Annex: Programme Targets (Denominators)

National Level

4

In-depth examples of triangulation to assess programme targets for the National and Regional/Provincial levels

World Health Organization, UNICEF, & U.S. Centers for Disease Control and Prevention

TRIANGULATION FOR IMPROVED DECISION-MAKING IN IMMUNIZATION PROGRAMMES

Working document: July 2020

Background

Triangulation is the synthesis of two or more existing data sources to address important questions for programme planning and decision-making.

Triangulation can include putting different data together in one graph or stitching information from several graphs together with a narrative thread. Triangulation requires critical thinking and basic analysis skills, but the activity goes beyond making graphs — it's about turning data into reliable information for action.

This guidance will walk you through an example of using the 10-step triangulation process (Fig) for **assessing immunization programme targets (denominators)** at the **national or regional/provincial level.** Other triangulation guidance, including a general overview, can be found online at https://tinyurl.com/triangulation-July2020.

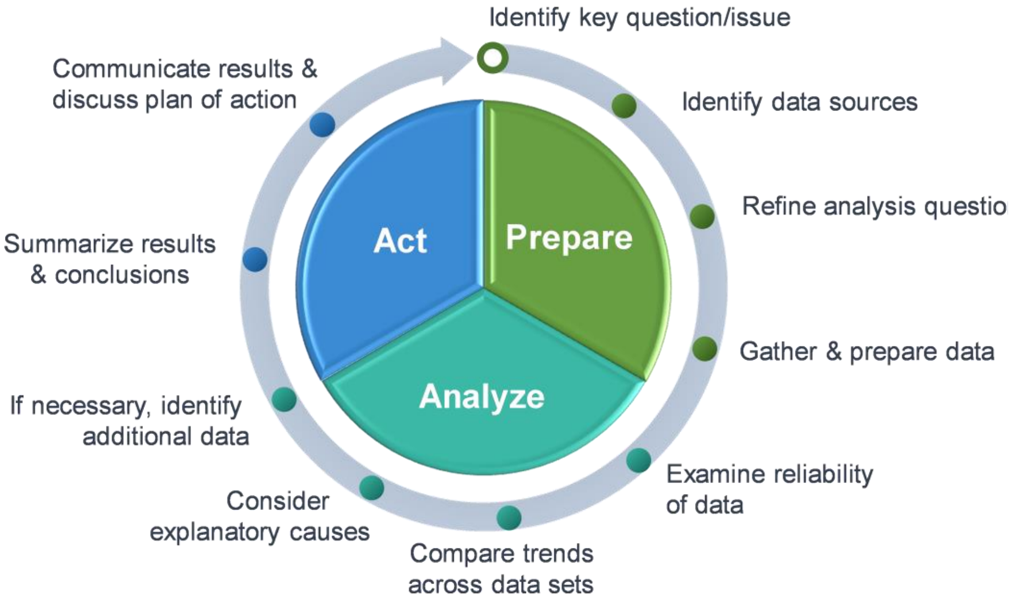


Fig. The 10-step EPI data triangulation process, starting with a key question and ending with a plan of action. The process can be repeated in an iterative fashion.

Introduction

Accurate target population estimates are necessary to calculate immunization coverage from EPI administrative data, at both a national and sub-national level. Additionally, reliable target estimates are needed for program planning (e.g. vaccine forecasting) and monitoring to find missed people for immunization. Target estimates may be less accurate in smaller geographic areas and areas with significant migration (e.g., urban places where people come for work). Additionally, different target estimates are needed for antigens targeting different age groups (e.g., target for BCG or Hep-B birth dose is the number of births; target for DTP1 or MCV1 is surviving infants, etc.).

It is important to note that the accuracy of target population estimates especially affects the precision of vaccination coverage rates as coverage levels increase (Figure 1). In fact, as coverage levels approach 100%, errors in target population estimates can mask differences in vaccination coverage rates, resulting in pockets of missed unvaccinated children.[1]

[1] Brown DW, Burton AH, Feeny G, Gacic-Dobo M. Avoiding the Will O' the Wisp: Challenges in Measuring High Levels of Immunization Coverage with Precision. World Journal of Vaccines. 2014;4(3):3.

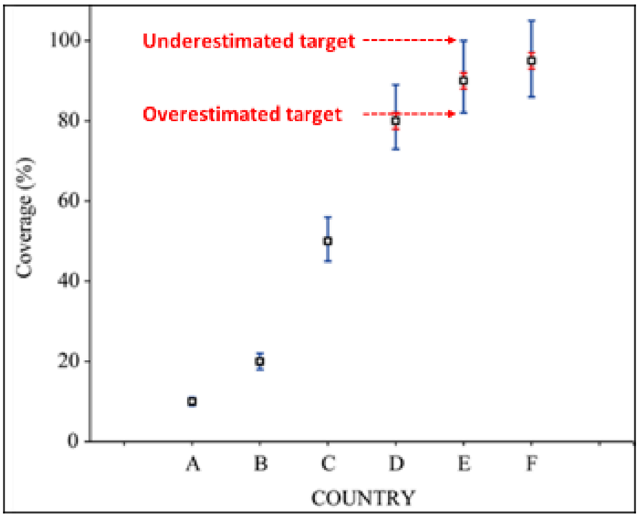


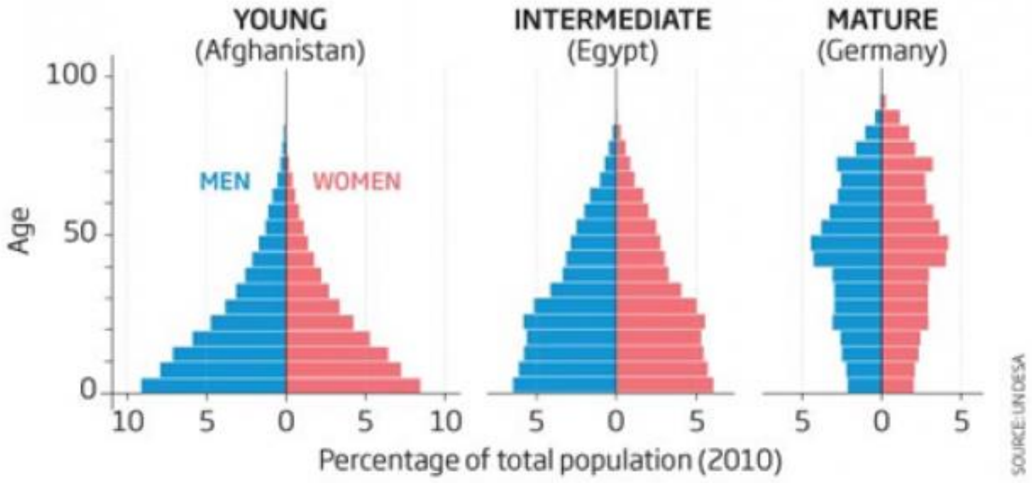
Figure 1: Effect of 10% error in target population estimates on different estimated immunization coverage rates[1]. At higher levels of coverage (>80%) the error in the target population estimate obscures the difference in immunization coverage.

Challenges in target population accuracy can be more deeply understood and addressed, in part, by comparing different data sources for your target population, or annual growth rates, crude birth rates (CBR), and infant mortality rates (IMR).[2] Useful comparisons across data sources include trends in denominators with numerators and coverage; analysis of differences in population targets and growth rates with external data sources; exploring underlying factors associated with issues with denominator accuracy; understanding migration patterns (seasonal for example) and considering those left-out of vaccination and other health services.

Country Example: What is the Problem?

Country X has national and sub-national administrative immunization coverage being reported over 100% across multiple antigens. The total population is growing because people are living to older ages, while births are likely decreasing each year (–0.71%, according to United Nations Population Division) because of where the country is within the "demographic transition" (Figure 2). However, the *infant* immunization target has increased annually (+1.42%) because a fixed *total* population growth rate (1.37%) is applied during health facility microplanning. Subnational variation in growth rates related to differences in birth rates, infant mortality, and migration patterns is also not accounted for, resulting in errors in local programme targets.

Figure 2: Demographic transition related to changes in birth and death rates (Source: Reardon. New Scientist, 2585; 19 May 2012)



While decisions around denominators are often outside of the control of the immunization programme, triangulation of different denominator data sources can give you a more in depth understanding of the reliability of the immunization target population estimates currently used in your program, including, but not limited to:

- An appropriate growth rate or IMR for your target population;
- Alternative denominator data sources that could be used for programmatic purposes;
- The need to change how the target population estimates are calculated.

Each data source has its own strengths and limitations, and triangulating these data sources will give you the necessary insight to understand 1) how to interpret immunization coverage data with existing target population estimate challenges; and, 2) which potential program improvement efforts are relevant to improve target population estimates (e.g., change in microplanning guidance and implementation).

Knowledge of how your target population is derived (e.g., applying growth rates, applying IMR, adding left-outs[3]) can help you identify relevant questions to frame your triangulation analysis. There may be known issues about the immunization target population in your area. This annex will describe how data triangulation at the national and regional administrative levels can help identify limitations with any one of these components and how it can affect your target population estimate. Potential solutions to denominator issues will be limited if there is no motivation for change.

Examples of reasons for inaccurate target population estimates

- Urbanization, migration, seeking care across geographic borders
- Outdated or inaccurate census estimates (groups not counted)
- Inaccurate methods of census projection or other estimation
- Lack of demographic knowledge among programme planners
- Suboptimal processes to monitor and improve data quality
- Artificial inflation related to incentives to achieve targets, especially where targets based on previous year's achievement
- Contrasting growth rates for total population vs. births

Available Resources

WHO "Assessing and Improving the Accuracy of Target Population Estimates for Immunization Coverage" (2015): https://www.who.int/immunization/monitoring_surveillance/data/Denominator_guide.pdf

PAHO. Tools for monitoring the coverage of integrated public health interventions: Vaccination and deworming of soil-transmitted helminthiasis (2017): http://iris.paho.org/xmlui/handle/123456789/34510

WHO. Handbook on the use, collection, and improvement of immunization data (June 2018 draft): https://www.dropbox.com/s/8ivdiu0g5xvnlbc/handbook.pdf?dl=1
[March 2020 version available by request: vpdata@who.int]

WHO. Data Quality Review (2017): https://www.who.int/healthinfo/tools_data_analysis/dqr_modules/en/

Stashko, et al. Assessing the quality and accuracy of national immunization program reported target population estimates from 2000 to 2016. *PLoS One*. 2019;14(7):e0216933: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0216933

Kaiser, et al. Trends in differences between births and surviving infants reported for immunization program planning and external data sources in Eastern and Southern Africa 2000-2013. *Vaccine*. 2016;34(9):1148-51.: https://www.ncbi.nlm.nih.gov/pubmed/26057134

[3] *Left-out* is the proportion of surviving infants who did not receive any doses of the specified vaccine.

Plan

Identify the key question

Developing specific questions based on common problems you have experienced could help direct the analysis and/or make it more relevant for your work. Example key questions are listed below.

Key questions
? How do national estimates of infant populations, birth growth rates, and IMR from different data sources compare?
? What is the extent of variation in targets and growth rates at sub-national level? Are there substantial differences in growth rates between urban vs. rural areas?

It is important to engage relevant stakeholders from all levels to develop the key question, identify and access the appropriate data sources and get agreement on the necessary action based on the findings. Relevant stakeholders could include demographers, Ministry of Health Statistics Division, National Statistics Office, and EPI staff from all levels.

Data Sources

Meet with local health, statistics, and civil registration/vital statistics offices in order to gather all available data that may be used to calculate target population estimates and analyze gaps that may exist. Data sources for both national and subnational population targets (where available) should be reviewed. Sources which have at least 5-10 years of data are useful for understanding trends within and between different data sources. The limitations and strengths of each data source should be recorded for consideration during interpretation of data triangulation analyses. Some example data sources include:

- Country census projections
- Civil Registration and Vital Statistics (CRVS) or other birth registration (including sample registration systems)
- Global Population estimates (United Nations Population Division World Population Prospects)
- Electronic Immunization Registries
- Local micro-censuses and house-to-house heads counts
- Household demographic surveys (include CBR, IMR)
- Health and demographic surveillance sites
- Immunization programme (microplan, BCG, Penta1 and PCV1 doses administered)
- Other programme data, e.g., campaign (polio, measles, Vitamin A, deworming), antenatal care, family planning, school or voting enrollment
- Modeled estimates (e.g., based on Geographic Information Systems, GIS)

Estimated numbers of births, crude birth rates, and infant mortality rates can usually be found in demographic statistics publications. Estimations of live births can be made using local crude birth rates and total population estimates. Estimated numbers of surviving infants must usually be calculated from estimated numbers of births and infant mortality rates. Use of a fixed conversion factor (e.g., 3% infants in total population) will result in errors in estimates and is not recommended because of variation by time and area. Growth rates may be available for your local area. However, use of age-specific growth rates (births, infants, or 0–4 years) is advised because of differences with that of the total population. Annual growth rates can be calculated from annual targets in two consecutive years (Formula Box).

Formula Box

$$Live\ Births = Total\ Population \times Crude\ Birth\ Rate\ /\ 1000$$

$$Live\ Births_{Year\ 2} = Live\ Births_{Year\ 1} \times (1 + Birth\ Growth\ Rate)$$

$$Surviving\ Infants = Births \times (1 - Infant\ Mortality\ Rate)$$

$$Birth\ Growth\ Rate^{4} = \left(\frac{Births\ in\ Year\ 2}{Births\ in\ Year\ 1}\right) - 1$$

$$Crude\ Birth\ Rate = \frac{Live\ Births}{Total\ Population} \times 1000$$

$$Infant\ Mortality\ Rate = \frac{(Births - Surviving\ Infants)}{Births} \times 1000$$

Gather & Prepare Data

Before starting, clarify what the source of population target is for various reporting levels. Often lower levels may use targets derived from program planning data (microplan, local health census) while the national level may need to report coverage through the WHO-UNICEF Joint Reporting Form (JRF)[5] using official census projection figures from the National Statistics Office. The source of denominator used can even vary across multiple administrative levels, i.e., from health facility, to district, to national; or between areas, for example, different subnational levels may use different approaches to obtaining single age population estimates.

It may take considerable effort to compile data across various sources and years in usable format. As you gather and compile different data sources, it is important to also obtain and review available background and documentation regarding each data source and associated methodology, and any changes to them. Consulting with the National Statistics Office could be valuable for uncovering other valuable information that may be available and useful for the exercise. Similarly, it would be useful to consider whether other well-performing programs in the country (e.g., family planning, antenatal care, disease control) have program data that could be useful for inclusion. Data of the same type for different years should be merged into one electronic file to allow analysis. Other specific considerations are described below in Table 1.

[4] This growth rate formula is for consecutive years. To calculate an annual growth rate from non-consecutive years (e.g., census projections for 2016 and 2020), you can use the following, where *ln* is natural logarithm and *n* is number of years:

$$Growth\ rate = \frac{ln(Births\ in\ Year_n\ /Births\ in\ Year_0)}{n}$$

[5] Data from JRF: https://www.who.int/immunization/monitoring_surveillance/routine/reporting/en/

Table 1: Key Considerations and Issues for Data Preparation and Use

Data source	Key Considerations for Preparation	Key issues for review
World Population Projection (UNDP)	• Estimates of live births/surviving infants , or in some cases children aged 0-11 months, should be available from WHO or UNICEF country office and/or online at: https://population.un.org/wpp • Only national level estimates available	• Should be available for all years • Estimated using national census, population-based surveys and demographic methods, but accuracy limited by quality of input data and/or time since census • Revisions occur every 2 years and can cause substantial increases in the denominator
Census-based projections	• Population projections for a defined period (e.g., 10 years) are usually available in one sheet • Confirm what source of projections are used by EPI for calculating coverage at national/ subnational level • Census projections usually become available 1-2 years after the actual census and they include estimates for the next several years, but also revisions to population estimates for previous years	• For projections from national statistics office, what is lowest level of estimation, how often are projections updated, and what methodology? (e.g., Differential growth rates included? Based on what data?) Are there estimates available for single ages or is the minimum level of disaggregation 12-59 months, for example? • If national statistics office did not estimate down to program implementation level, or by single age group, did EPI derive its own estimates for program use at central level, or is it done by each subnational level? • What methodology was used and what year were projections developed?
Civil registration and vital statistics (CRVS) systems	• May require contacting other ministries (e.g., Ministry of Planning; Ministry of Justice) & obtaining official permission to access & use data • Obtain information on the geographic extent of implementation & estimates of completeness (including proportions of facility & community events captured)	• What is the percentage of live births registered, and how is this calculated? • Is there substantial variation in registration by subnational area? • Are community births captured? If registration primarily captures facility births in areas where the proportion of community births is substantial, will need supplemental information sources to account for community birth estimates.
Immunization programme data	• National data reported to WHO/UNICEF Joint Reporting Form (JRF): https://www.who.int/immunization/monitoring_surveillance/data/en • Identify methodology used for deriving microplan estimate, e.g., health census, birth registration, previous year's vaccine doses given • What data source used for calculating coverage, i.e., annual microplan summary table vs. aggregated total of monthly reports? • Note any changes in administrative coverage reporting systems • Define what system should be used for which years and why	• If derived from routine reporting, what is completeness of data? • Presence of improbable coverage values such as 0% and >100%? • If different targets are reported for different antigen doses, do the figures make sense when comparing with one another? • Any change in reporting system, completeness, or representativeness over time? • Are all vaccination sites included in reporting (e.g., private providers)? • Any available data on accuracy of numerator (e.g., from a recent Data Quality Assessment/Audit (DQA))?
WHO/UNICEF Estimates of National Immunization Coverage (WUENIC)	• Time series of national estimates available online in MS Excel: https://www.who.int/immunization/monitoring_surveillance/data/en/ • Subnational estimates may be derived through WUENIC-like process using draft WHO guidance (can be requested to vpdata@who.int)	• Data should be complete for all years, but grade of confidence, meaning the confidence in the estimates, may vary (can review in country pdfs)

Household Surveys (DHS, MICS, EPI)	• Contain useful data: CBR, IMR, and subnational coverage estimates
	• Note uncertainty around point estimates (95% confidence intervals)
	• Consider using several recent surveys if different methodologies and/or differences in estimated coverage
	• May need to extract data from multiple survey reports to put them in useful electronic format (i.e., rather than PDF report)
		• What are the differences in methodology by survey?
		  - Are subnational coverage survey estimates available? What level?
		  - Are the 95% confidence intervals too broad?
		  - Is it a representative sample (e.g., DHS, MICS, vaccination coverage surveys using current WHO guidance) or a convenience sample (e.g., old 30x7 EPI method)?
		• What percentage of respondents showed cards to verify vaccination status?

Other data from National Statistics Office	• May be found from looking at publications on website • Better to meet with Statistics Office to discuss • May require official permission to obtain data	• Which sub-national areas contain special populations (e.g., migrant communities? • Are there data relevant to these special populations? • What is the methodology, geographic extent and/or target populations of survey/census?
Other program data	• Review recent multiple indicator surveys (DHS, MICS) to determine any other programs with high survey coverage that might have useful data • May require official permission to obtain data	• Are there other program data that can be used to complement gaps in existing data, i.e., added value?

Analyze

Assess reliability and potential limitations of data sources

Look at each of the data sources to assess reliability and to identify outliers, missing values, and potential data quality concerns. The quality and reliability of the data must be considered as well as the strengths, weaknesses and best usages for each type of data. See Table 1 for specific considerations for each type of data.

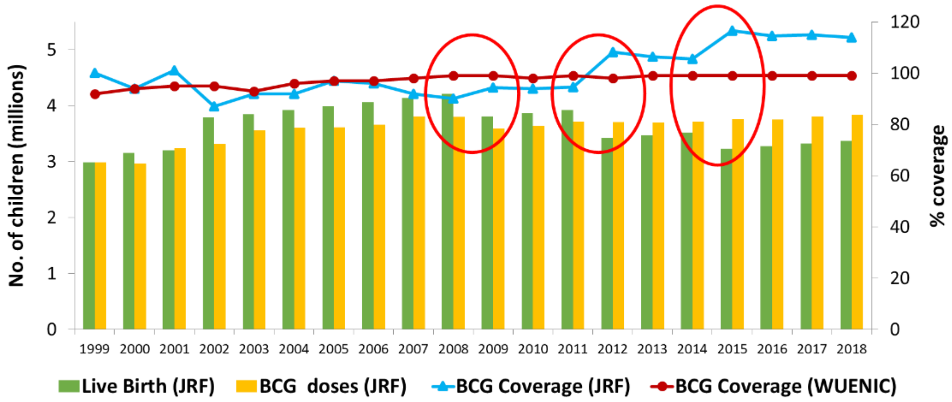
While reviewing each denominator source, consider the following:

- Is the trend as expected? Is the recent trend increasing or has it decreased or plateaued?
- How do the trends across sub-national areas compare?
- Are there areas with over 100% coverage? Does coverage data quality vary by population size or by urban/rural areas?
- Are there year-to-year changes in the denominator exceeding a 10% difference?[6]
- Do any changes coincide with changes in geographic boundaries, changes to the data used, collection methods, data entry errors, recent in-migration from border areas, etc.?
- How frequently are key data fields missing? How will any challenges noted with data completeness affect your interpretations?

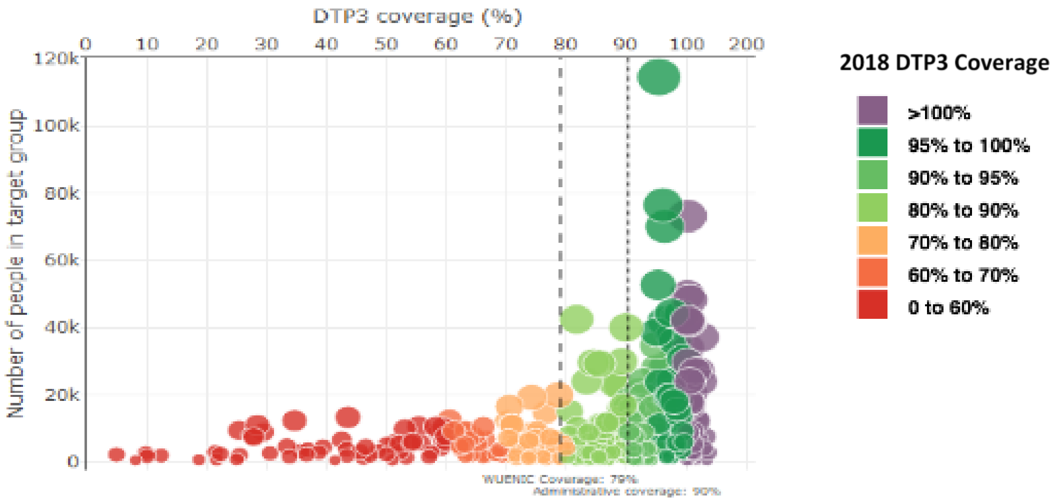
Suggested analyses to assess data reliability
a. Completeness and timeliness of reporting, and any missing denominator data.
b. Trends in reported program denominators (targets), numerators, and coverage over time for any unlikely trends or outliers (>100% coverage, large annual variation, zero/missing reports).
c. Compare the administrative immunization coverage estimates by sub-national population size and for urban/rural areas.
d. Consistency between reported denominators for different non-BCG antigens, if reported separately; consistency of denominators for BCG and HepB birth dose, if relevant.
e. Sum of subnational denominator estimates equals national denominator estimate.

Relevant examples are shown below for (b) and (c) (Example 1 and 2, respectively). See also the Guidance Annex 3 on Immunization Programme Monitoring for relevant examples for this step.

[6] $Percent\ change = \frac{Absolute\ value\ of\ (Year\ 1 - Year\ 2)}{Average\ of\ (Year\ 1\ and\ Year\ 2)} \times 100\%$



Example 1. Comparison of BCG doses, live births, administrative coverage, and WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), County X, 1999-2018. This graph helps visualize the impact of numerator and denominator changes on coverage. In 2009, both live births and BCG doses decreased, with no change in BCG coverage. In 2012 and 2015, the live births decreased and coverage increased. BCG coverage estimates from WUENIC remained relatively stable over time.



Example 2. Bubble chart of district DTP3 coverage vs the number of children in the target group, Country X, 2018. Bubble size is proportional to the number of children in the target group, with larger bubbles corresponding to higher target groups (y-axis). Bubbles are colored based on coverage level for the subnational area (x-axis). Vertical lines depict the national WUENIC and administrative immunization coverage estimates. The graph helps visualize whether >100% coverage and/or low coverage tend to occur in small population areas, where small differences in the denominator may cause large differences in coverage. In the example above, the lowest coverage occurs in a proportion of small population areas (e.g. small bubbles in red), and the areas with largest population tend to have higher coverage (e.g. larger bubbles in dark green and purple). (Source: https://www.who.int/immunization/monitoring_surveillance/data/subnational/en/)

Compare trends across data sets (triangulation analyses and synthesis)

Suggested comparisons
A. Trends in target population estimates and alternative population sources
B. Growth rates for target populations over time and across sources
C. Crude birth rates across data sources
D. Infant mortality rates across data sources
E. Coverage re-computed based on different denominator sources vs. coverage survey estimates
F. Vaccine stock/supply and population target estimates
G. Considering those left-out of programme targets using various sources

Ranked order of reliability of population data sources

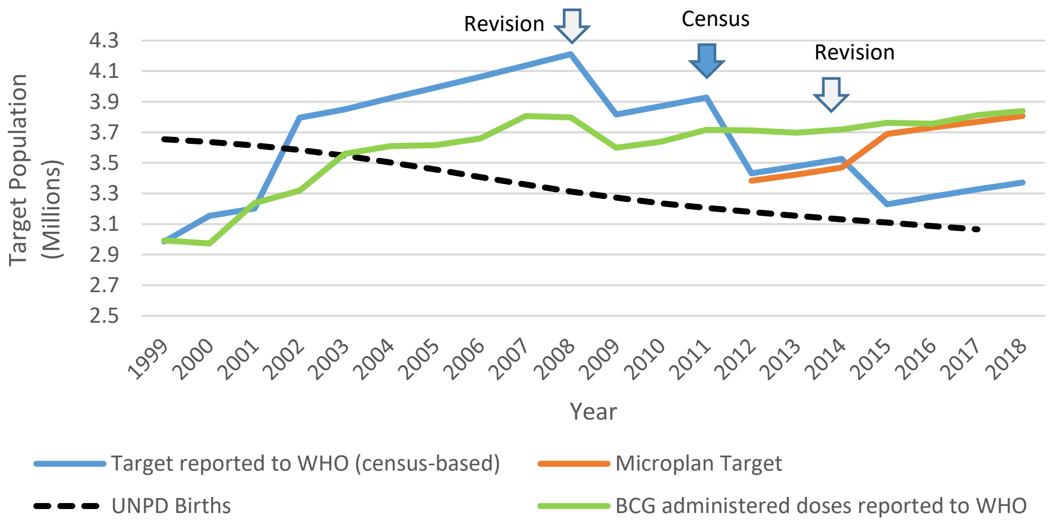
1. Births from CRVS or birth/immunization registry, if high proportion of births enrolled
2. Births from recent census projections (conducted within last 10–15 years)
3. Births estimated from: Total population projection x CBR (census <10–15 years old)
4. Birth projections from the census (conducted within last 10–15 years)
5. Local enumerations (head counts)
6. Non-census-based sources, like immunization program data (e.g., BCG, Penta1 doses)
7. World Population Prospects

A. Trends in target population estimates and alternative population sources

Evaluating immunization program data (e.g., microplan, BCG, Penta1) and other relevant population data sources (e.g., census, CRVS, birth registries) in a time series graph for at least the past 5–10 years is helpful for comparing trends and identifying anomalies, like large annual changes (>10%). Across data sources, a percent difference of <10% is considered good agreement. Explore potential reasons for discrepancies.

Data required: Sources of national and sub-national target population estimates (births or surviving infants), such as census population projections, UNPD World Population Prospects estimates, microplan target population estimates, CRVS estimates, BCG/DTP1 doses administered, and other population data sources. Because BCG is given after birth and may be given in hospitals other than where infants reside, DTP1 could be a more relevant comparison. Similarly, the number of births may be overestimated if using birth registration and the municipality has a maternity hospital or is located near a border, where newborns may be registered outside family's usual place of residence.

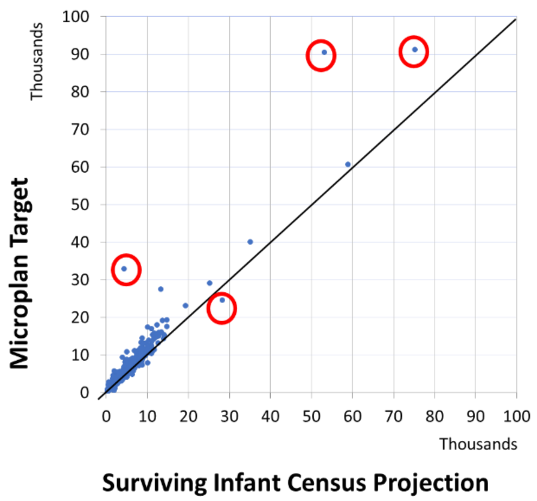
Potential output: Line graph or scatter plot comparing different target population estimates (e.g., births, surviving infants) by year. Arrows to depict when national censuses were conducted and projections revised.



Example 3. National Target Population Estimates Across Data Sources, Country A, 1999-2018.
While the births estimated by U.N. Population Division's (UNPD) World Population Prospects in Country A are decreasing over time, country data sources show higher numbers and increasing trends in births. Further discussion with the national immunization programme revealed that the census-based immunization program projections (blue line) applied a +1.3% growth rate for the total population. Action: As a result, the programme had to revise the census-based projections every few years in an attempt to adjust for the unlikely increase in births.

World Population Prospects

Estimates of population, births, deaths, and indicators like crude birth rates (CBR) and infant mortality rates (IMR) are available for all countries of the world during 1950-2099. The estimates are updated every two years using triangulation of available national data (e.g., censuses, household surveys) for components of demographic change (fertility, child, adult and overall mortality, international migration) by the United Nations Population Division. The relevant sheet to download is called **Annual Demographic Indicators.xlsx** and is available at: https://population.un.org/wpp/Download/SpecialAggregates/EconomicTrading/



Example 4. Comparison of census projections and microplan targets by district, Country A, 2018. Microplan target is generally higher than census projection target. Outliers usually corresponded to changes in borders of catchment area (e.g., formation of a new municipality).

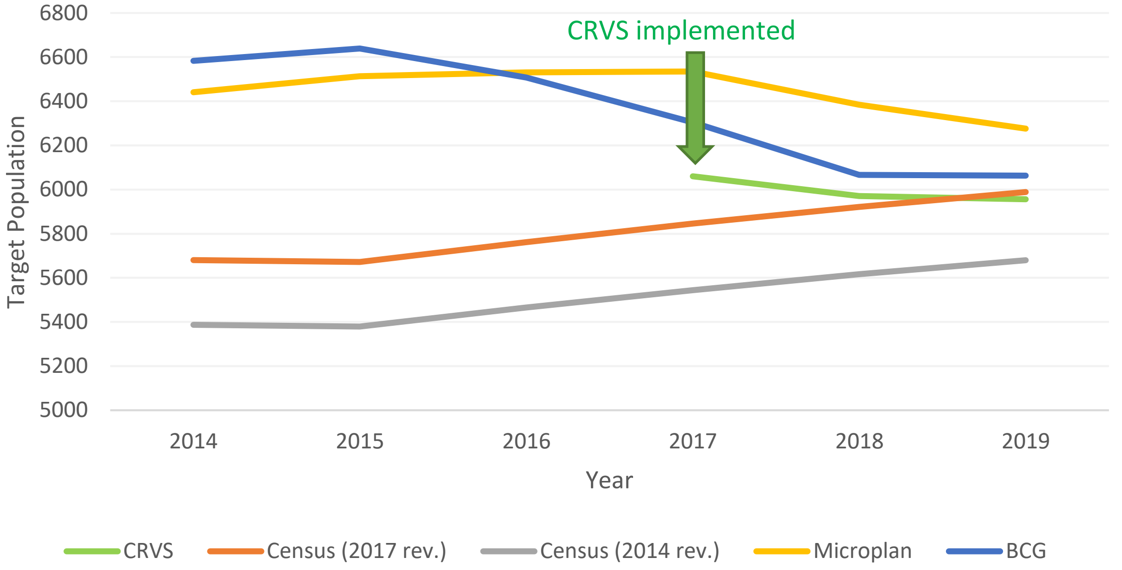
Civil Registration and Vital Statistics Systems (CRVS)

Most national statistical systems have only two primary sources for annual numbers of births: 1) population projection estimates from a recent national census, and 2) a civil registration and vital statistics (CRVS) system. If available and successfully implemented, CRVS systems are the gold standard as a source of population estimates because the systems continuously collect information on births and deaths as the events occur throughout the country, making the data the most accurate, current, and geographically detailed. While there is increased uptake of CRVS in some countries, progress in low- and middle-income countries has been slow. Sample registration systems are a potential data source in some countries that lack comprehensive CRVS systems.

The long-term goal for improving denominators will be to promote the development of a CRVS system that will provide target population estimates sufficiently accurate to monitor immunization coverage, especially when coverage is high. Civil registration systems are classified as "complete" if they cover 90% or more of all live births taking place within a country or area.

Please see the Civil registration and vital statistics (CRVS) Resource Kit available from the World Health Organization: https://www.who.int/healthinfo/civil_registration/en/.

Sub-national Example of Comparing Target Population Estimates Data Sources



Example 5. Sub-national Target Population Estimate Data Sources, District X, Country A, 2014-2019

Data sources available for the district are two revised projections of the 2011 census, microplan data based on BCG vaccine delivery, BCG doses, and Civil Registration and Vital Statistics (CRVS). Please note: the range of the Y-axis is adjusted to better illustrate differences in estimated births.

District X was one of the pilot areas chosen to implement a CRVS program since 2017. The district's CRVS is relatively high performing, registering over 90% of births within the first 45 days after birth. The district also tracks children from outside the district who receive immunization services within the district. District staff had noted a decline in vaccinations provided for several years, with their target being overestimated. Because of the high quality of the CRVS, the district decided to use its CRVS data as the base target population, plus the enumerated outsiders for their microplan. As a result, the district EPI manager feels confident that they have a more accurate estimate for their annual target population. Measles surveillance shows a few confirmed measles cases, but all are under 9 months of age (ineligible for vaccination), supporting the district's belief that the local target estimates are appropriate.

Action: Given the success of CRVS to determine accurate target population estimates in District X, the national immunization program hopes to increasingly rely on CRVS as it is expanded into other districts as part of efforts towards Sustainable Development Goals (SDG), which will ultimately improve the quality of microplanning and sub-national target population estimates. The trajectory of building a robust and sustainable system throughout the country will be long (see also CRVS box on previous page).

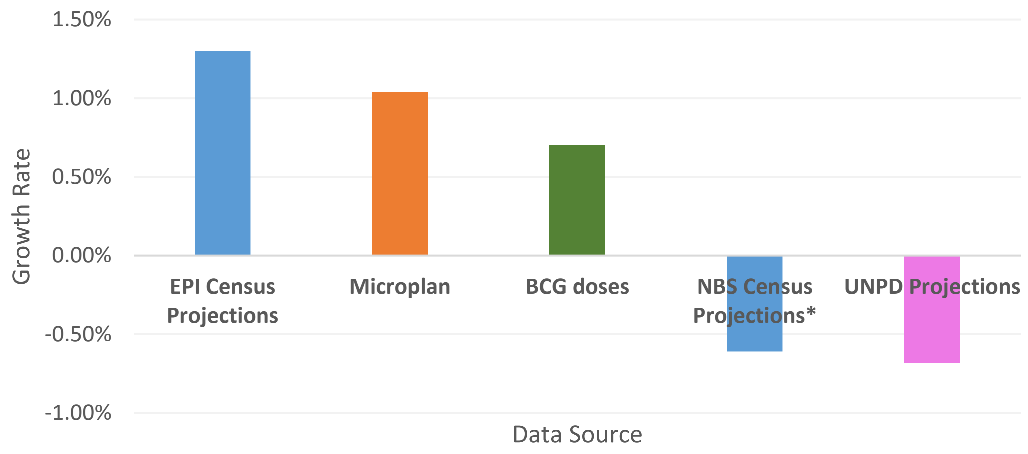
B. Compare growth rates for target populations over time & across sources

Compare trends in annual growth rates for various local population data sources in a time series graph for at least the past 5–10 years. Relevant questions are whether trends are going in the same direction and how the observed growth rates compare with any growth rate assumptions used during microplan target estimation. National official birth growth rates and national estimates from World Population Prospects are helpful benchmarks. Annual changes of >10% are unlikely at the national level, but may be possible at the subnational level related to changes in geographic boundaries, mass migration, or could also reporting errors.

Data required: Different sources of national and/or sub-national target population estimates (see above in A). Calculate the annual growth rates for each source using consecutive years of target population estimates with the following formula:

$$Growth\ Rate^{7} = \left(\frac{Target\ in\ Year\ 2}{Target\ in\ Year\ 1}\right) - 1$$

National example of comparing target population growth rates across data sources



Example 6. Comparison of target population growth rates by data source, Country A, 2012-2018.

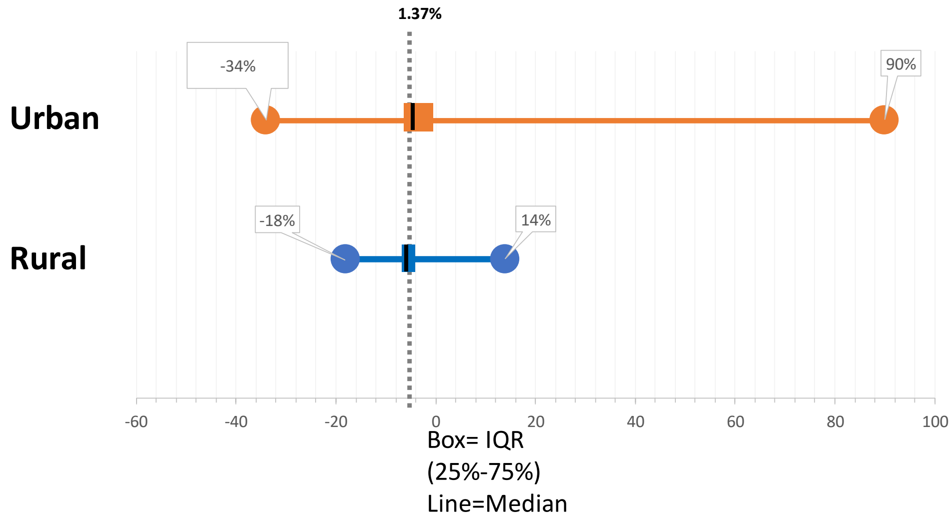
National immunization program data sources show positive growth rates, compared to the projections from the National Statistics Office and UNPD's World Population, which show negative growth rates. The census projections used by the national immunization program applied a total population growth rate of around 1.3%. This growth rate is related to the total population, rather than being specific for the infant population. Subnational variation in growth rate is not typically accounted for.

Action: After conducting the data triangulation analysis in 2019, Country A decided to revise their 2020 national microplan guidance to not apply a growth rate in hopes of halting the inflation of the national target population estimate. The programme would like to develop and pilot the application of district-level growth rates for births for the next planning cycle.

Potential outputs: A bar graph of growth rates across different data sources. Barbell plot or histogram of distribution/range of growth rates for urban vs. rural sub-national areas.

[7] This formula is for consecutive years. To calculate an annual growth rate from non-consecutive years (e.g., census projections for 2016 and 2020), you can use the following, where *ln* is natural logarithm and *n* is number of years:

$$Growth\ rate = \frac{ln(Population\ in\ Year_n\ /Population\ in\ Year_0)}{n}$$



Example 7. Range of microplan growth rates by urban/rural, Country A, 2017-2018.

The barbell graph depicts the range and interquartile range (IQR) of growth rates for microplan data during 2017-2018 by urban/rural areas. While the microplan practice is to apply the national growth rate for the total population of +1.37%, sub-national microplan target estimates have a wide range of growth rates. Growth rates in urban areas have a much wider variation than rural areas, with some urban areas having implausible growth rates, suggesting data entry errors or changes in catchment areas. Action: As a result, the national immunization programme plans to explore using other data sources to determine more accurate national and district-level growth rates.

C. Crude birth rate across data sources

This comparison is especially relevant if a fixed conversion factor (e.g., 3% of infants in the total population) is being applied to a total population estimate in order to estimate live births, which results in errors from variation over time and by area. For example, one could compare the difference in the CBR implied from the fixed conversion method with independent CBR estimates (e.g., World Population Prospects, surveys). If different CBRs are not being applied at the subnational level to account for different fertility rates, consider potential difference in birth estimation by subnational area or urban/rural under different CBR assumptions.

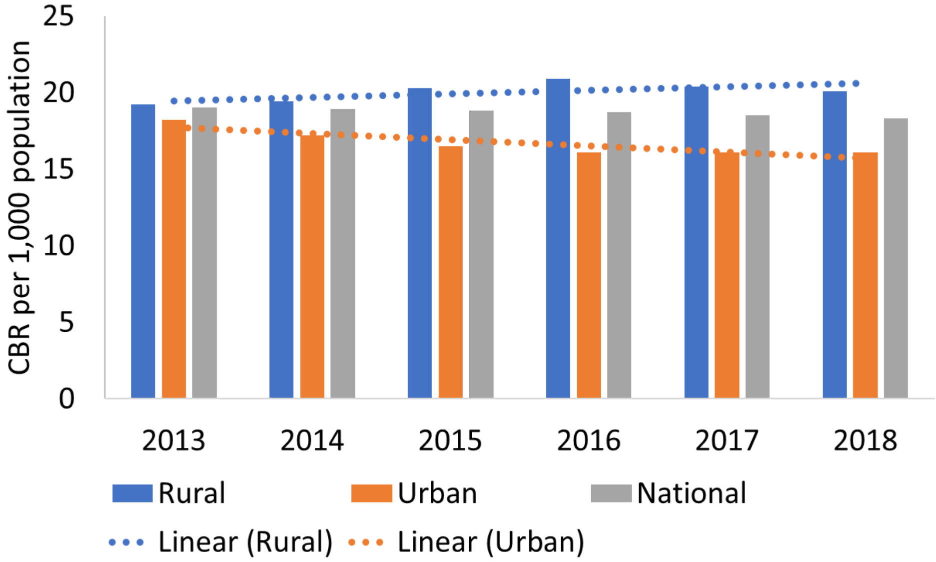
Data required: Raw national and/or sub-national target population estimate figures and total population estimates for each data source by year (e.g., for the past 5–10 years). Calculate the implied CBR for each data source:

$$Crude\ Birth\ Rate = \frac{Live\ Births}{Total\ Population} \times 1000$$

Comparisons can be made to CBRs from the World Population Prospects,[8] recent censuses (use “adjusted” CBR), CVRS with good completeness (covering >90% or more of all live births taking place within a country or area), DHS or MICS surveys, or other demographic or reproductive health surveys. Given that a large range in subnational fertility rates is possible, reviewing subnational comparisons of CBRs and the range by urban/rural is encouraged.

[8] Relevant sheet is the Annual Demographic Indicators (.xlsx) available at: https://population.un.org/wpp/Download/SpecialAggregates/EconomicTrading/

Potential output: A combination graph of comparing births and CBRs computed across different data sources. Bar graph showing trends, or histogram/barbell plot showing variation in distribution by subnational area or urban/rural.



Example 8. Crude Birth Rate (CBR) per 1,000 mid-year population by urban and rural areas, Country X, 2012-2016. CBR data comes from an annual population-based household demographic survey completed by the national statistics office; CBR estimates are available down to the district level. Urban birth rates are declining over time, and differences between urban and rural birth rates is growing. Action: Based on these observations, Country X is considering changing the microplan guidance to account for local variation in trends of future estimated births (e.g., declining fertility rates, especially in urban areas), rather than applying the same positive growth rate for all sub-national areas.

D. Implied infant mortality rates across data sources

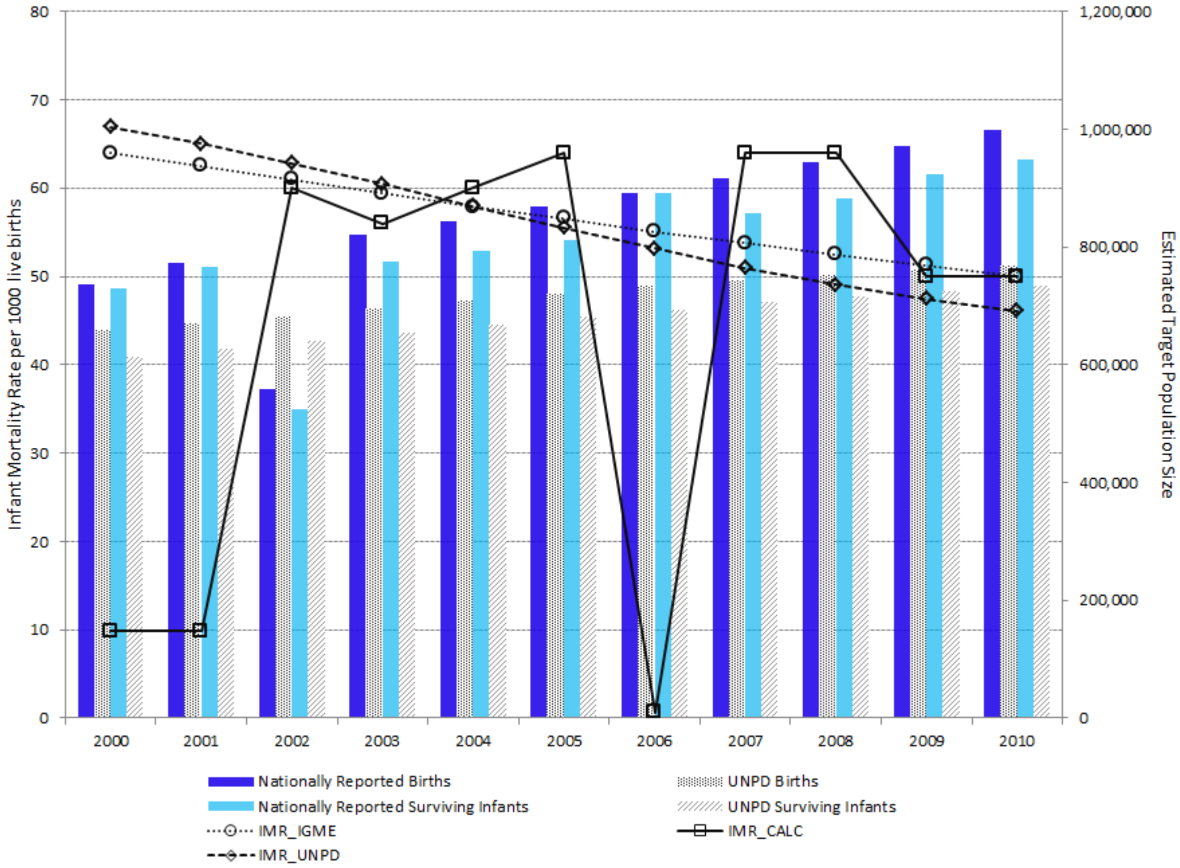
This comparison is relevant if different targets for births and surviving infants are used (versus using a single microplan target). The relevant question is whether the implied IMR from the estimates used for births and surviving infants makes sense (e.g., is not a negative number), and how it compares to external IMR estimates from the United Nations Interagency Group on Child Mortality Estimation (IGME) [http://www.childmortality.org/] and World Population Prospects (WPP).[9]

Data required: IMR estimates from IGME, WPP, and demographic surveys; national and/or sub-national births and surviving infant targets for each data source by year (e.g., past 5-10 years). Calculate the implied IMR for each population data source:

$$Infant\ Mortality\ Rate\ = \frac{(Births\ -\ Surviving\ Infants)}{Births} \times 1000$$

Potential output: A combination graph of comparing births, surviving infants, and IMRs computed across different data sources.

[9] Relevant sheet is the Annual Demographic Indicators (.xlsx) available at: https://population.un.org/wpp/Download/SpecialAggregates/EconomicTrading/



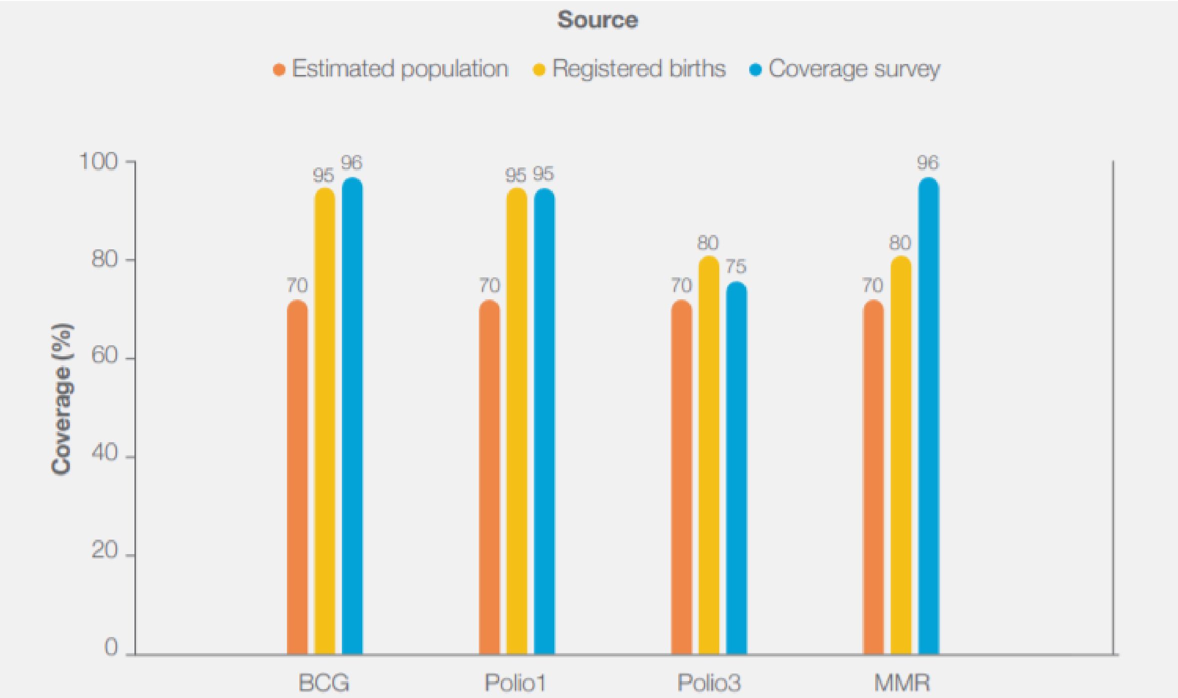
Example 9. Comparison of nationally reported live births and surviving infants with those of the United Nations Population Division (UNPD) and of infant mortality rates from the United Nations Interagency Group on Child Mortality Estimation (IGME), UNPD and computed from nationally reported data, Country C, 2000 – 2010. Country-reported live births and surviving infants increased over time and were higher than UNPD estimates, in every year except 2002. IGME and UNPD estimates of IMR decreased over time, in line with improved health outcomes. Calculated IMRs from the reported data varied highly from year-to-year; in some years the calculated IMR was close to that estimated by IGME and UNPD; in other years the IMR was much too low. Action: the country could further investigate years where the national IMR was much lower than IGME and UNPD estimates and determine if a more accurate source of IMR could be used in the future by the programme.
(Source: Brown et al. 2013: https://sites.google.com/site/infantmortalityrate/)

E. Coverage re-computed based on different denominator sources vs. coverage survey estimates

Calculating vaccination coverages estimates according to different denominators allows you to examine the impact on the range of coverage values. Relevant questions are how the calculated values compare with vaccination coverage survey estimates, and whether some population estimates produce values that are closer or further away from the coverage survey values.

Data required: Number of children vaccinated for each antigen of interest; target population estimates according to different data sources; coverage survey point estimates and 95% confidence intervals by antigen.

Potential output: A bar graph, where each bar depicts the immunization coverage calculated using a different denominator estimate. For comparing estimates across many subnational areas, scatter plots by antigen may be useful.



Data source for denominator	Number
Projected population census	90,000
Reported live births	70,000
Sample	Sample = 1,000 Accuracy level = 10%

What accounts for differences in the coverage denominators?

Example 9. Vaccination coverage calculated based on different denominator sources compared with coverage survey estimates by type of vaccine, Country D. Use of registered births as a denominator produces coverage estimates closer to the survey estimate for BCG and Polio1 than the census projections. It has been shown that coverage surveys that rely heavily on caregiver recall often underestimate coverage of multidose vaccines (e.g., Polio3). Coverage for measles vaccine or other vaccines delivered through campaigns can sometimes be overestimated if the survey questionnaire does not clearly distinguish campaign and routine doses, and caregiver's recall is used (Source: PAHO coverage monitoring guide).

F. Vaccine stock/supply and population target estimates

Reported vaccine stock data (e.g., vials used) are a commonly available data source and provide a ready opportunity for comparison with programme targets and doses administered. Analysis of stock data reported from the service delivery level should most closely match vaccine administration data, but there could be data quality challenges (e.g., gaps in reporting). The comparisons are especially easy for vaccines given in a single dose vial or where vaccine wastage is low, but the comparison can be made for all vaccines.

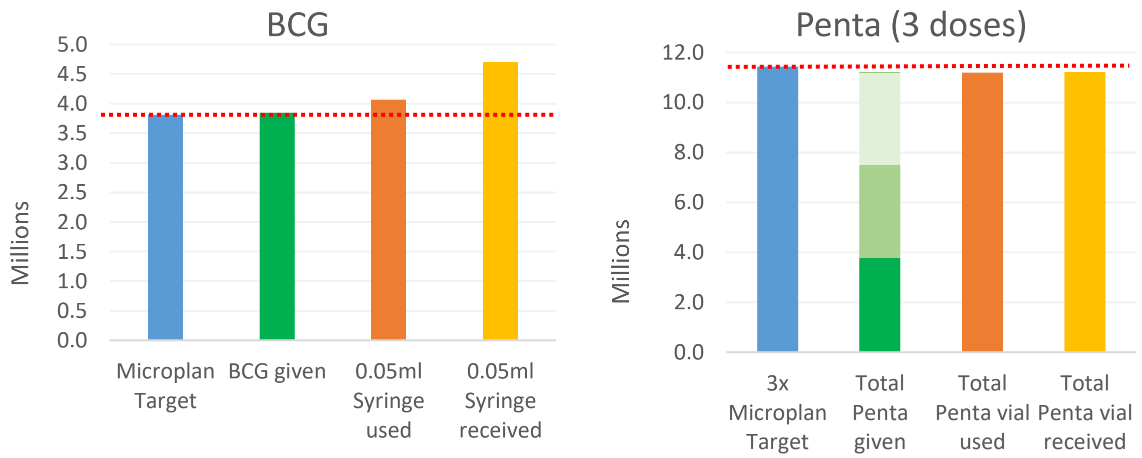
The question is whether degree of difference between the target, doses given, and vaccine dose/vials used is beyond what could be explained by vaccination coverage (e.g., missed children). If coverage is low or the reported numerator (doses given) is unreliable, another check is to multiply the programme target (doses given) by a coverage survey estimate or WUENIC, and compare this figure (i.e., minimum required to achieve the estimated coverage given the target used) to the vaccine doses used (stock). Another question is whether insufficient stock (e.g., stock-outs) suggests that targets are underestimated; checking for over-estimated targets can be challenging without conducting an additional vaccine stock inventory to verify that this is not a reporting error.

Data required: Total vaccine doses given (stock); total vaccine doses administered (e.g., Penta1 + Penta2 + Penta3 at 0-11 months & 12-23 months; MCV1 + MCV2 at 0-11 months & 12-23 months); vaccine stock-outs; other logistics data, e.g., 0.05 ml syringes for comparison with BCG doses used; coverage survey estimates or WUENIC; microplan target and other population estimates (e.g., census projections, [World Population Prospects](#)). For antigens where multiple vaccine doses are given, it may be relevant to compare vaccine stock to a multiple of the target population (e.g., multiply the target by three for the total Penta doses given). For multi-dose vaccine vials, you can covert vials to doses by multiplying by the number of doses in vial presentation (e.g., multiply by two for 2-dose vial).

Potential outputs: A bar or line graph depicting trends in the population target, number of doses administered, number of doses used, number of doses received and/or available at the national level by year/month for different vaccines. Scatter plot of bar graph comparing the number of doses administered and doses used or doses received by sub-district or health facilities for different vaccines.

Notes:

- Interpret results with care depending on quality of data in the administrative reporting and stock management system.
- The number of doses shipped and received from the vaccine depot is an approximate comparison against doses used. However, because there can already be doses leftover from the previous month (opening balance/previous stock), it is possible for doses used to exceed the number of doses received.
- Use of other logistics data (e.g., syringes) is possible, but may be challenging based on distribution and data recording practices (data quality).



Example 10. Bar graph comparison of microplan target, doses given, and sub-district stock (vials/syringes used/received) for BCG & Penta3, Country E, 2018. The 0.05ml syringes are only used for BCG administration, and were not in gross excess of the microplan target and BCG doses given, considering practices of giving handfuls of syringes to vaccinators. Total Penta doses given is Penta1 + Penta2 + Penta3, and the Penta vaccine used is a single-dose vial. The number of Penta vials used and received at the sub-district level compare reasonably with 3-times the microplan target, considering vaccination coverage by WUENIC (99% for DTP1, 98% for DTP3). Based on the analysis, there was no evidence of gross overestimation of the target population from coverage, vaccine stock and shipment data. However, it is possible that there were similar reporting errors in the administrative vaccination and vaccine stock data reported through the same electronic information system. Further independent confirmation is that the country received 11 million doses from Gavi in 2018, plus an existing 1.5 million in stock in January 2018. Action: the evidence provided in this analysis should be communicated to programme policy decision makers for consideration to ensure any future changes in immunization target estimates do not result in vaccine stock and supply issues.

G. Considering those left-out of programme targets using various sources

Use of service data for programme targets is recommended only when census data are outdated and not usable (see Data Reliability Box on p.9). If using administrative vaccination data as a target, where the number of doses of BCG or Penta1 delivered last year becomes next year's target, an adjustment is needed to account for left-outs.[3] For example, the number of vaccine doses administered is divided by the most recent district coverage survey estimate for that antigen to get the adjusted target:

Example: 100,000 vaccinated / 0.95 coverage = 105,263 target

Adjusting for completeness of reporting or registration can be more complicated depending on assumptions of whether the facility was working at the same level during the missing reporting period as before and after.[10] If a reliable estimate of the absolute numbers of infants missed by the program is available (i.e., from name-based registration or tallies), this number could be added to the estimate, instead of dividing by a percentage.

For coverage surveys and surveillance, denominator innacuracies are not a limitation. One point is to review this data and consider whether the areas and groups identified to have low coverage survey estimates or with many zero-dose or under-vaccinated measles or other VPD cases (e.g., local migrant workers camp or slum areas) are being adequately included in microplans.

For special areas subject to rapid in- or out-migration, there may be special censuses or head counts conducted by the immunization programme, national statistics office, or non-governmental organizations. These data sources may be relevant for producing local targets estimates for these areas.

Example: Improving Target Estimates Using Health Facility Data, Kenya

Kenya uses projections from the 2009 Census as the denominator to calculate sub-national vaccination coverage, but errors in sub-national estimates typically lead to unusually high or low vaccination coverage. Data from the 2014 Demographic Health Survey (DHS) showed coverage with first antenatal care visit (ANC1) and first dose of pentavalent vaccine (Penta1) was ≥ 95% in most (41 of 47) counties. In an effort to improve sub-national target population estimates, it was decided to re-calculate county-level indicators from health facility data using the following steps:

1) Assess trends in reporting completeness and consistency of ANC1 and Penta1 coverage calculated with census projection-based denominators; identify and correct outliers.
2) Adjust the ANC1 and Penta1 numerators for facility reporting completeness.
3) Adjust the reported ANC1 and Penta1 for left-outs based on coverage survey estimates to derive target populations for pregnancies, deliveries, and infants.
4) Use the adjusted numerators and denominators to calculate subnational coverages of immunizations, ANC (first and fourth visits), and facility-based deliveries.

Triangulation of health facility data provided alternative sub-national target estimates for health facilities with otherwise very outdated census or survey data. Triangulation also allowed monitoring of coverage trends over time. Enabling factors for successful use of this method were a strong administrative reporting system with relatively high completeness, involvement of the private sector, good data quality, and a recently conducted high quality DHS with county-level estimates. More information can be found at the reference below:

Maina et al. (2017). Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5689197/pdf/BLT.17.194399.pdf

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[10] Formula for the adjustment is: $n_{adjusted} = n + n(1/(c) - 1) *k$, where *n* is the service output (vaccinations), *c* is reporting completeness, *k* is the adjustment factor. If missing reports are considered to indicate that no services were provided during the period, then *k* = 0 (no adjustment for incomplete reporting). If services are provided, but at a different level than before, incomplete reporting is an indication of a lower service provision and *k* is between 0 and 1 (Maina et al. 2017).

Consider local knowledge & evaluate explanatory causes

It is important to consider local knowledge and context during the synthesis of your data triangulation analyses. This will allow you to more accurately interpret the data, including explanatory causes or hypothesis and develop more targeted questions and program improvement efforts.

Key considerations
Consider governance, policies, and guidance around target population estimates at the national and sub-national level and the role it plays in program planning (e.g. microplanning).
Areas with small populations, which may be unstable, and where small differences in the denominator may cause large differences in coverage.
Subnational differences in birth rates (e.g., may be >2-fold difference between urban and rural areas or in between areas with different ethnic/religious groups).
Differential migration patterns (e.g., urbanization).
Data qualiy issues (see Program Performance Annex 3).

Act

Summarize the key findings concerning denominators from your analysis of multiple data sources. Next, consider whether the findings from the denominator triangulation lead to actionable recommendations to improve the denominators in your area. Based on your understanding of the issues, develop simple key messages and potential actions for relevant stakeholders and different levels. Providing examples of key issues and their importance, based on contextual information (e.g., known demographic trends, time since last census) or discussions with local staff, will help support your message.

This guide does not provide a step-by-step method for how to improve denominator accuracy, but the WHO Denominator guide describes an approach summarized in the box below.

Improving Denominators

- Choose an alternative target population estimate (see ranked order of data source reliability on p. 9)
    - Estimate births for future years using growth rates, if needed (i.e., not needed for census projections already accounting for growth)
    - Consider completeness of your estimate and adjust for left-outs (for programme data and birth registration data)
- Prorate estimates for subnational levels based on known commodity (e.g., vaccine doses given)
- Use births to calculate surviving infants for subnational levels

There are no “magic bullets” to fix denominators in the short-term. When developing potential action items, consider the availability of resources and staff who would be involved in implementation of the action plan. Actions can be prioritized based on what is feasible for the short-term versus long-term, based on what will take more time to address. Consider the implications of any large changes to targets, e.g., potential vaccine stock-outs. If issues related to training needs or data quality issues arise, opportunities to conduct supportive supervision might be relevant. Your action plan may also include conducting regular triangulation analyses in the future.

Denominators are often outside of the control of the immunization programme. If you decide you would like to change the denominator based on your analysis, discuss the rationale with supervisors with decision-making authority, including staff at the Ministry of Health and/or national statistics office. If changes are made to the annual microplan, include the source of the denominator and any adjustments made with a description of the rationale.

Example: Recommendations & Action Plan, Country A

After presenting the data triangulation exercise findings, the Triangulation Team developed the following recommendations with national immunization program leadership and partners:

Time Period	Recommendations
Short-term	• Evaluate implementation and impact of changes to the 2020 microplan guidance • Compare measles vaccination campaign microplan and routine microplan • Raise awareness of changing demographic trends nationally and locally
Medium-term	• Consider pilot use of local growth rates for microplanning • Add reference data to DHIS2 or another health information system (e.g. census projections, migrant data, CRVS) • Build capacity for triangulation of population data at subnational level
Long-term	• Support expansion of CRVS — relevant for improved EPI targets • Improve methods of projecting live births/surviving infants for upcoming census • After 5 years, consider inter-censal projection revisions to be done with National Statistics Office

Example: Changing calculation of microplan target estimates, Mozambique

In Mozambique, the Ministry of Health has used one methodology since 1979 to estimate the size of target populations for all health programs, including immunization. Each year, census population projections are multiplied by a uniform conversion factor across all provinces and districts to determine subnational-level denominators. This approach produces unreliable estimates at the subnational level because it overlooks the considerable variations in demographic change (e.g., births, deaths, migration) that affect provinces, districts, and communities.

With the engagement of all relevant stakeholders, the county is taking the following steps towards revising target population estimates at the sub-national level:

- **Identify problems with the traditional method of estimating denominators and target populations**, including the use of a uniform growth rate across districts and provinces and the same 3.9% fixed conversion factor to estimate the population of children aged <12 months.
- **Develop new province/district-appropriate conversion factors for target population**. Rather than using the standard 3.9% change coefficient, the team used 2016/2017 population projections generated from 2007 census findings, disaggregated down to provincial and district levels (and in single age groups when needed).
- **Test the validity of the new conversion factors over time** by comparing provincial- and district-level population projections for the period 2016 to 2020 (based on the 2007 census), and then calculating conversion factors for each year using the corresponding numbers of live births.

This approach has the potential to achieve greater accuracy when estimating the size of a target population. More information can be found at the reference below:

USAID. Maternal and Child Survival Program. https://www.mcsprogram.org/wp-content/uploads/dlm_uploads/2019/01/MCSP-MZ-Brief-TargetPopulationMethodology.pdf

Resources

National estimates of births, surviving infants, CBR, and IMR are available for most countries from the UN Population Division's *World Population Prospects*: https://population.un.org/wpp/

- Relevant sheet is the Annual Demographic Indicators (.xlsx) available at: https://population.un.org/wpp/Download/SpecialAggregates/EconomicTrading/

National child mortality estimates (e.g., IMR) based on the research of the UN Inter-agency Group for Child Mortality Estimation (IGME): http://www.childmortality.org/

WHO. Assessing and improving the accuracy of target population estimates for immunization coverage (2015 draft):
https://www.who.int/immunization/monitoring_surveillance/data/Denominator_guide.pdf?ua=1

WHO. Handbook on the use, collection, and improvement of immunization data (June 2018 draft):
https://www.dropbox.com/s/8ivdiu0g5xvnlbc/handbook.pdf?dl=1
[Updated version available by request at vpdata@who.int]

Analysis and use of health facility data: Guidance for Programme Managers (February 2018 working document) Available at: https://www.who.int/healthinfo/tools_data_analysis_routine_facility/en/

WHO. Data Quality Review (DQR) Toolkit (2019). Available at:
https://www.who.int/healthinfo/tools_data_analysis/dqr_modules/en/

PAHO. Tools for monitoring the coverage of integrated public health interventions: Vaccination and deworming of soil-transmitted helminthiasis (2017). Available at:
http://iris.paho.org/xmlui/handle/123456789/34510

Brown et al. A review of target population estimates and implied infant mortality rates from national EPI programmes during 2000-2010: https://sites.google.com/site/infantmortalityrate/

Maina et al. Using health-facility data to assess subnational coverage of maternal and child health indicators, Kenya. Bull World Health Organ. 2017;95(10):683–694.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5689197/pdf/BLT.17.194399.pdf

Maternal and Child Survival Program (MCSP) Mozambique Program Brief: Addressing the Denominator Conundrum for Maternal and Child Health Programs: a New Methodology
https://www.mcsprogram.org/wp-content/uploads/dlm_uploads/2019/01/MCSP-MZ-Brief-TargetPopulationMethodology.pdf

Stashko. Assessing the quality and accuracy of national immunization program reported target population estimates from 2000 to 2016. PLoS One. 2019 Jul 9;14(7):e0216933.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0216933

Reaching Every District (RED) strategy:
https://www.who.int/immunization/programmes_systems/service_delivery/red/en/

WHO. Training for Mid-Level Managers (MLM):
https://www.who.int/immunization/documents/mlm/en/

WHO. Immunization in Practice: A practical guide for health staff:
https://www.who.int/immunization/documents/mlm/en/

WHO Regional Office for Europe. Tailoring Immunization Programmes (TIP): www.euro.who.int/tip

WHO Effective communication of immunization data: www.euro.who.int/datacommunication

Acknowledgments

This document was authored by Heather Scobie, Angela Montesanti, and Michelle Morales from the Centers for Disease Control and Prevention (CDC) in Atlanta; Jan Grevendonk, Carolina Danovaro, and Marta Gacic-Dobo from World Health Organization Headquarters (WHO) in Geneva; and Mamadou Diallo from UNICEF Headquarters in New York.

Substantive input was received by the Strategic Advisory Group of Experts Working Group on the Quality and Use of Immunization and Surveillance Data, including Jaleela Jawad (Ministry of Health, Bahrain), Noni MacDonald (Dalhousie University, Canada), Michael Edelstein (Public Health England, and member of the Technical Consultation on Data Triangulation), Ana Morice (Independent Consultant, Costa Rica), Hashim Elmousaad (Independent Consultant, Pakistan), as well as the following participants in the Technical Consultation on Data Triangulation: David W. Brown from Brown Consulting Group International LLC; Tove Ryman from Bill and Melinda Gates Foundation; Riswana Soundardjee, Gustavo Correa, Lee Hampton, and Laura Craw, from Gavi, the Vaccine Alliance; Danni Daniels and Siddhartha Data from WHO Office for the European Region. We thank Roberta Pastore for the WHO Office for the Western Pacific Region; Minal Patel and Adam Cohen from WHO; Rajendra Bohara and Selina Ahmed from the WHO Country Office for Bangladesh; Lora Shimp, Adriana Alminana, Lisa Oot, and Wendy Prosser from John Snow Inc.; and Denise Traicoff, Aaron Wallace, Paul Chenoweth, Aybuke Koyuncu, Dmitri Prybylski, Jennie Harris, Gavin Grant, Kathleen Wannemuehler, Dieula Tchoualeu, Ben Dahl, Louie Rosencrans, Lauren Davidson, Sara Jacenko, Alyssa Wong, Joel Adegoke, Chung-Won Lee, Carla Lee from CDC, who reviewed drafts of this document and provided constructive comments. We also thank Chris Murrill, Sadhna Patel, Kristie Clarke, Susan Reef, and Morgane Donadel who provided valuable inputs when developing the triangulation framework. Additionally, we are grateful to the many colleagues who provided feedback through SurveyMonkey® and opportunities at the EPI Partners' Meeting in Budapest, Hungary (2018), WHO Region of the Eastern Mediterranean Monitoring Workshop, WHO Scholar course on Triangulation for Immunization Programme Improvement, and country workshops.

Disclaimer

Heather Scobie, Angela Montesanti and Michelle Morales work with the U.S. Centers for Disease Control and Prevention. Use of trade names is for identification only and does not imply endorsement by the Public Health Service or by the U.S. Department of Health and Human Services. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.

Jan Grevendonk, M. Carolina Danovaro[-Holliday] and Marta Gacic-Dobo work for the World Health Organization. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions, policy or views of the World Health Organization.

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