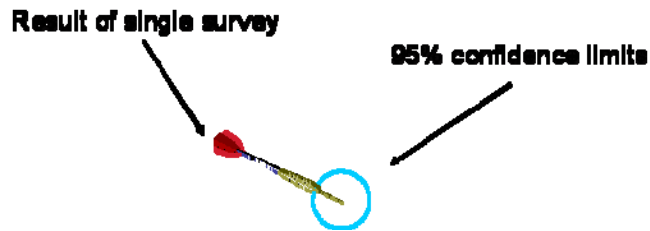
Of course, in practice, we are almost never able to do multiple surveys to check precision and we never know the true population value (else, why would we be doing the study?) So we do one survey in a population in which you do not know the true value, and you end up with a single dart (or the result from a single survey), but no dartboard showing the true population value (Figure A3-8).

Figure A3-8: Result in Practice



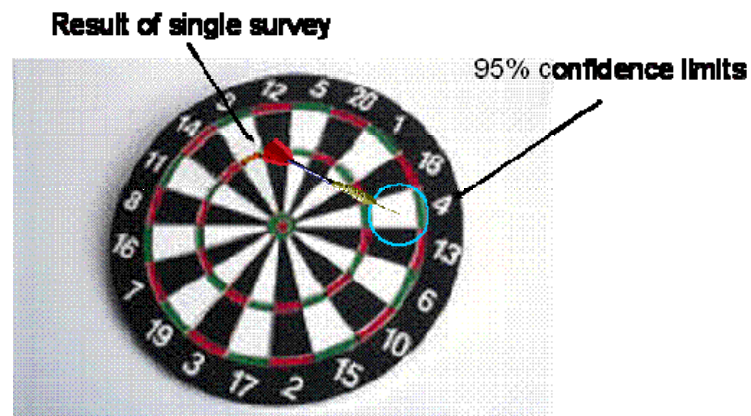
But this one dart doesn't tell us much. Where is the true population value? Is this a useful estimate? Can we make programmatic decisions based on this survey result? A confidence interval (usually a 95% confidence interval is chosen) will give us some measure of the precision of our estimate (Figure A3-9).

Figure A3-9. Result in Practice with Confidence Interval



Remember: having precision does not necessarily mean that the result is accurate (that is, there is little bias). If this survey had lots of bias, the result may still be far from the true population value. So, just having narrow confidence intervals producing good precision does not necessarily mean that the survey result will be close to the true population value. If there is bias which produces inaccuracy, you will draw very misleading conclusions.

Figure A3-10. Interpretation of Result in Practice



Since we cannot control for bias by larger samples or statistical methods (there is no *cure*), it is important to *prevent* it. This prevention is most effective if done prior to data collection by ensuring that survey questions are valid and reliable, using correct measurement techniques, and carrying out the sampling correctly and randomly. Thus it is recommended that you have experts review your survey plans, provide ongoing training to field workers, ensure field supervision, and perform interim quality checks on data. This is important since if you have bias in your survey, you may never know it. You may make inappropriate decisions about programmes based on invalid results.

Annex 4: Summary of the two categories of methods for estimating population size

Category 1: Methods based on data collected in an at-risk population		
Method name and description	Advantages	Disadvantages
<p>Census method counts all members of the population.</p> <p>Enumeration develops a sampling frame then counts all members of the population at a sample of places listed in the sampling frame.</p>	<p>Census method is easy to explain as it simply attempts to count all members of the population.</p> <p>Enumeration method maps then covers just a fraction of the population.</p>	<ul style="list-style-type: none"> ▪ Most-at-risk populations are often hidden. Both methods will miss members of the population not visible to the public. ▪ Community guides are necessary to improve access. ▪ Census is time-consuming and expensive to conduct. ▪ Enumeration method requires a reliable sample frame of venues. ▪ Overestimate if population is mobile and double counted. ▪ Underestimate if populations are well hidden.
<p>Capture-Recapture methods calculate the total size of a population based on two independent captures (samples) of population members:</p> <ul style="list-style-type: none"> ▪ Capture 1: ‘tag’ and count number tagged. ▪ Capture 2: ‘tag’: keep track of who was ‘retagged’ and who is ‘first time tagged’. 	<ul style="list-style-type: none"> ▪ A simple capture-recapture method is relatively easy to use. ▪ Does not require much data. ▪ Does not require statistical expertise. 	<p>Relies on assumptions that are hard to meet in normal field conditions:</p> <ul style="list-style-type: none"> ▪ Two samples are independent and not correlated. ▪ Each population member has an equal chance of selection. ▪ Each member is correctly identified as ‘capture’ or ‘recapture’. ▪ No major in/out migration is occurring. ▪ Sample size is large enough to be meaningful.
<p>Multiplier methods compare two independent sources of data for most-at-risk populations</p> <ul style="list-style-type: none"> ▪ Source 1: count/listing of persons who accessed a service <p>Source 2: count of population who accessed service from representative survey of population of interest</p>	<ul style="list-style-type: none"> ▪ Straightforward if data sources are available. ▪ Flexible method, useful in many circumstances. 	<ul style="list-style-type: none"> ▪ The two data sources must be independent. ▪ The data sources must define the population in the same way. ▪ Time periods, age ranges and geographic areas must be aligned. <p>Data collected from existing sources may be inaccurate.</p>

Annex 4: Summary of the two categories of methods for estimating population size, contd.

Category 2: Methods based on data collected from the general population		
Method name and description	Advantages	Disadvantages
<p>Population survey methods with general population behaviour questions.</p> <ul style="list-style-type: none"> Directly ask respondents whether they have specific behaviours that put them at increased risk to HIV (such as selling sex, injecting non-medical drugs, men having sex with other men) 	<ul style="list-style-type: none"> Surveys are common and familiar. Easy to implement if there is a list of key population. Straightforward to analyse and easy to explain to data users. 	<ul style="list-style-type: none"> Difficult to use when the behaviours are rare or stigmatized. Only reaches people residing in households, schools or other institutions used to create the sampling frame. Respondents are unlikely to admit to high risk or stigmatized behaviours if the interview is not confidential or if the interviewer is not skilled at establishing trust and rapport.
<p>Network scale-up methods are based on the idea that people's social networks reflect the general population.</p> <ul style="list-style-type: none"> Ask a random sample in the general population to estimate number of people they know, and how many of those people have the behaviour of interest. 	<ul style="list-style-type: none"> Can generate estimates from general population rather than hard-to-reach populations. Individuals are often more likely to report on the behaviour of others instead of their own behaviour. A single survey can be used to create a size estimates for multiple hidden populations. 	<ul style="list-style-type: none"> Average personal network size difficult to estimate. Subgroups may not associate with members of the general population. Respondent may be unaware someone in his/her network engages in behaviour of interest. Respondents may be hesitant to admit to knowing individuals with the specified behaviour.

Source: Adapted from Monitoring and Evaluation Guidelines for HIV Prevention for Men Who Have Sex with Men. MERG Technical Working Group on Most at Risk Populations. Draft December 2009.

Annex 5: Answers to Selected Warm-up Questions and Exercises

Comments are provided in italics for each unit's selected questions and case studies. Unit questions are designed to stimulate small group discussion among participants in the workshop or class. Thus, answers to only selected questions and case studies are provided.

Unit A: Exercises

Warm-up questions

1. Which of the following is **not** a reason why programme managers need to know the size of a priority population?
 - a. They need to know the seriousness of the epidemic.
 - b. They need to know where prevention efforts are needed.
 - c. *They need to be able to identify members of the population.*
 - d. They need to know what resources are needed to create good prevention programmes.
2. List three users or consumer groups that use population size estimates. Do they have the same needs?

Analysts or technical experts, policy- or decision-makers, and members of the community. Each user or consumer group has different tasks and/or needs for the size estimation data.

3. List three reasons why a country would want to estimate the size of a high-risk population.
 - 1) *The size of the target population is important in convincing policy-makers of the existence and magnitude of the public health problem.*
 - 2) *Good estimates of population size help to prioritize target populations.*
 - 3) *Prevention of new HIV infection requires targeted contact with a large proportion of the high risk population and it is difficult to plan for adequate services if you have no idea how many people require services.*
 - 4) *Estimates of population size are important for evaluating prevention efforts.*
 - 5) *Countries need to determine where to focus their financial resources and how to cost their response.*

4. True or False? Focusing studies on most-at-risk populations can lead to increased stigma and discrimination.

True. Caution must be taken when conducting size estimation among most-at-risk populations which are often marginalised and are ignored by government and policies. Care must be taken with dissemination of information.

5. Put the following steps in order from one to 10:

Steps to implement population size estimates	
<i>Step 6</i>	Compile all existing data and collect additional data
<i>Step 7</i>	Analyse and interpret the results
<i>Step 8</i>	Document the process
<i>Step 1</i>	Determine the use of the size estimate
<i>Step 5</i>	Decide on the method
<i>Step 2</i>	Determine when the size estimate will be needed
<i>Step 10</i>	Use the size estimates
<i>Step 9</i>	Disseminate the results
<i>Step 4</i>	Review existing size estimates
<i>Step 3</i>	Define the population and geographic area

Apply what you've learned/Case study

You are interested in estimating the size of the female sex worker population in District X. You locate a report from a nongovernmental organization applying for a grant for HIV prevention. The report contains the following statements:

- Experts estimate the number of sex workers in District X to be about 1.4 million.
- There are more than 100 brothels in District X and 15 of them are described in detail in the report.
- The average number of women working in these brothels is 117.
- Twenty percent of clients come from neighboring District Y.
- Twice as many sex workers work outside the brothels as in them.
- Only about 10% of brothel-based sex workers in District X receive regular screening and treatment for HIV.
- Rates of condom use are low among sex workers.

Discuss the utility of these estimates? Are you in favor of making a new estimate? Why or why not?

Important aspects of this analysis include questions about:

- *How were the data collected (on which the estimates were made)?*
- *Are the 15 brothels described in the report descriptive all brothels in the District?*
- *What is the distribution of women working in the brothels, in addition to the average? Do some establishments have a large number of workers while others have very few?*
- *How was condom use assessed? What is “low”?*

Unit B: Exercises

Warm-up questions

1. True or false? Most data used for size estimation have consistent definitions of key populations.

False. While standard (UNGAS) definitions exist for most key populations, data collection instruments do not always use these. For example, a mapping activity may define men who have sex with men as any man who has ever had sexual relations with a man, while voluntary counselling and testing data may define men who have sex with men as a male who has had such relations at least once in the last six months. Adoption of standard definitions will facilitate comparison over time and from one country to another.

2. List three types of institutions that would help you access most-at-risk populations.

Drug treatment clinics; hospital emergency wards; nongovernmental organization registrations; schools; the justice system

3. Why is timing so important to consider when you plan to do your size estimation?
 - a. Your estimation should coincide with a costing exercise, such as a national strategic planning process.
 - b. Depending on the type of size estimation you do, you should consider the implementation schedules of larger household surveys.
 - c. Your estimation should assist with the larger HIV monitoring and evaluation activities.
 - d. All of the above.
4. List three factors that can affect the prevalence of risk behaviours and, therefore, the size of the population at risk.

Social acceptability, economic circumstance, changes in drug distribution routes or tourism patterns, seasonal migration, political forces.

5. For certain key populations, can data outside the health sector be useful for estimating population size? Give an example and discuss the appropriateness of using this data.

Police arrest records for drug use or sex work. However, these records may not identify which persons are drug users or sex workers because they may have been charged with other offenses.

6. List three potential harms to participants in estimating population size for persons at risk for HIV infection.

Physical: public or domestic attack, stigma from health care providers

Legal: arrest, prosecution, denial of certain rights

Social: discrimination, loss of employment, isolation

7. List at least three ways data on HIV risk behaviors can be protected from disclosure.

Anonymous collection, aggregation of data, confidentiality agreements, computer security, destruction of information

8. What is a very useful tool commonly used in the preparation or formative work for size estimation activities?

- a. Interviewer training
- b. Mapping
- c. Providing free treatment
- d. Creating pamphlets describing the activity

Apply what you've learned/Case study

1. Consider the problem in Unit A of interpreting estimates from a non-governmental organization about the size of the population of female sex workers. What is important for tracking such estimates over time?
2. You are the health officer in charge of HIV surveillance for Province X in Y Country. You have been asked to design and implement a special HIV risk survey among male patients with acute urethritis who attend the clinic at the provincial referral hospital.

- You decide to proceed by first assessing HIV seroprevalence. You are weighing two choices:
 - A self-administered questionnaire and an additional blood test for HIV and syphilis.
 - A blinded survey of all patients who have blood drawn for syphilis serologies. Approximately 50 percent of patients with acute urethritis have serum samples drawn for syphilis. There is no standard protocol for when to order these serologies.
- For which option would you need informed patient consent?

Both options involve risk with blood draw. Option 1 has an additional risk with tests for syphilis. Option 2 minimizes risk of disclosure with the blinded survey, but lack of standard protocol presents additional risks. Informed consent should be obtained for either option.

- How likely are each of the two options to yield an accurate estimate of the prevalence of HIV infection in this population?

In this case, accuracy will depend on the participants' perception of trust in the investigator and of confidentiality of information.

- In which option would individual confidentiality be better protected?

UNIT C: EXERCISES

Warm-up questions

1. List one strength and one weakness of the census method for size estimation?

The strengths of the census methods are: it is a full count of the population, it is less time- and resource-consuming than other methods where a list or sampling frame exists, more information than just the size of the population can be obtained, such as social context and risk profiles at each site, and it can be well utilized if used for prevention or intervention in a local setting.

Some weaknesses are: most at risk populations are hidden so this method will miss some members of the population, can be time consuming and very resource intensive for hidden populations or for situations where the population at risk is geographically dispersed, stigma against the population may preclude self-identification as a population member, and large field teams are required for the count to be completed in a time period short enough to mitigate the complications of high mobility patterns.

2. True or false? A list of all places that members of a population frequent is necessary for many enumeration methods.

True. This method begins with a list or sampling frame, chooses a sample of “units” (i.e. brothels or shooting galleries) from within that list, and counts only the individuals within those chosen units.

3. In the capture-recapture method, if the assumption that the two sources of data are independent is violated, what would be the effect on the population size estimate?

If there is a positive dependence, there would be an under-estimate of the population size estimate. For example, if being included in the first sample increases a person’s chance of being included in any subsequent samples, the populations will be underestimated. The reverse is true if there is a negative dependence.

4. True or false? When using the multiplier method, both sources of data must be randomly selected.

False. Only one source of data (i.e. the population) needs to be randomly selected. The other (i.e. registry data) need not be random.

5. True or false? Multiplier methods can be used for making national estimates of population size.

True. If a national survey exists or is being planned, multiplier methods can be used for making national estimates of population size.

**Case study C-1:
Census and
enumerator
methods**

Programme managers in a city suspect the number of female sex workers may have changed and they need an updated estimate to apply for funding from international AIDS organizations for this population.

The programme managers decide to consider whether the reported population varies by type of establishment so that future services can be targeted correctly.

Staff members visited every entertainment establishment within the study area and counted the female sex workers working and not working that day.

A total of 3,521 were identified. Of these, 42% were found in karaoke centres and 26% in hair salons; 7% were street-based, and the remainder were found in massage centres and night clubs.

- a. What type of estimation method is being used here?

Census method

- b. Using these data, make an estimate of the number of female sex workers in the country.

We would conclude that the population size of female sex workers who tended to gather in or near these kinds of establishments was 3,521.

- c. What sources of error are important in interpreting your estimate?

The method tends to underestimate if the population is very hard to reach.

**Case Study C-2:
Capture-recapture
with two samples**

A country is experiencing rapidly expanding drug use associated with HIV infection. The country needs to estimate the number of injection drug users to evaluate the feasibility of intervention programmes. The health ministry has available data from two existing data sources:

- Data source one is a database of records from a social insurance system based on residency. It includes information on people receiving drug treatment or who have had a drug overdose.
- Data source two is a police database with information on criminal offences, including if illicit drugs are injected.
- Both data sources contain information on gender, day/month/year of birth, and initials.
- Investigators restrict analysis to persons 15-44 years old. Records outside this age range, records without full identifying information, or multiple records with the same unique set of identifiers are deleted from the analysis.
 - Insurance records identify 1,299 injection drug users
 - Police records identify 5,311
 - 873 persons are identified to be in both data sources.

From the above data, how would your team do the following:

- a. Draw the table useful for capture-recapture analysis and fill in the appropriate cells.

		Police records		
		Yes	No	
Insurance	Yes	873	b	M = 1299
	No	c	x	
		C = 5311		N = R + b + c + x

- b. Estimate the total number of injection drug users in this population.

The total number of injection drug users is estimated as

$$N = (5311)(1299)/873 = 7,903.$$

- c. Suppose that persons who appear in the police database are denied access to the social insurance system. What effect will this relationship have on your estimate?

Recall that these are reasonable calculations if the assumptions hold: both samples are selected randomly and the two sources are independent. The team assumes no relationship between a person having access to the social insurance system and being included in the police database. If the assumption of independence is not satisfied, the estimate may be biased.

- d. Consider the difficulty of distinguishing injection drug users from non-injection drug users from arrest records. What are the implications of this problem and would it lead to an underestimate or overestimate of the size of the population?

**Case Study C.3
Multiplier-method
using programme
based and unique
object multipliers
in India**

Programme managers uses two multipliers to estimate the size of the sex worker populations in 6 states in India. They conducted a series of integrated biological and behavioral surveys among sex workers to use with the multipliers. , conducting 30 surveys among sex workers in 25 districts in six states, 12 surveys in high-risk men who have sex with men in 11 districts in four states, and five surveys of injection drug users in five districts in three states.

For the purposes of this estimation, two data sources were used:

Data source 1: Programme based multipliers and unique object multipliers

- Multiplier 1 came from service statistics recorded by organizations working with female sex workers,
- Multiplier 2 came from a unique object distributed to female sex workers.

Data source 2: Survey

- The integrated biological and behavioural surveys were sampled using either respondent-driven sampling or time-location sampling. These sampling methods approximate probability sampling methods to obtain a random sample.

- a. Were these multipliers from randomly selected samples?

The integrated biological and behavioural survey was randomly selected; however, neither multiplier was random.

The questions used in the survey were designed to be compatible with the data routinely collected and available from local service providers. Indicators included:

- Proportion reporting being registered with the service provider,
 - Proportion reporting contact by a peer in the past month,
 - Proportion reporting receiving a project health card in the past year, and
 - Proportion visiting the service provider in the past year or in the past three months.
- b. List three difficulties that you might encounter when using these types of sources for multipliers.
- *Only service providers that did individual tracking could provide information on the number of individuals who had visited the clinic during a given timeframe*
 - *Others had information on number of visits, but not on number of individuals.*
 - *Investigators had no control over what data the service providers tracked in the integrated biological and behavioural survey or how well they tracked it.*

The investigators had no control over what data the service providers tracked. Due to anticipated challenges with these methods an additional multiplier was used that would be controlled by the survey team. This was known as the unique object multiplier.

In this case, the unique object was a key chain designed to be uniquely memorable and distributed in several of the districts in advance of the survey. The key chain was distributed to persons within the bounds of the survey coverage area who matched the definition of the population whose size was being estimated. Respondents were asked in the survey if they had received the key chain.

- c. In the majority of cases both the programme based multipliers and the unique object multiplier combined with the survey yielded lower size estimates than existing data from programme data. List some of the reasons for this discrepancy.

Potential problems with data source 1:

- *Ineligible people were included in the programme counts*
- *Unique object were distributed to ineligible people*

Potential problems with data source 2:

- *Selection bias in the survey leading to non-independence between data sources. This could happen if those in contact with the service provider are more likely to be included in the survey than those not in the programme.*
- *The survey questions were not specific or adequately matched to the programme-based multipliers*
- *People reported having received a unique object or being in a programme when they had not received the object or were not in the programme*
- *The survey sample was not truly random.*

Although the key chain was not randomly distributed, this did not violate the assumptions for the method.

- d. What do you think are the main safeguards against these biases?

The main safeguard against these biases is to make sure the probability survey is as close as possible to being random. The unique object method has the potential advantage of being easier to control by the survey team so that some biases are avoided.

UNIT D: EXERCISES

Warm-up questions

1. True or false? Adding direct questions in population-based surveys to estimate population size is most useful when a behaviour is rare.

False. Surveys are less useful when a behaviour is rare (it may not be reflected in the sample selected) or when those at risk are not found in gathering places, households, schools, or other institutions. In addition, if behaviour has been stigmatized within a society, respondents may be less truthful with the interviewer, especially when the interview is not conducted in a confidential setting, such as a household.

2. Identify one significant advantage that the network-scale up method has over other methods.

It does not require members of hidden populations to identify themselves to surveyors; the questions can be incorporated into existing household surveys, and therefore can generate estimates at the level of the domains of those surveys (typically national or provincial); the method can create size estimations for multiple hidden populations in one survey.

3. True or false? The main challenge of the network scale-up method is asking respondents to estimate their average personal network size.

True. It is difficult for people to measure their networks as well as come to an agreement about what it means “to know” someone.

4. List two methods used for estimating personal network size.

Summation method and the known population method.

5. Which of the following is **not** a bias associated with the network scale-up method?
 - a. The size of a network varies among individuals.
 - b. *All individuals will be asked the same questions in the same way.*
 - c. Some subgroups may be less likely to associate with members of the general population.
 - d. A respondent may be unaware that someone in his/her network is a member of the subpopulation of interest.

Case study D1

To estimate the size of a population of injection drug users, a network scale-up approach is implemented in a region of approximately 19,000 people. In this region, a Demographic and Health Survey has been conducted. Thus, the investigators have access to national estimates of population sizes in several categories:

- Characteristics of households
- Fertility
- Family planning
- Early childhood mortality
- Maternal and child health and nutrition
- HIV knowledge and behaviors
- Malaria knowledge and behaviors

A second survey is now conducted in the region by village health workers who make household visits. Among other questions, respondents were asked: “How many members of <subpopulation> do you know?” The list of subpopulations used as well as best national estimates are given in **Table D-4**.

Table D-4. Subpopulations Used, Demographic and Health Survey Estimate, and Mean Number Known to Respondents

Subpopulation	Size of subpopulation	Mean number known to respondents
Women aged 14-25 years with no education	657,000	2.43
Has at least one telephone	10,600	5.76
Can name any method of contraception	18,500	1.68
Has had a child die aged < 1 month	6,200	3.42
Women smoking tobacco	10,000	4.06
Heard of HIV/AIDS	16,000	3.20
Know an injection drug user	?	0.56

1. How would you describe a barrier effect in this context? How could you assess the effect of this potential bias?

2.

Barrier effect refers to the fact that because of location or situation in society, respondents may not interact with members of the subpopulation of interest randomly.

2. Describe a transmission effect for this context and the potential impact it may have on your estimate.

Respondents acquaintances may not share their injecting drug behavior either because it is associated with stigma or embarrassment, it is not the subject of common conversation, or it is confidential and usually not shared in this context.

3. In this context, which of the three assumptions is likely to be most important? Why?

Averaging over all respondents gives a mean network size of 117 (standard deviation = 89; data not shown).

4. How could you use this information to estimate the size of the injecting drug user population? Comment on how this estimate could be used.

The mean number of injecting drug users known to respondents is 0.56. So using the equation:

$$e = t \left\{ 1 - (1 - p_r)^{1/c} \right\}$$

We can calculate that the estimated size of this population is
 $e = 19,000 * \{1 - (1 - 0.56)^{1/117}\} = 19,000 * 0.007 = 132.$

This estimator is probably biased (low) due to the fact that we did not use the other known subpopulation sizes and acquaintances. An estimate using the other six populations would probably be more accurate.

UNIT E: Exercises

Warm-up questions

1. Which method is best for use with brothel-based sex workers?
 - a. *Census method*
 - b. Multiplier method
 - c. Capture-recapture method
 - d. Network scale-up method
 - e. None of the above

2. What method should be considered for injection drug users when the existing and available data are fairly good?
 - a. Census method
 - b. Multiplier method
 - c. *Capture-recapture method*
 - d. Network scale-up method
 - e. None of the above

3. What method should be considered for use with men who have sex with men if no data sources are available and a new population-based survey is planned?
 - a. Census method
 - b. *Survey method*
 - c. Capture-recapture method
 - d. Network scale-up method
 - e. None of the above

4. List two issues to keep in mind for estimating the size of the most-at-risk adolescent population if data are available

If there are large biases in the sampling structure, the proportions in different age groups might be biased; know the inclusion criteria for the survey.

5. What are three key questions to ask yourself after doing an inventory of existing data to determine whether they are appropriate for population size estimation?
 1. *Does the data allow identification of members of the particular subpopulation?*
 2. *How good is the data quality?*
 3. *Do legal or other regulations prevent sharing data with public health officials?*

Small group discussion

1. You need to make an estimate of the injection drug user population among sex workers in your country. List aspects that you will need to consider in defining this population.

In deciding on which criteria to use for defining the population of interest for a prevalence estimation exercise, one criterion should be to adopt commonly used categories, wherever possible. For example, for a estimates of drug use, categories used by member nations reporting to the United Nations may be helpful (see www.unodc.org). Here are a few examples:

Time periods. For each index drug, the annual reports questionnaire asks whether it was “ever used” (sometimes called lifetime use) and whether it was used “in the past 12 months”. Other measures typically used in this area include “in the past month” (sometimes called current use) and the concept of “daily use” in the past month, which, typically, is operationally defined as “using on 20 or more days in the month prior to interview”.

Route of administration. Since drug injecting is associated with transmission of HIV infection, route of administration may be an important data element to collect. Typical routes of administration include: oral consumption (eating, drinking and swallowing); sniffing or snorting (inhaling up the nose); smoking or inhaling sublimite (“chasing the dragon”); and injecting. Thus, a separate question may be used to ask about lifetime and current injecting experiences and possibly the extent to which the individual has shared injecting equipment with others (see www.emcdda.org). Consider local terminology and stigmatization associated with the behavior.

2. In your county, what is the most important consideration in choosing among the methods for estimating population size?

Case Study E-1

A local study in region R produced an estimated injection drug user population of approximately 37,000. Use this finding to estimate the number in the entire country.

If one third of the population of the country resides in the local area, provide an estimate of the number of injection drug users in the country. What is one major problem with this approach?

It would be concluded that there were 111,000 (3 x 37,000) injection drug users in the country. A major problem with this approach is that it assumes no regional differences in drug use. If region R were a major urban area, port city, or border crossing, then it may not be representative of more rural regions.

UNIT F: Exercises

Warm-up questions

1. True or false? Extrapolation refers to the use of known data from some regions to apply estimates for other regions.

True

2. List one advantage and one disadvantage of extrapolation.

1. *Strengths: uses existing data sources; provides ways to get estimates when little data is available*
2. *Weaknesses: must consider geographic variability; must know how local data sources are developed; definitions from data must match your population definition*

3. What is the difference between reliability and validity?

Reliability: does the question elicit the same response from one time to the next.

Validity: does the question measure what it is intended to measure.

4. True or false? Unlike other surveillance activities, it is not necessary to document the process when undertaking size estimation.

False

5. What is the main reason to time the dissemination activities based on the priority level of the stakeholder?
 - a. To make sure funding is available for all necessary dissemination activities
 - b. *To incorporate feedback before the final report or next dissemination meeting*
 - c. To ensure the findings demonstrate what the primary stakeholders want to hear
 - d. All of the above.

6. How can data from size estimation activities be used?
 - a. To design interventions.
 - b. To understand your epidemic.
 - c. To report UNGASS indicators.
 - d. *All of the above.*

F-1. Small group discussion

Country X has a generalized HIV epidemic and growing concern about the rise of injecting drug use in the capital city. The National AIDS Commission recently conducted an Integrated Biological and Behavioural Survey of Persons who Inject Drugs in the capital city using respondent driven sampling. They incorporated Population Size Estimation into this activity as well. The surveillance team used two methods to estimate the size of the injection drug user population. This included three service data multipliers and a unique object multiplier.

Population Size Estimation Methods:

HIV Care: A local HIV Care clinic provides ongoing care and treatment for HIV-infected individuals. During the initial visit for HIV care, the nurse records the most likely mode of transmission in the patient charts through patient history and physical exam. The clinic was able to provide the surveillance team with a count of the number of patients for whom injection drug use was the most likely source of their HIV infection. There were a total of 3241 patients identified as injection drug users who received care and/or treatment at the clinic during the previous calendar year. In the subsequent respondent driven sampling survey, participants were asked if they had ever received HIV care from that specific clinic in the previous calendar year. A total of 13.2% of survey respondents reported that they had received care or treatment for their HIV infection at that clinic during this time period.

1. Calculate the population size estimate of persons who inject drugs using the clinic data and the survey response:

Police Arrests: The Capital City Police Department provided the surveillance team with a count of the number of individuals who were arrested for injection drug use in the last calendar year. There were a total of 2760 different individuals arrested in the previous calendar year for injection drug use. In the subsequent respondent driven sampling survey, participants were asked if they were arrested for injection drug use in the previous calendar year. A total of 12.3% of survey respondents reported that they were arrested during the previous calendar year for injection drug use.

2. Calculate the population size estimate of persons who inject drugs using the police data and the survey response:

Hospital Emergency Room Data: The surveillance team received a count of the number of individuals admitted into the emergency room at the Capital City Hospital for wound care in the 6 month period between July and December of the previous year. There were 187 individuals treated for wound care in the emergency room during this period. Based on information in patient records, hospital staff were not able to exclude people who received care for wounds unassociated with injecting drug use, but considered this number to be small. In the subsequent respondent driven sampling survey, participants were asked if they had received wound care in the emergency room at the Capital City Hospital between July and December of the previous year. A total of 1.4% of survey respondents reported that they received wound care at the Capital City Hospital during this time period.

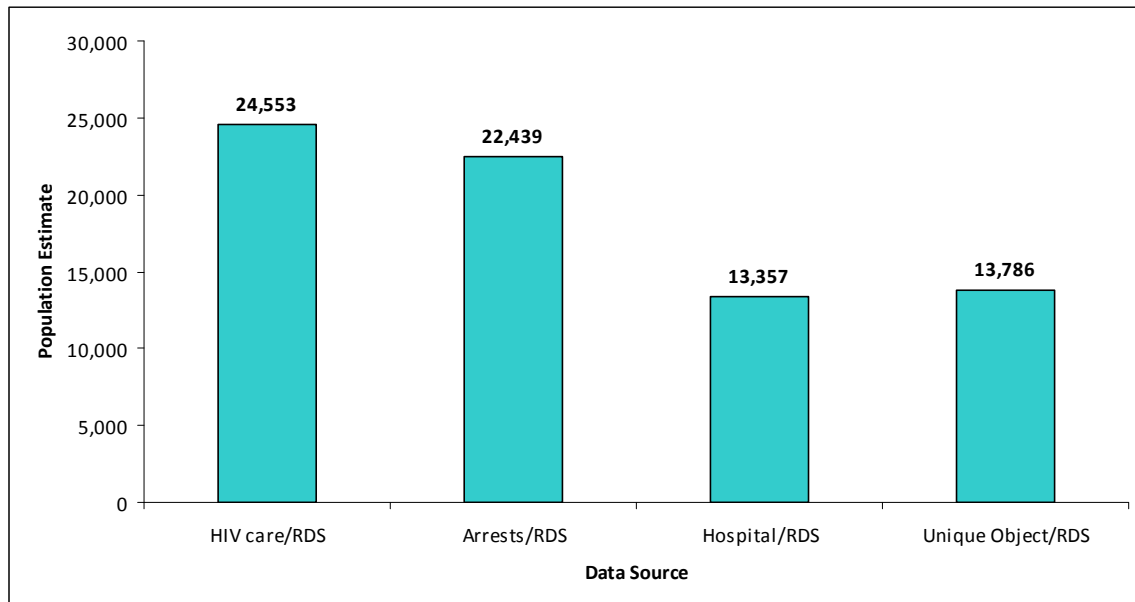
3. Calculate the population size estimate of persons who inject drugs using the Capital City Hospital emergency room data and the survey response:

Unique Object: Two weeks prior to the respondent driven sampling survey, peer educators from a local community outreach project were sent out to distribute 500 unique beaded bracelets to people they identified as persons who inject drugs. They attempted to ensure that each person received only one bracelet and asked recipients to keep the bracelet because they might be asked about it in the future by project staff. After the unique object distribution was completed. The surveillance team found out that only 386 bracelets were actually distributed and peer educators distributed the bracelet to people they were friends with. In the subsequent respondent driven sampling survey, participants were asked if they had received the beaded bracelet in the preceding two weeks along with verification questions to ensure that they had really received one of

the bracelets distributed by study staff. A total of 2.8% of survey respondents reported that they received a beaded bracelet from study staff.

4. Calculate the population size estimate of persons who inject drugs using the unique object data and the survey response:

The population size estimates calculated using the various data sources are in the figure below. Did you get the same estimates?



5. What are some potential biases associated with each estimate? What steps could you take to limit these biases?

6. Of the four sources used to generate the population estimate, are there certain sources that may be more reliable than others? Why?

7. What number will you decide to present in your report as the size estimate of persons who inject drugs in Country X?

8. What other method would you use to estimate the population size of persons who inject drugs in the Capital City of Country X? What biases might these methods have?

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